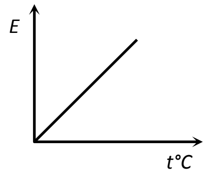
13.KINETIC THEORY

Single Correct Answer Type

1. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational moles, the total internal energy of the system is
a) 4 RT b) 15 RT c) 9 RT d) 11 RT

2. A gas at the temperature 250 K is contained in a closed vessel. If the gas is heated through 1K, then the percentage increase in its pressure will be
a) 0.4% b) 0.2% c) 0.1% d) 0.8%

3. The graph which represents the variation of mean kinetic energy of molecules with temperature t°C is

a)


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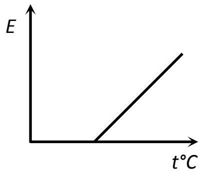

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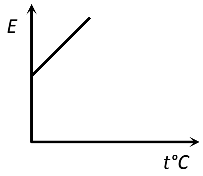

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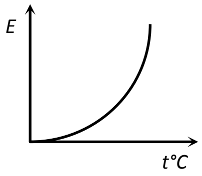


4. The gas in vessel is subjected to a pressure of 20 atmosphere at a temperature 27°C. The pressure of the gas in a vessel after one half of the gas is released from the vessel and the temperature of the remainder is raised by 50°C is
a) 8.5 atm b) 10.8 atm c) 11.7 atm d) 17 atm

5. A given mass of a gas is allowed to expand freely until its volume becomes double. If C_b and C_a are the velocities of sound in this gas before and after expansion respectively, then C_a is equal to
a) $2C_b$ b) $\sqrt{2}C_b$ c) C_b d) $\frac{1}{\sqrt{2}}C_b$

6. The relation between the gas pressure P and average kinetic energy per unit volume E is
a) $P=\frac{1}{2}E$ b) $P=E$ c) $P=\frac{3}{2}E$ d) $P=\frac{2}{3}E$

7. If 2 mol of an ideal monatomic gas at temperature T_0 are mixed with 4 mol of another ideal monatomic gas at temperature $2T_0$, then the temperature of the mixture is
a) $\frac{5}{3}T_0$ b) $\frac{3}{2}T_0$ c) $\frac{4}{3}T_0$ d) $\frac{5}{4}T_0$

8. A steel tape measures the length of a copper rod as 90.0 cm, when both are at 10°C, the calibration temperature, for the tape. What would be tape read for the length of the rod when both are at 30°C.Given, α for steel 1.2×10^{-5}°C^{-1} and α for copper is 1.7×10^{-5}°C^{-1}.
a) 90.01 cm b) 89.90 cm c) 90.22 cm d) 89.80 cm

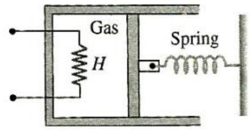
9. The specific heats of argon at constant pressure and constant volume are 525 J/kg and 315 J/kg, respectively. Its density at NTP will be
a) 1.77 kg/m^3 b) 0.77 kg/m^3 c) 1.77 g/m^3 d) 0.77 g/m^3

10. A box contains N molecules of a perfect gas at temperature $T_1$and pressure P_1. The number of molecules in the box is doubled keeping the total kinetic energy of the gas same as before. If the new pressure is P_2 and temperature T_2 then
a) $P_2=P_1, T_2=T_1$ b) $P_2=P_1, T_2=\frac{T_1}{2}$ c) $P_2=2P_1, T_2=T_1$ d) $P_2=2P_1, T_2=\frac{T_1}{2}$

11. Find the ratio of specific heat at constant pressure to the specific heat constant volume for NH_3
a) 1.33 b) 1.44 c) 1.28 d) 1.67

12. An ideal monatomic gas is confined in a cylinder by a spring-loaded piston of cross-section 8×10^3 m^2. Initially the gas is at 300 K and occupies a volume of 2.4×10^{-3}m^3 and the spring is in a relaxed state. The gas is heated by a small heater coil H. The force constant of the spring is 8000 N/m and the atmospheric pressure is 1.0×10^5Pa. The cylinder and piston are thermally insulated. The piston and the spring are massless and there is no heat loss through heater coil wire leads and thermal capacity of the heater coil is negligible. With all the above assumptions, if the gas is heated by the heater until the piston moves out

slowly by 0.1 m, then the final temperature is



a) 400 K b) 800 K c) 1200 K d) 300 K

13. An ideal gas ($\gamma = 1.5$) is expanded adiabatically. How many times has the gas to be expanded to reduce the root mean-square velocity of molecules becomes half?
a) 4 times b) 16 times c) 8 times d) 2 times

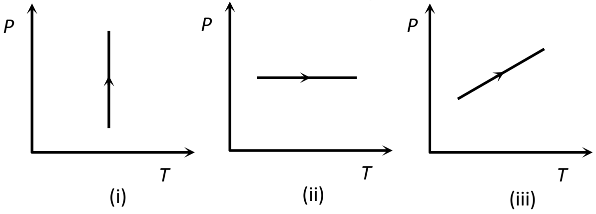
14. The temperature of the hydrogen at which the average speed of its molecules is equal to that of oxygen molecules at a temperature of 31°C, is
a) −216°C b) −235°C c) −254°C d) −264°C

15. At 0 K which of the following properties of a gas will be zero
a) Kinetic energy b) Potential energy c) Vibrational energy d) Density

16. The root mean square velocity of a gas molecule of mass m at a given temperature is proportional to
a) m^0 b) m c) $\sqrt{m}$ d) $\frac{1}{\sqrt{m}}$

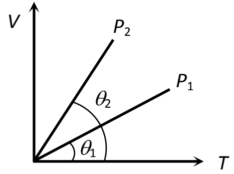
17. The temperature of the mixture of one mole of helium and one mole of hydrogen is increased from 0°C to 100°C at constant pressure. The amount of heat delivered will be
a) 600 cal b) 1200 cal c) 1800 cal d) 3600 cal

18. Pressure versus temperature graphs of an ideal gas are as shown in figure. Choose the wrong statement



a) Density of gas is increasing in graph (i) b) Density of gas is decreasing in graph (ii)
c) Density of gas is constant in graph (iii) d) None of these

19. The figure shows the volume V versus temperature T graphs for a certain mass of a perfect gas at two constant pressures of P_1 and P_2. What inference can you draw from the graphs



a) $P_1 > P_2$ b) $P_1 < P_2$
c) $P_1 = P_2$ d) No interference can be drawn due to insufficient information

20. Kinetic theory of gases was put forward by
a) Einstein b) Newton c) Maxwell d) Raman

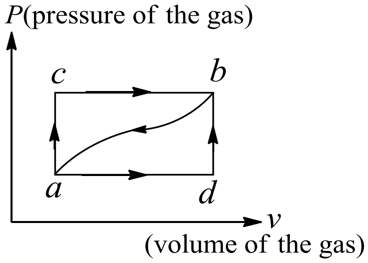
21. According to the kinetic theory of gases the $r.m.s.$ velocity of gas molecules is directly proportional to
a) T b) $\sqrt{T}$ c) T^2 d) $1/\sqrt{T}$

22. The temperature at which the average translational kinetic energy of a molecule is equal to the energy gained by an electron in accelerating from rest through a potential difference of 1 $volt$ is
a) $4.6 \times 10^3 K$ b) $11.6 \times 10^3 K$ c) $23.2 \times 10^3 K$ d) $7.7 \times 10^3 K$

23. The value of $\frac{pV}{T}$ for one mole of an ideal gas is nearly equal to
a) 2 J mol^{-1} K^{-1} b) 8.3 J mol^{-1} K^{-1} c) 4.2 J mol^{-1} K^{-1} d) 2 cal mol^{-1} K^{-1}

24. Forty calories of heat is needed to raise the temperature of 1 mol of an ideal monatomic gas from 20°C to 30°C at a constant pressure. The amount of heat required to raise its temperature over the same interval at a constant volume $R = 2 \text{ cal mol}^{-3}\text{K}^{-1}$) is
a) 20 cal b) 40 cal c) 60 cal d) 80 cal

25. When an ideal gas is taken from state a to b, along a path abc, 84 kJ of heat flows into the gas and the gas does 32 kJ of work. The following conclusions are drawn. Mark the one which is not correct



a) If the work done along the path abc is 10.5 kJ, the heat that will flow into the gas is 62.5 kJ

b) When the gas is returned from b to a along the curved path, the work done on the gas is 21 kJ, and the system absorbs 73 kJ of heat

c) If $U_a = 0, U_d = 42$ kJ, and the work done along the path adb is 10.5 kJ then the heat absorbed in the process ad is 52.5 kJ

d) If $U_a = 0, U_d = 42$ kJ, heat absorbed in the process db is 10 kJ

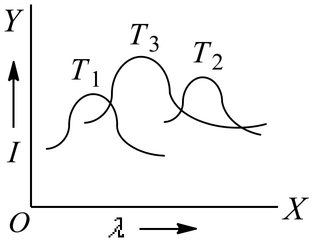
26. A gas is filled in a closed container and its molecules are moving in horizontal direction with uniform acceleration. Neglecting acceleration due to gravity, the pressure inside the container is

a) Uniform everywhere
b) Less in the front
c) Less at the back
d) Less at the top

27. The average translational kinetic energy of O_2 (relative molar mass 32) molecules at a particular at a particular temperature is 0.048 eV. The translational kinetic energy of N_2 (relative molar mass 28) molecules in eV at that temperature is

a) 0.0015
b) 0.003
c) 0.048
d) 0.768

28. The plots of intensity versus wavelength for three black bodies at temperatures T_1, T_2 and T_3, respectively are as shown. Their temperature are such that



a) $T_1 > T_2 > T_3$
b) $T_1 > T_3 > T_2$
c) $T_2 > T_3 > T_1$
d) $T_3 > T_2 > T_1$

29. If $r.m.s.$ velocity of a gas is $V_{rms} = 1840\ m/s$ and its density $\rho = 8.99 \times 10^{-2} kg/m^3$, the pressure of the gas will be

a) $1.01\ N/m^2$
b) $1.01 \times 10^3 N/m^2$
c) $1.01 \times 10^5 N/m^2$
d) $1.01 \times 10^7 N/m^2$

30. A fixed mass of gas is first heated isobarically to double the volume and then cooled isochorically to decrease the temperature back to the initial value. By what factor would the work done by the gas decreased, had the process been isothermal?

a) 2
b) ½
c) In 2
d) In 3

31. A cylinder of radius r and thermal conductivity K_1 is surrounded by a cylindrical shell of linear radius r and outer radius$2r$, whose thermal conductivity is K_2. There is no loss of heat across cylindrical surfaces, when the ends of the combined system are maintained at temperatures T_1 and T_2. The effective thermal conductivity of the system, in the steady state is

a) $\frac{K_1 K_2}{K_1 + K_2}$
b) $K_1 + K_2$
c) $\frac{K_1 + 3K_2}{4}$
d) $\frac{3K_1 + K_2}{4}$

32. If C_p and C_v denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then

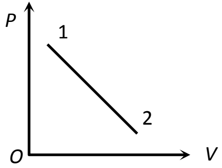
a) $C_p - C_v = R/28$
b) $C_p - C_v = R/14$
c) $C_p - C_v = R$
d) $C_p - C_v = 28R$

33. The rate of cooling at 600 K, if surrounding temperature is 300 K is$R$. The rate of cooling at 900 K is

a) $\frac{16}{3}R$ b) $2\ R$ c) $3\ R$ d) $\frac{2}{3}R$

34. For ideal gas, which statement is not true
a) It obeys Boyle's law
b) If follows $PV = RT$
c) Internal energy depends on temperature only
d) It follows Vander-Waal's equation

35. A volume V and pressure P diagram was obtained from state 1 to state 2 when a given mass of a gas is subjected to temperature changes. During this process the gas is



a) Heated continuously
b) Cooled continuously
c) Heated in the beginning and cooled towards the end
d) Cooled in the beginning and heated towards the end

36. At constant volume, temperature is increased. Then
a) Collision on walls will be less
b) Number of collisions per unit time will increase
c) Collisions will be in straight lines
d) Collisions will not change

37. The gases carbon-monoxide (CO) and nitrogen at the same temperature have kinetic energies E_1 and E_2 respectively. Then
a) $E_1 = E_2$
b) $E_1 > E_2$
c) $E_1 < E_2$
d) E_1 and E_2 cannot be compared

38. Read the given statements and decide which is/are correct on the basis of kinetic theory of gases
(I) Energy of one molecule at absolute temperature is zero
(II) $r.m.s.$ speeds of different gases are same at same temperature
(III) For one gram of all ideal gas kinetic energy is same at same temperature
(IV) For one mole of all ideal gases mean kinetic energy is same at same temperature
a) All are correct b) I and IV are correct c) IV is correct d) None of these

39. The pressure is exerted by the gas on the walls of the container because
a) It loses kinetic energy
b) It sticks with the walls
c) On collision with the walls there is a change in momentum
d) It is accelerated towards the walls

40. The volume of a gas at 20°C is 200 ml. If the temperature is reduced to −20°C at constant pressure, its volume will be
a) 172.6 ml b) 17.26 ml c) 192.7 ml d) 19.27 ml

41. A monoatomic gas is kept at room temperature $300K$. Calculate the average kinetic energy of gas molecule (Use $k = 1.38 \times 10^{-23} MKS$ units)
a) $0.138 eV$ b) $0.062 eV$ c) $0.039 eV$ d) $0.013 eV$

42. In kinetic theory of gases, which of the following statements regarding elastic collisions of the molecules is wrong
a) Kinetic energy is lost in collisions
b) Kinetic energy remains constant in collision
c) Momentum is conserved in collision
d) Pressure of the gas remains constant in collisions

43. The value of critical temperature in terms of Vander Waal's constant a and b is
a) $T_c = \frac{8a}{27Rb}$ b) $T_c = \frac{a}{2Rb}$ c) $T_c = \frac{8}{27Rb}$ d) $T_c = \frac{27a}{8Rb}$

44. The root mean square velocity of gas molecules at 27°C is 1365 ms^{-1}. The gas is
a) O_2 b) He c) N_2 d) CO_2

45. If the intermolecular forces vanish away, the volume occupied by the molecules contained in 4.5 kg water at standard temperature and pressure will be given by
a) $5.6\mathrm{m}^3$ b) $4.5\mathrm{m}^3$ c) 11.2L d) $11.2\mathrm{m}^3$

46. Temperature remaining constant, the pressure of gas is decreased by 20%. The percentage change in volume

a) Increases by 20% b) Decreases by 20% c) Increases by 25% d) decreases by 25%

47. At a given temperature the $r.m.s.$ velocity of molecules of the gas is

a) Same

b) Proportional to molecular weight

c) Inversely proportional to molecular weight

d) Inversely proportional to square root of molecular weight

48. The temperature of a gas contained in a closed vessel of constant volume increases by 1°C when the pressure of the gas is increased by 1%. The initial temperature of the gas is

a) 100 K b) 273°C c) 100°C d) 200 K

49. The volume of a gas at pressure $21 \times 10^4 N/m^2$ and temperature 27°C is 83 $litres$. If $R = 8.3\, J/mol\, K$, then the quantity of gas in $g - mole$ will be

a) 15 b) 42 c) 7 d) 14

50. The average kinetic energy of a gas at −23°C and 75 cm pressure is $5 \times 10^{-14} erg$ for H_2. The mean kinetic energy of the O_2 at 227°C and 150 cm pressure will be

a) $80 \times 10^{-14} erg$ b) $20 \times 10^{-14} erg$ c) $40 \times 10^{-14} erg$ d) $10 \times 10^{-14} erg$

51. Steam at 100°C is passed into 1.1 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15°C till the temperature of the calorimeter and its contents rises to 80°C. The mass of the steam condensed in kilograms is

a) 0.130 b) 0.065 c) 0.260 d) 0.135

52. Which of the following statements about kinetic theory of gases is wrong

a) The molecules of a gas are in continuous random motion

b) The molecules continuously undergo inelastic collisions

c) The molecules do not interact with each other except during collisions

d) The collisions amongst the molecules are of short duration

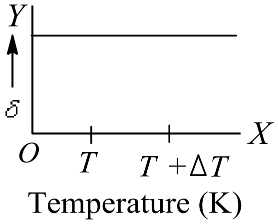
53. Which of the following formula is wrong

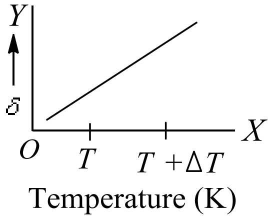
a) $C_V = \frac{R}{\gamma - 1}$ b) $C_P = \frac{\gamma R}{\gamma - 1}$ c) $C_P / C_V = \gamma$ d) $C_P - C_V = 2R$

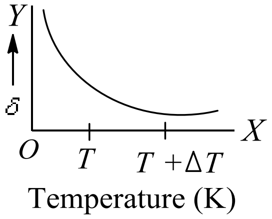
54. Volume, pressure and temperature of an ideal gas are V, P and T respectively. If mass of its molecule is m, then its density is [k = boltzmann's constant]

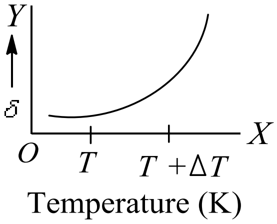
a) mkT b) $\frac{P}{kT}$ c) $\frac{P}{kTV}$ d) $\frac{Pm}{kT}$

55. An ideal gas is initially at temperature T and the volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quantity $\delta = \Delta T / V \Delta T$ varies with temperature as

a) 

b) 

c) 

d) 

56. The equation for an ideal gas is $PV = RT$, where V represents the volume of

a) 1 g gas b) Any mass of the gas c) One $g\ mol\ gas$ d) One $litre$ gas

57. A black body is at a temperature of 2880 K. The energy of radiation emitted by this body with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm 1500 nm is U_3. Wien's constant, $b = 2.88 \times 10^6$ nm-K. Then

a) $U_1 = 0$ b) $U_3 = 0$ c) $U_1 > U_2$ d) $U_2 > U_1$

58. When the temperature of a gas is raised from 27°C to 90°C, the percentage increase in the $r.m.s.$ velocity of the molecules will be

a) 10% b) 15% c) 20% d) 17.5%

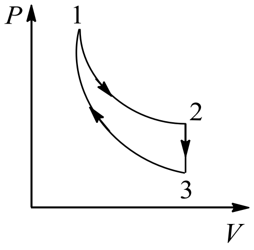
59. If the mean free path of atoms is doubled then the pressure of gas will become
a) $P/4$
b) $P/2$
c) $P/8$
d) P

60. The temperature of a gas at pressure P and volume V is 27°C. Keeping its volume constant if its temperature is raised to 927°C, then its pressure wil be
a) 2 P
b) 3 P
c) 4 P
d) 6 P

61. For an ideal gas
a) C_p is less than C_V
b) C_p is equal to C_V
c) C_p is greater than C_V
d) $C_p = C_V = 0$

62. Which law states that effect of pressure is same for all portions
a) Pascal's law
b) Gay Lussac's law
c) Dalton's law
d) None of these

63. Three processes compose a thermodynamic cycle shown in the accompanying $P - V$ diagram. Process $1 \rightarrow 2$ takes place at constant temperature, process $2 \rightarrow 3$ takes place at constant volume and process $3 \rightarrow 1$ is adiabatic. During is 10 J. During process $3 \rightarrow 1$, 20J of work is done on the system. Which of the following statements is incorrect?



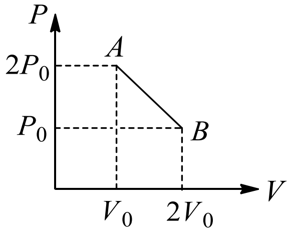
a) $(\Delta U)_{\text{cycle}} = 0$
b) $(\Delta Q)_{\text{cycle}} = 10$ J
c) $(\Delta Q)_1 \rightarrow_2 = 30$ J
d) During process $1 \rightarrow 2$, work is done on the system

64. One mole of monoatomic gas and three moles of diatomic gas are put together in a container. The molar specific heat (in J K^{-1} mol^{-1}) at constant volume is ($R = 8.3$ J K^{-1} mol^{-1})
a) 18.7
b) 18.9
c) 19.2
d) None of these

65. The degrees of freedom of a stationary rigid body about its axis will be
a) One
b) Two
c) Three
d) Four

66. The pressure and temperature of an ideal gas in a closed vessel are 720 kPa and 40°C respectively. If $\frac{1}{4}$th of the gas is released from the vessel and the temperature of the remaining gas is raised to 353°C, the final pressure of the gas is
a) 1440 kPa
b) 1080 kPa
c) 720 kPa
d) 540 kPa

67. n moles of an ideal gas undergoes a process $A \rightarrow B$ as shown in figure. Maximum temperature of the gas during the process is:

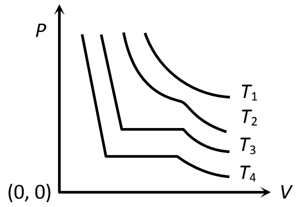


a) $\frac{3P_0V_0}{2nR}$
b) $\frac{9P_0V_0}{4nR}$
c) $\frac{9P_0V_0}{2nR}$
d) $\frac{9P_0V_0}{nR}$

68. The relationship between pressure and the density of a gas expressed by Boyle's law, $P = KD$ holds true
a) For any gas under any conditions
b) For some gases under any conditions
c) Only if the temperature is kept constant
d) Only if the density is constant

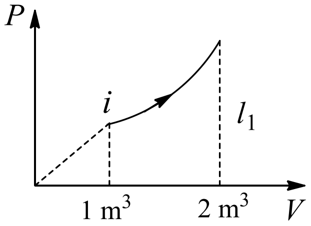
69. Five moles of hydrogen gas are heated from 30°C to 60°C at constant pressure. Heat to the gas is (given R =2 cal/mol degree)
a) 750 cal
b) 630 cal
c) 1050 cal
d) 1470 cal

70. The change in volume V with respect to an increase in pressure P has been shown in the figure for a non-ideal gas at four different temperatures T_1, T_2, T_3 and T_4. The critical temperature of the gas is



a) T_1 b) T_2 c) T_3 d) T_4

71. A sample of ideal gas is expanded to twice its original volume of $1\ \text{m}^3$ in a quasi-static process for which $P = \alpha V^2$ with $\alpha = 3 \times 10^5 \text{Pa/m}^6$ as shown in figure. Work done by the expanding gas is



a) 8×10^5J b) 7×10^5J c) 6×10^5J d) 3×10^5J

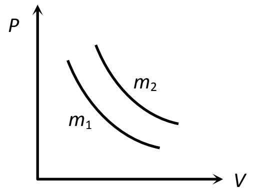
72. The temperature of an ideal gas is increased from 27°C to 127°C, then percentage increase in V_{rms} is
a) 37% b) 11% c) 33% d) 15.5%

73. Two spheres made of same material have radii in the ratio1 : 2. Both are at same temperature. Ratio of heat radiation energy emitted per second by them is
a) 1 : 2 b) 1 : 4 c) 1 : 8 d) 1 : 16

74. If for hydrogen $C_p - C_v = m$ and for nitrogen $C_p - C_v = n$, where $C_p$andC_v refer to specific heats per unit mass respectively at constant pressure and constant volume, the relation between m and n is (molecular weight of hydrogen =2 and molecular weight of nitrogen = 14)
a) $n = 14m$ b) $n = 7m$ c) $m = 7n$ d) $m = 14n$

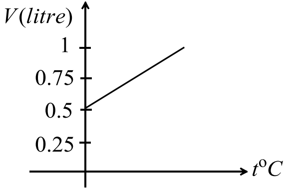
75. When an ideal gas ($\gamma = 5/3$) is heated under constant pressure, what percentage of given heat energy will be utilized in doing external work?
a) 40% b) 30% c) 60% d) 20%

76. Two different isotherms representing the relationship between pressure p and volume V at a given temperature of the same ideal gas are shown for masses m_1 and m_2 of the gas respectively in the figure given, then



a) $m_1 > m_2$ b) $m_1 = m_2$ c) $m_1 < m_2$ d) $m_1 \gtrless m_2$

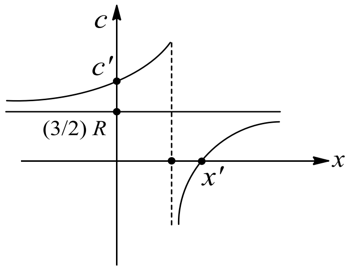
77. Graph between volume and temperature for a gas is shown in figure. If α = volume coefficient of gas $= \frac{1}{273} per$°C, then what is the volume of gas at a temperature of 819°C



a) $1 \times 10^{-3}\ m^3$ b) $2 \times 10^{-3}\ m^3$ c) $3 \times 10^{-3}\ m^3$ d) $4 \times 10^{-3}\ m^3$

78. The average translational kinetic energy of a hydrogen gas molecules at NTP will be
[Boltzmann's constant $k_B = 1.38 \times 10^{-23} J/K$]
a) $0.186 \times 10^{-20} Joule$ b) $0.372 \times 10^{-20} Joule$ c) $0.56 \times 10^{-20} Joule$ d) $5.6 \times 10^{-20} Joule$

79. One mole of an ideal gas is taken along the process in which PV =constant. The graph shown represents the variation of molar heat capacity of such a gas with respect to $'x'$. The values of c' and x', respectively, are given by



a) $\frac{5}{2}R, \frac{5}{2}$ b) $\frac{5}{2}R, \frac{5}{3}$ c) $\frac{7}{2}R, \frac{7}{2}$ d) $\frac{5}{2}R, \frac{7}{5}$

80. Three samples of the same gas A, B and $C (\gamma = 3/2)$ initially have equal volume. Now the volume of each sample is doubled. The process is adiabatic for A, isobaric for B and isothermal for C. If the final pressures are equal for all the three samples, the ratio of their initial pressures is

a) $2\sqrt{2}: 2: 1$ b) $2\sqrt{2}: 1: 2$ c) $\sqrt{2}: 1: 2$ d) $2: 1: \sqrt{2}$

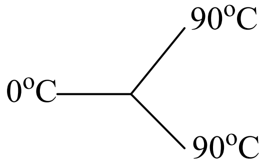
81. The density of a substance at 0°C is 10 g/cc and at 100°C, its density is 9.7 g/cc. The coefficient of linear expansion of the substance is

a) 10^{-4} °C^{-1} b) 10^{-2} °C^{-1} c) 10^{-3} °C^{-1} d) 10^{2} °C^{-1}

82. At 100 K and 0.1 atmospheric pressure, the volume of helium gas is 10 $litres$. If volume and pressure are doubled, its temperature will change to

a) 400 K b) 127 K c) 200 K d) 25 K

83. Three rods made of same material and having the same cross section have been joined as shown in figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C, respectively. The temperature of the junction of the three rods will be

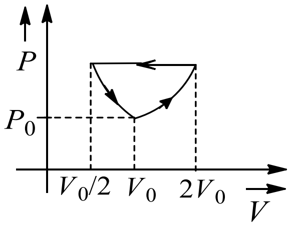


a) 45°C b) 60°C c) 30°C d) 20°C

84. Which one of the following is not an assumption of kinetic theory of gases?

a) The volume occupied by the molecules of the gas is negligible
b) The force of attraction between the molecules is negligible
c) The collision between the molecules are elastic
d) All molecules have same speed

85. One mole of an ideal gas at pressure P_0 and temperature T_0 is expanded in isothermally to twice its volume and then compressed at constant pressure to $(V_0/2)$ and the gas is brought back to original state by a process in which $P \alpha V$ (pressure is directly proportional to volume). The correct temperature of the process is

a)


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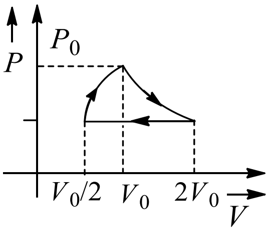
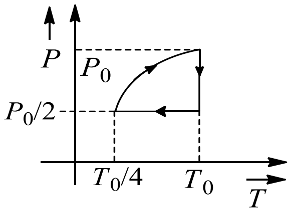
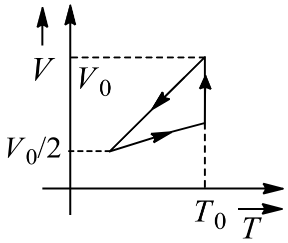


c)


d)


86. If R = universal gas constant, the amount of heat needed to raise the temperature of 2 mol of an ideal

monatomic gas from 273 K to 373 K when no work is done is

a) $100R$ b) $150R$ c) $300R$ d) $500R$

87. 1 cm^3 of water at its boiling point absorbs 540 cal of heat to become steam with a volume of 1.671 cm^3. If the atmospheric pressure is $1.013 \times 10^5 \text{N/m}^2$ and the mechanical equivalent of heat = 4.19 J/cal, the energy spent in this process in overcoming intermolecular forces is

a) 540 cal b) 40 cal c) 500cal d) Zero

88. The density of a polyatomic gas in standard conditions is 0.795 kgm^{-3}. The specific heat of the gas at constant volume is

a) $930 \text{ J} - \text{kg}^{-1}\text{K}^{-1}$ b) $1400 \text{ J} - \text{kg}^{-1}\text{K}^{-1}$ c) $1120 \text{ J} - \text{kg}^{-1}\text{K}^{-1}$ d) $1600 \text{ J} - \text{kg}^{-1}\text{K}^{-1}$

89. The average kinetic energy of a gas molecule can be determined by knowing

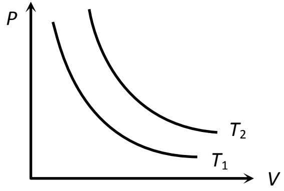
a) The number of molecules in the gas b) The pressure of the gas only

c) The temperature of the gas only d) None of the above is enough by itself

90. What is the value of $\frac{R}{C_P}$ for diatomic gas

a) 3/4 b) 3/5 c) 2/7 d) 5/7

91. The adjoining figure shows graph of pressure and volume of a gas at two temperatures T_1 and T_2. Which of the following inferences is correct



a) $T_1 > T_2$ b) $T_1 = T_2$

c) $T_1 < T_2$ d) No interference can be drawn

92. In Vander Waal's equation a and b represent $\left(P + \frac{a}{V^2}\right)(V - b) = RT$

a) Both a and b represent correction in volume

b) Both a and b represent adhesive force between molecules

c) a represents adhesive force between molecules and b correction in volume

d) a represents correction in volume and b represents adhesive force between molecules

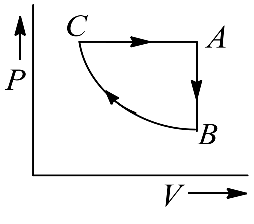
93. Molecular motion shows itself as

a) Temperature b) Internal Energy c) Friction d) Viscosity

94. 10 moles of an ideal monoatomic gas at 10°C is mixed with 20 moles of another monoatomic gas at 20°C. Then the temperature of the mixture is

a) 15.5°C b) 15°C c) 16°C d) 16.6°C

95. A sample of an ideal gas is taken through the cyclic process $ABCA$ shown in figure. It rejects 50 J of heat during the part AB, does not absorb or reject the heat during BC, and accepts 70 J of heat during CA. Forty joules of work is done on the gas during the part BC. The internal energies at B and C, respectively, will be



a) 1450 J and 1410 J b) 1550 J and 1590 J

c) 1450 J and 1490 J d) 1550 J and 1510 J

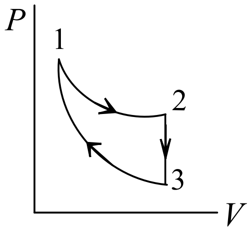
96. In thermal equilibrium, the average velocity of gas molecules is

a) Proportional to $\sqrt{T}$ b) Proportional to T^2 c) Proportional to T^3 d) Zero

97. Argon gas is adiabatically compressed to half its volume. If P, V and T represent the pressure, volume and temperature of the gaseous system, respectively, at any stage, then correct equation representing the process is

a) $TV^{2/5}$ =constant b) $VP^{5/3}$=constant c) $TP^{-2/5}$ =constant d) $PT^{2/5}$= constant

98. Three processes compose a thermodynamic cycle shown in the accompanying $P - V$, diagram an ideal gas



Process 1 → 2 takes place at constant temperature, during this process 60 J of heat enters the system

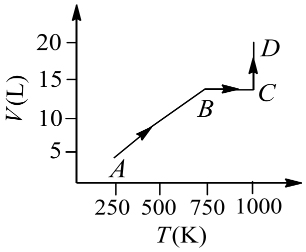
Process 2 → 3 takes place at constant volume. During this process 40 J of heat leaves the system

Process 3 → 1 is adiabatic

What is the change in internal energy of the system during process 3 → 1?

a) −40 J b) −20 J c) +20 J d) +40 J

99. Two moles of helium gas are taken along the path $ABCD$ (as shown in figure). The work done by the gas is



a) $2000R\left(\frac{1}{2}+\text{In}\frac{4}{3}\right)$ b) $500R(3+\text{In }4)$ c) $500R\left(2+\text{In}\frac{16}{9}\right)$ d) $1000R\left(1+\text{In}\frac{16}{9}\right)$

100. If number of molecules of H_2 are double than that of O_2, then ratio of kinetic energy of hydrogen and that of oxygen at 300 K is

a) 1 : 1 b) 1 : 2 c) 2 : 1 d) 1 : 16

101. If 2 moles of diatomic gas and 1 mole of monatomic gas are mixed, then the ratio of specific heats for the mixture is

a) $\frac{7}{3}$ b) $\frac{5}{4}$ c) $\frac{19}{13}$ d) $\frac{15}{19}$

102. If 1 mole of a monatomic gas ($\gamma = 5/3$) is mixed with 1 mole of a diatomic gas ($\gamma = 7/5$), the value of γ for the mixture is

a) 1.40 b) 1.50 c) 1.53 d) 3.07

103. If p is the pressure, V the volume, R the ags constant, k the Boltzmann's constant and T the absolute temperature, then the number of molecules in the given mass of the gas is given by

a) $\frac{pV}{RT}$ b) $\frac{pV}{kT}$ c) $\frac{pR}{T}$ d) pV

104. A gas is at 1 atm pressure with a volume 800 cm^3. When 100 J of heat is supplied to the gas, it expands to 1 L at constant pressure. The change in its internal energy is

a) 80 J b) −80 J c) 20 J d) −20 J

105. Air is filled at 60°C in a vessel of open mouth. The vessel is heated to a temperature T so that 1/4th part of air escapes. Assuming the volume of vessel remaining constant, the value of $T$is

a) 80°C b) 444°C c) 333°C d) 171°C

106. A cylinder rolls without slipping down an inclined plane, the number of degrees of freedom it has, is

a) 2 b) 3 c) 5 d) 1

107. One litre of oxygen at a pressure of 1 atm and two litres of nitrogen at a pressure of 0.5 atm, are introduced into a vessel of volume 1 L. If there is no change in temperature, the final pressure of the mixture of gas (in atm) is

a) 1.5 b) 2.5 c) 2 d) 4

108. The mass of a gas molecule can be computed from the specific heat at constant volume. C_v for argon is 0.075 kcal/kg K. The molecular weight of an argon atom is ($R = 2$cal/mol K)

a) 40 kg b) 40×10^{-3}kg c) 20 kg d) 20×10^{-3}kg

109. When an air bubble of radius $'r'$ rises from the bottom to the surface of a lake, its radius becomes $5r/4$

(the pressure of the atmosphere is equal to the 10 m height of water column). If the temperature is constant and the surface tension is neglected, the depth of the lake is

a) 3.53 m b) 6.53 m c) 9.53 m d) 12.53 m

110. A gas is collected over the water at 25°C. The total pressure of moist gas was 735 mm of mercury. If the aqueous vapour pressure at 25°C is 23.8 mm. Then the pressure of dry gas is

a) 760 mm b) 758.8 mm c) 710.8 mm d) 711.2 mm

111. A vessel of volume 20 L contains a mixture of hydrogen and helium at temperature of 27°C and pressure 2.0 atm. The mass of the mixture is 5 g. Assuming the gases to be ideal, the ratio of the mass of hydrogen to that of helium in the given mixture will be

a) 1:2 b) 2:3 c) 2:1 d) 2:5

112. A spherical black body with a radius of 12 cm radiates 450 W power at 50 K. If the radius were halved and the temperature doubled, the power radiated in watts would be

a) 225 b) 450 c) 900 d) 1800

113. A cylinder of fixed capacity 44.8 $litre$ contains a monoatomic gas at standard temperature and pressure. The amount of heat required to cylinder by 10°C will be

($R =$ universal gas constant)

a) R b) $10R$ c) $20R$ d) $30R$

114. Air is pumped into an automobile tube upto a pressure of 200 kPa in the morning when the air temperature is 22°C. During the day, temperature rises to 42°C and the tube expands by 2%. The pressure of the air in the tube at this temperature, will be approximately

a) 212 kPa b) 209 kPa c) 206 kPa d) 200 kPa

115. A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then the pressure in the compartment is

a) Same everywhere b) Lower in the front side

c) Lower in the rear side d) Lower in the upper side

116. What is an ideal gas?

a) One that consists of molecules b) A gas satisfying the assumptions of kinetic theory

c) A gas having Maxwellian distribution of speed d) A gas consisting of massless particles

117. If mass of He is 4 times that of hydrogen, then mean velocity of He is

a) 2 times of H-mean value

b) $\frac{1}{2}$ times of H-mean value

c) 4 times of H-mean value

d) Same as H-mean value

118. A diatomic molecule has how many degrees of freedom

a) 3 b) 4 c) 5 d) 6

119. In the relation $n = \frac{PV}{RT}, n =$

a) Number of molecules b) Atomic number c) Mass number d) Number of moles

120. $r.m.s.$ velocity of nitrogen molecules at NTP is

a) 492 m/s b) 517 m/s c) 546 m/s d) 33 m/s

121. An ideal gas expands isothermally from volume V_1toV_2 and is then compressed to original volume V_1 adiabatically. Initial pressure is P_1 and final pressure is P_3. The total work done is W. Then

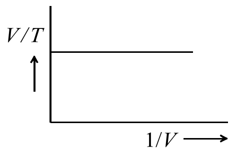
a) $P_3 > P_1, W > 0$ b) $P_3 < P_1, W < 0$ c) $P_3 > P_1, W < 0$ d) $P_3 = P_1, W = 0$

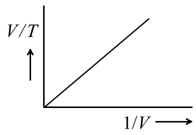
122. According to Maxwell's law of distribution of velocities of molecules, the most probable velocity is

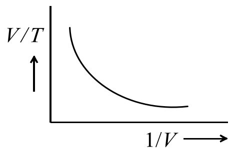
a) Greater than the mean velocity b) Equal to the mean velocity

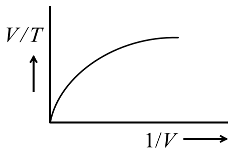
c) Equal to the root mean square velocity d) Less than the root mean square velocity

123. Which one of the following graph is correct at constant pressure

a) 

b) 

c) 

d) 

124. If the oxygen (O_2) has root mean square velocity of $C\ ms^{-1}$, then root mean square velocity of the hydrogen (H_2) will be

a) $C\ ms^{-1}$ b) $\frac{1}{C} ms^{-1}$ c) $4C\ ms^{-1}$ d) $\frac{C}{4} ms^{-1}$

125. The diameter of oxygen molecule is $2.94 \times 10^{-10} m$. The Vander Waal's gas constant $'b'$ in m^3/mol will be

a) 3.2 b) 16 c) 32×10^{-4} d) 32×10^{-6}

126. Hydrogen gas is filled in a balloon at 20°C. If temperature is made 40°C, pressure remaining same, what fraction of hydrogen will come out?

a) 0.07 b) 0.25 c) 0.5 d) 0.75

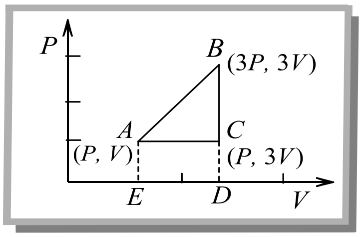
127. The root mean square speed of hydrogen molecules at 300 K is 1930 m/s. Then the root mean square speed of oxygen molecules at 900 K will be

a) $1930\sqrt{3}\ m/s$ b) 836 m/s c) 63 m/s d) $\frac{1930}{\sqrt{3}} m/s$

128. If the temperature of an ideal gas increases three times, then its rms velocity will become

a) $\sqrt{3}$ times b) 3 times c) One third d) Remains same

129. An ideal gas is taken around $ABCD$ as shown in the above $P - V$ diagram. The work done during a cycle is



a) $2PV$ b) PV c) $1/2PV$ d) Zero

130. The temperature of an ideal at atmospheric pressure is $300K$ and volume $1m^3$. If temperature and volume become double, then pressure will be

a) $10^5 N/m^2$ b) $2 \times 10^5 N/m^2$ c) $0.5 \times 10^5 N/m^2$ d) $4 \times 10^5 N/m^2$

131. The temperature of a gas is -68°C. At what temperature will the average kinetic energy of its molecules be twice that of at -68°C?

a) 137°C b) 127°C c) 100°C d) 105°C

132. A bubble is at the bottom of the lake of depth h. As the bubble comes to sea level, its radius increases three times. If atmospheric pressure is equal to l metre of water column, then h is equal to

a) $26\ l$ b) l c) $25\ l$ d) $30\ l$

133. A cylinder of radius R made of a material of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius R and outer radius $2R$ made of a material of thermal conductivity K_2. The two ends of the combined system are maintained at two different temperatures. There is no loss of heat across the cylindrical surface and the system is in the steady state. The effective thermal conductivity of the system is

a) $K_1 + K_2$ b) $\frac{K_1K_2}{(K_1 + K_2)}$ c) $\frac{(K_1 + 3K_2)}{4}$ d) $\frac{(3K_1 + K_2)}{4}$

134. The pressure is P, volume V and temperature T of a gas in the jar A and the other gas in the jar B is at pressure $2P$, volume $V/4$ and temperature $2T$, then the ratio of the number of molecules in the jar A and B will be

a) 1 : 1 b) 1 : 2 c) 2 : 1 d) 4 : 1

135. An ideal gas expands in such a manner that its pressure and volume can be relates by equation $PV^2 =$ constant. During this process, the gas is

a) Heated b) Cooled

c) Neither heated nor cooled
d) First heated and then cooled

136. Pressure of an ideal gas is increased by keeping temperature constant. What is the effect on kinetic energy of molecules?
a) Increases
b) Decrease
c) No change
d) Can't be determined

137. The ratio of mean kinetic energy of hydrogen and oxygen at a given temperature is
a) 1 : 16
b) 1 : 8
c) 1 : 4
d) 1 : 1

138. A gas is filled in a cylinder, its temperature is increased by 20% on kelvin scale and volume is reduced by 10%. How much percentage of the gas will leak out
a) 30%
b) 40%
c) 15%
d) 25%

139. The capacity of a vessel is 3 L. It contains 6 g oxygen, 8 g nitrogen and 5 g CO_2 mixture at 27°C. If R =8.31 J/mol K, the the pressure in the vessel in N/m^2 will be (approx)
a) 5×10^5
b) 5×10^4
c) 10^6
d) 10^5

140. The average translational energy and the rms speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21}J and 484 m/s, respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour)
a) 12.42×10^{-21}J, 968 m/s
b) 8.78×10^{-21}J, 684 m/s
c) 6.21×10^{-21}J, 968 m/s
d) 12.42×10^{-21}J, 684 m/s

141. A fixed mass of helium gas is made to undergo a process in which its pressure various linearly from 1 kPa to 2 kPa, in relation to its volume as the latter various from 0.2 m^3 to 0.4 m^3. The heat absorbed by the gas will be
a) 300 J
b) 900 J
c) 1200 J
d) 1500 J

142. A gas mixture consists of 2 mol of oxygen and 4 mol of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is
a) $4RT$
b) $15RT$
c) $9RT$
d) $11RT$

143. A certain ideal gas undergoes a polytropic process $PV^n =$ constant such that the molar specific heat during the process is negative. If the ratio of the specific heats of the gas be γ, then the rage of values of n will be
a) $0 < n < \gamma$
b) $1 < n < \gamma$
c) $n = \gamma$
d) $n > \gamma$

144. A closed vessel contains 8 g of oxygen and 7 g of nitrogen. The total pressure is 10 atm at a given temperature. If now oxygen is absorbed by introducing a suitable absorbent, the pressure of the remaining gas in atm will be
a) 2
b) 10
c) 4
d) 5

145. The ratio of root mean square velocity of O_3 and O_2 is
a) 1: 1
b) 2: 3
c) 3: 2
d) $\sqrt{2} : \sqrt{3}$

146. The pressure and volume of saturated water vapour are P and V respectively. It is compressed isothermally thereby volume becomes $V/2$, the final pressure will be
a) More than $2P$
b) P
c) $2P$
d) $4P$

147. Two spheres made of same substance have diameters in the ratio1 : 2. Their thermal capacities are in the ratio of
a) 1 : 2
b) 1 : 8
c) 1 : 4
d) 2 : 1

148. The molecular weight of a gas is 44. The volume occupied by 2.2 g of this gas at 0°C and 2 atm. pressure will be
a) 0.56 *litre*
b) 1.2 *litres*
c) 2.4 *litres*
d) 5.6 *litres*

149. 22 g of CO_2 at 27°C is mixed with 16 g of oxygen at 37°C. The temperature of the mixture is
a) 32°C
b) 27°C
c) 37°C
d) 30°C

150. The equation of state of a gas is given by $\left(P + \frac{aT^2}{V}\right) V^c = (RT + b)$, where a, b, c and R are constants. The isotherms can be represented by $P = AV^m - BV^n$, where A and B depend only on temperature and
a) $m = -c$ and $n = -1$
b) $m = c$ and $n = 1$
c) $m = -c$ and $n = 1$
d) $m = c$ and $n = -1$

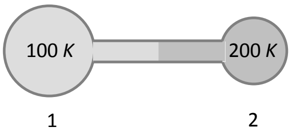
151. A gas is allowed to expand isothermally. The root mean square velocity of the molecules
a) Will increase
b) Will decrease

c) Will remain unchanged d) Depends on the other factors

152. An ideal gas is filled in a vessel, then
a) If it is placed inside a moving train, its temperature increases
b) Its centre of mass moves randomly
c) Its temperature remains constant in a moving car
d) None of these

153. The velocity of 4 gas molecules are given by 1 km/s, 3 km/s, 5 km/s and 7 km/s. Calculate the difference between average and rms velocity.
a) 0.338 b) 0.438 c) 0.583 d) 0.683

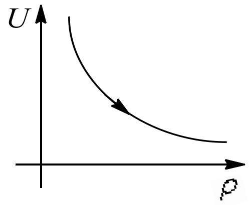
154. Figure shows two flasks connected to each other. The volume of the flask 1 is twice that of flask 2. The system is filled with an ideal gas at temperature 100 K and 200 K respectively. If the mass of the gas in 1 be m then what is the mass of the gas in flask 2

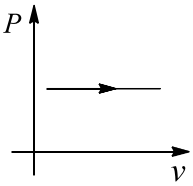


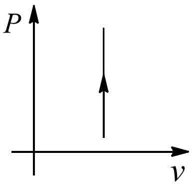
a) m b) $m/2$ c) $m/4$ d) $m/8$

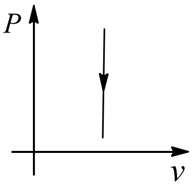
155. Oxygen gas is made to undergo a process in which its molar heat capacity C depends on its absolute temperature Tas $C = \alpha T$. Work done by it when heated from an initial temperature T_0 to a final temperature $2T_0$, will be
a) $4\alpha T_0^2$ b) $(\alpha T_0 - R)\frac{3T_0}{2}$ c) $(3\alpha T_0 - 5R)\frac{T_0}{2}$ d) None of these

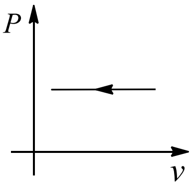
156. Variation of internal energy with density of 1 mole of monatomic gas is depicted in figure. Corresponding variation of pressure with volume can be depicted as (assume the curve is rectangular hyperbola)



a) 

b) 

c) 

d) 

157. To what temperature should the hydrogen at room temperature (27°C) be heated at constant pressure so that the R.M.S. velocity of its molecules becomes double of its previous value
a) 1200°C b) 927°C c) 600°C d) 108°C

158. Two cylinder A and B fitted with pistons contain equal amount of an ideal diatomic gas at 300 K. The piston of A is free to move while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30K, then the rise in temperature of the gas in B is
a) 30 K b) 18 K c) 50 K d) 42 K

159. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_p/C_v for the gas is
a) $\frac{3}{2}$ b) $\frac{4}{3}$ c) 2 d) $\frac{5}{3}$

160. The molecular weights of O_2 and N_2 are 32 and 28 respectively. At 15°C, the pressure of 1 g O_2 will be the same as that of 1 g N_2 in the same bottle at the temperature
a) −21°C b) 13°C c) 15°C d) 56.4°C

161. The kinetic energy of translation of 20 g of oxygen at 47°C is (molecular wt. of oxygen is 32 g/mol and R = $8.3 J/mol/K$)
a) 2490 *joules* b) 2490 *ergs* c) 830 *joules* d) 124.5 *joules*

162. The amount of heat required to convert 10 g of ice at −10°C into steam at 100°C is (in calories)

a) 6400 b) 5400 c) 7200 d) 7250

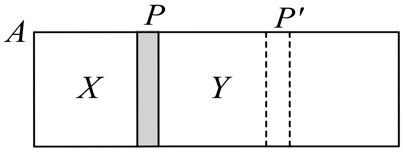
163. A gaseous mixture consists of 16g of helium and 16g of oxygen. The ratio $\frac{C_P}{C_V}$ of the mixture is

a) 1.4 b) 1.54 c) 1.59 d) 1.62

164. A gas at 27°C temperature and 30 atmospheric pressure is allowed to expand to the atmospheric pressure. If the volume becomes 10 times its initial volume, then the final temperature becomes

a) 100°C b) 173°C c) 273°C d) −173°C

165. A cylindrical chamber A of uniform cross section is divided into two parts X and Y by a movable piston P which can slide without friction inside the chamber. Initially part X contains 1 mol of a monochromatic gas and Y contains 2 mol of a diatomic gas, and the volumes of X and Y are in the ratio 1:2 with both parts X and Y being at the same temperature T. Assuming the gases to be ideal, the work W that will be done in moving the piston slowly to the position where the ratio of the volumers of $X$and Y is 2:1 will be



a) $-5.8T$ b) $8.3T$ c) $12.3T$ d) Zero

166. One mole of gas having $\gamma = 7/5$ is mixed with 1 mole of a gas having γ =4/3. What will be the γ for the mixture?

a) $\frac{15}{11}$ b) $\frac{5}{13}$ c) $\frac{5}{11}$ d) $\frac{15}{13}$

167. The specific heat at constant volume for the monatomic argon is 0.075 kcal/kg-K, whereas its gram molecular specific heat is C_v=2.98 cal/mol/K. The mass of the argon atom is (Avogadro' s number $= 6.02 \times 10^{23}$ molecules/mol)

a) 6.60×10^{-23}g b) 3.30×10^{-23}g c) 2.20×10^{-23}g d) 13.20×10^{-23}g

168. An ideal gas is expanding such that pT^2= constant. The coefficient of volume expansion of the gas is

a) $\frac{1}{T}$ b) $\frac{2}{T}$ c) $\frac{3}{T}$ d) $\frac{4}{T}$

169. Three perfect gases at absolute temperature T_1, T_2 and T_3 are mixed. The masses of molecules are m_1, m_2 and m_3 and the number of molecules are n_1, n_2 and n_3 respectively. Assuming no loss of energy, the final temperature of the mixture is

a) $\frac{n_1T_1 + n_2T_2 + n_3T_3}{n_1 + n_2 + n_3}$ b) $\frac{n_1{T_1}^2 + n_2{T_2}^2 + n_3{T_3}^2}{n_1T_1 + n_2T_2 + n_3T_3}$

c) $\frac{{n_1}^2{T_1}^2 + {n_2}^2{T_2}^2 + {n_3}^2{T_3}^2}{n_1T_1 + n_2T_2 + n_3T_3}$ d) $\frac{T_1 + T_2 + T_3}{3}$

170. The temperature of argon, kept in a vessel, is raised by 1°C at a constant volume. The total heat supplied to the gas is a combination of translation and rotational energies. Their respective shares are

a) 60% and 40% b) 40% and 60% c) 50% and 50% d) 100% and 0%

171. The molecules of a given mass of a gas have a rms velocity of 200 m/s at 27°C and 1.0×10^5 N/m^2 pressure. When the temperature is 127°C and pressure is 0.5×10^5N/m^2, the rms velocity in m/s will be

a) $\frac{100\sqrt{2}}{3}$ b) $100\sqrt{2}$ c) $\frac{400}{\sqrt{3}}$ d) None of these

172. A lead bullet of 10 g travelling at 300 ms^{-1} strikes against a block of wood comes to rest. Assuming 50% of heat is absorbed by the bullet, the increase in is temperature is (Specific heat of lead = 150 JkgK^{-1})

a) 100°C b) 125°C c) 150°C d) 200°C

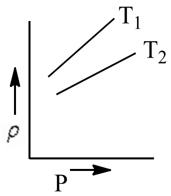
173. The kinetic energy, due to translation motion, of most of the molecules of an ideal gas at absolute temperature T is

a) kT b) k/T c) T/k d) $1/kT$

174. One mole of a monoatomic ideal gas is mixed with one mole of a diatomic ideal gas. The molar specific heat of the mixture at constant volume is

a) $(3/2)R$ b) $(5/2)R$ c) $2\ R$ d) $4\ R$

175. The density (ρ) versus pressure (P) of a given mass of an ideal gas is shown at two temperatures T_1 and T_2



Then relation between T_1 and T_2 may be

a) $T_1 > T_2$ b) $T_2 > T_1$

c) $T_1 = T_2$ d) All the three are possible

176. A balloon contains $500m^3$ of helium at 27°C and 1 atmosphere pressure. The volume of the helium at -3°C temperature and 0.5 atmosphere pressure will be

a) $500\ m^3$ b) $700\ m^3$ c) $900\ m^3$ d) $1000\ m^3$

177. Two cylindrical conductors A and B of same metallic material have their diameters in the ratio 1 : 2 and lengths in the ratio2 : 1. If the temperature difference between their ends is same, the ratio of heat conducted respectively by A and B per second is

a) 1 : 2 b) 1 : 4 c) 1 : 16 d) 1 : 8

178. If V_H, V_N and V_0 denote the root –mean square velocities of molecules of hydrogen, nitrogen and oxygen respectively at a given temperature, then

a) $V_N > V_O > V_H$ b) $V_H > V_N > V_O$ c) $V_O = V_N = V_H$ d) $V_O > V_H > V_N$

179. Consider a gas with density ρ and $\bar{c}$ as the root mean square velocity of its molecules contained in a volume. If the system moves as whole with velocity v, then the pressure exerted by the gas is

a) $\frac{1}{3}\rho\bar{c}^2$ b) $\frac{1}{3}\rho(c+v)^2$ c) $\frac{1}{3}\rho(\bar{c}-v)^2$ d) $\frac{1}{3}\rho(c^{-2}-v)^2$

180. Two chambers containing m_1 and m_2 gram of a gas at pressures p_1 and p_2 respectively are put in communication with each other, temperature remaining constant. The common pressure reached will be

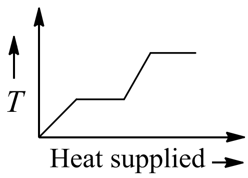
a) $\frac{p_1p_2(m_1+m_2)}{p_2m_1+p_1m_2}$ b) $\frac{p_1p_2m_1}{p_2m_1+p_1m_2}$ c) $\frac{m_1m_2(p_1+p_2)}{p_2m_1+p_1m_2}$ d) $\frac{m_1m_2p_2}{p_2m_1+p_1m_2}$

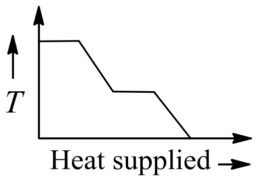
181. At the same temperature and pressure and volume of two gases, which of the following quantities is constant

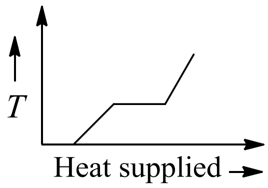
a) Total number of molecules b) Average kinetic energy

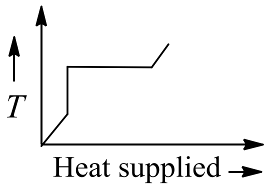
c) Root mean square velocity d) Mean free path

182. A block of ice at -10°C is slowly heated and converted to steam at 100°C. Which of the following curves respresents the phenomenon qualitatively?

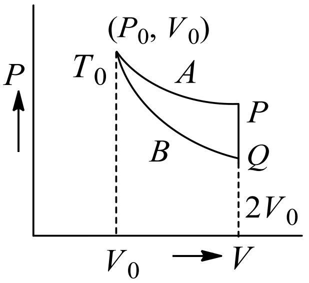
a) 

b) 

c) 

d) 

183. An ideal gas (1 mol, monatomic) is in the initial state P(see figure) on an isothermal A at temperature T_0. It is brought under a constant volume $(2V_0)$process to Q which lies on an adiabatic B intersecting the isothermal A at (P_0, V_0, T_0). The change in the internal energy of the gas during then process is (in terms of T_0) $(2^{2/3} = 1.587)$

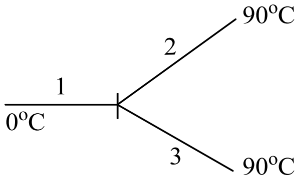


a) $2.3T_0$ b) $-4.6T_0$ c) $-2.3T_0$ d) $4.6T_0$

184. The tyre of a motor car contains air at 15°C . If the temperature increases to 35°C , the approximate percentage increase is (ignore to expansion of tyre)

a) 7 b) 9 c) 11 d) 13

185. Three rods made of same material and having same cross-section have been joined as shown in figure. Each rod is of same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of the junction of the three rods will be



a) 45°C b) 60°C c) 30°C d) 20°C

186. Five moles of hydrogen ($\gamma = 7/5$), initially at STP, is compressed adiabatically so that its temperature becomes 400°C. The increase in the internal energy of the gas in kilojoules is ($R = 8.30$J/mol-K):

a) 21.55 b) 41.50 c) 65.55 d) 80.55

187. Two gases A and B having same pressure p, volume V and absolute temperature T are mixed. If the mixture has the volume and temperature as V and T respectively, then the pressure of the mixture is

a) $2p$ b) p c) $\frac{p}{2}$ d) $4p$

188. Under constant temperature, graph between P and $1/V$ is

a) Parabola b) Hyperbola c) Straight line d) Circle

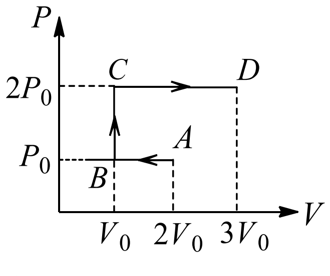
189. For a gas $\gamma = 7/5$. The gas may probably be

a) Helium b) Hydrogen c) Argon d) Neon

190. Speed of sound in a gas is v and $r.m.s.$ velocity of the gas molecules is c. The ratio of v to c is

a) $\frac{3}{\gamma}$ b) $\frac{\gamma}{3}$ c) $\sqrt{\frac{3}{\gamma}}$ d) $\sqrt{\frac{\gamma}{3}}$

191. $P - V$ diagram of an ideal gas is as shown in figure. Work done by the gas in the process $ABCD$ is



a) $4P_0V_0$ b) $2P_0V_0$ c) $3P_0V_0$ d) P_0V_0

192. The $r.m.s.$ velocity of a gas at a certain temperature is $\sqrt{2}$ times than that of the oxygen molecules at that temperature. The gas can be

a) H_2 b) He c) CH_4 d) SO_2

193. A closed gas cylinder is divided into two parts by a piston held tight. The pressure and volume of gas in two parts respectively are $(P, 5V)$ and $(10P, V)$. If now the piston is left free and the system undergoes isothermal process, then the volume of the gas in two parts respectively are

a) $2V, 4V$ b) $3V, 3V$ c) $5V, V$ d) $4V, 2V$

194. What is the velocity of wave in monoatomic gas having pressure 1 $kilopascal$ and density 2.6 kg/m^3
a) 3.6 m/s b) $8.9 \times 10^3 m/s$ c) Zero d) None of these

195. On giving equal amount of heat at constant volume to 1 $mole$ of a monoatomic and a diatomic gas the rise in temperature
a) Monoatomic b) Diatomic c) Same for both d) Can not be predicted

196. The average kinetic energy of a gas molecules is
a) Proportional to pressure of gas b) Inversely proportional to volume of gas
c) Inversely proportional to absolute temperature of gas d) Directly proportional to absolute temperature of gas

197. 70 cal of heat are required to raise the temperature of 2 mole of an ideal gas at constant pressure from 30°C to 35°C. The amount of heat required to raise the temperature of the same sample of the gas through the same range at constant volume is nearly (Gas coristant = 1.99 cal $K^{-1} - mol^{-1}$)
a) 30 cal b) 50 cal c) 70 cal d) 90 cal

198. At a given temperature, the pressure of an ideal gas of density ρ is proportional to
a) $\frac{1}{\rho^2}$ b) $\frac{1}{\rho}$ c) ρ^2 d) ρ

199. Find the amount of work done to increase the temperature of 1 mol of an ideal gas by 30°C if it is expanding under the condition $V \propto T^{2/3}$
a) 166.2 J b) 136.2 J c) 126.2 J d) None of these

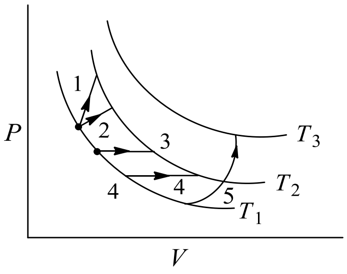
200. Two moles of an ideal gas at 300 K were cooled at constant volume so that the pressure is reduced to half the initial value. Then as a result of heating at constant pressure, the gas expands till it attains the original temperature. Find the total heat absorbed by the gas, if R is the gas constant
a) $150R$ J b) $300R$ J c) $75R$ J d) $100R$ J

201. In a certain region of space there are only 5 molecules per cm^2 on an average. The temperature there is 3 K. The pressure of this dilute gas is ($k = 1.38 \times 10^{-23}$ JK^{-1})
a) 20.7×10^{-17} Nm^{-1} b) 15.3×10^{-13} Nm^{-1} c) 2.3×10^{-10} Nm^{-1} d) 5.3×10^{-5} Nm^{-1}

202. If γ is the ratio of specific heats and R is the universal gas constant, then the molar specific heat at constant volume C_v is given by
a) γR b) $\frac{(\gamma - 1)R}{\gamma}$ c) $\frac{R}{\gamma - 1}$ d) $\frac{\gamma R}{\gamma - 1}$

203. The temperature gradient in the earth's crust is 32°C km^{-1} and the mean conductivity of earth is 0.008 $cals^{-1}cm^{-1}{}^\circ C^{-1}$. Considering earth to be a sphere of radius 6000 km loss of heat by earth everyday is about
a) 10^{30} cal b) 10^{40} cal c) 10^{20} cal d) 10^{18} cal

204. Figure shows five paths traversed by a gas on a $P - V$ diagram
$\Delta U_1, \Delta U_2, \Delta U_3, \Delta U_4$ and ΔU_5 are the change in initernal energy of the gas in paths 1, 2, 3, 4, and 5 respectively. Then



a) $\Delta U_5 > \Delta U_3$ b) $\Delta U_3 > \Delta U_5$ c) $\Delta U_1 > \Delta U_2$ d) $\Delta U_2 > \Delta U_5$

205. For a gas at a temperature T the root-mean-square velocity v_{rms}, the most probable speed v_{mp}, and the average speed v_{av} obey the relationship
a) $v_{av} > v_{rms} > v_{mp}$ b) $v_{rms} > v_{av} > v_{mp}$ c) $v_{mp} > v_{av} > v_{rms}$ d) $v_{mp} > v_{rms} > v_{av}$

206. Cooking gas containers are kept in a lorry moving with uniform speed. The temperature of the gas

molecules inside will

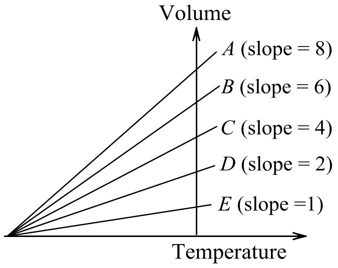
a) Increase b) Decrease

c) Remain same d) Decrease for some, while increase for others

207. Specific heats of monoatomic and diatomic gases are same and satisfy the relation which is

a) $C_p(mono) = C_p(dia)$ b) $C_p(mono) = C_v(dia)$ c) $C_v(mono) = C_v(dia)$ d) $C_v(mono) = C_p(dia)$

208. The expansion of an ideal gas of mass m at a constant pressure P is given by the straight line D. Then the expansion of the same ideal gas of mass $2m$ at a pressure $P/2$ is given by the straight line



a) E b) C c) B d) A

209. If pressure a gas contained in a closed vessel is increased by 0.4% when heated by 1°C, the initial temperature must be

a) 250 K b) 250°C c) 2500 K d) 25°C

210. One kg of a diatomic gas is at a pressure of 8×10^4 Nm^{-2}. The density of the gas is 4 kgm^{-3}. What is the energy of the gas due to its thermal motion?

a) 3×10^4 J b) 5×10^4 J c) 6×10^4 J d) 7×10^4 J

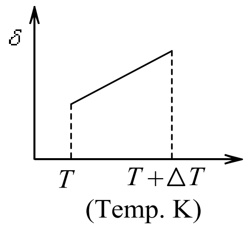
211. The $r.m.s.$ speed of the molecules of a gas at a pressure $10^5 Pa$ and temperature 0°C is $0.5 km$ sec^{-1}. If the pressure is kept constant but temperature is raised to 819°C, the velocity will become

a) 1.5 kms^{-1} b) 2 kms^{-1} c) 5 kms^{-1} d) 1 kms^{-1}

212. If the ratio of specific heat of a gas at constant pressure to that at constant volume is γ, then change in internal energy of the mass of gas, when the volume changes from V to $2V$ at constant pressure p, is

a) $R/(\gamma - 1)$ b) pV c) $pV/(\gamma - 1)$ d) $\gamma pV/(\gamma - 1)$

213. An ideal gas in initially at a temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quality $\delta = \Delta V / V \Delta T$ varies with temperature as

a)


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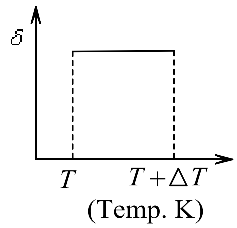
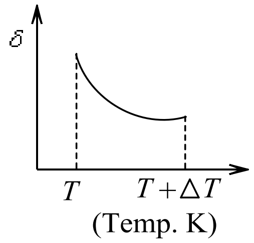
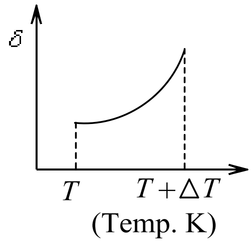


c)


d)


214. Two gases of equal mass are in thermal equilibrium. If P_a, P_b and V_a and V_b are their respective pressure and volumes, then which relation is true

a) $P_a \neq P_b; V_a = V_b$ b) $P_a = P_b; V_a \neq V_b$ c) $\frac{P_a}{V_a} = \frac{P_b}{V_b}$ d) $P_a V_a = P_b V_b$

215. According to the kinetic theory of gases, at absolute temperature

a) Water freezes b) Liquid helium freezes

c) Molecular motion stops d) Liquid hydrogen freezes

216. The product of the pressure and volume of an ideal gas is

a) A constant b) Approx. equal to the universal gas constant

c) Directly proportional to its temperature d) Inversely proportional to its temperature

217. The molar heat capacity at constant volume of oxygen gas at STP is nearly $\frac{5R}{2}$ and it approaches $\frac{7R}{2}$ as the temperature is increased. This happens because at higher temperature

a) Oxygen becomes triatomic b) Oxygen does not behaves as an ideal gas

c) Oxygen molecules rotate more vigorously d) Oxygen molecules start vibrating

218. For one gram mol of a gas, the value of R in the equation $PV = RT$ is nearly

a) 2 cal/K b) 10 cal/K c) 0.2 cal/K d) 200 cal/K

219. Relationship between P, V, and E for a gas is

a) $P = \frac{3}{2}EV$ b) $V = \frac{2}{3}EP$ c) $PV = \frac{3}{2}E$ d) $PV = \frac{2}{3}E$

220. A flask of volume 10^3 cc is completely filled with mercury at 0°C. The coefficient of cubical expansion of mercury is 180×10^{-6}°C^{-1} and that of glass is40×10^{-6}°C^{-1}.

If the flask in now placed in boiling water at 100°C, how much mercury will overflow?

a) 7 cc b) 14 cc c) 21 cc d) 28 cc

221. Considering the gases to be ideal, the value of $\gamma = \frac{C_P}{C_V}$ for a gaseous mixture consisting of 3 moles of carbon dioxide and 2 moles of oxygen will be $(\gamma_{O_2} = 1.4, \gamma_{CO_2} = 1.3)$

a) 1.37 b) 1.34 c) 1.55 d) 1.63

222. The kinetic energy of one gram molecule of a gas at normal temperature and pressure is $(R = 8.31\, J/mol - K)$

a) $0.56 \times 10^4\, J$ b) $1.3 \times 10^2\, J$ c) $2.7 \times 10^2\, J$ d) $3.4 \times 10^3 J$

223. The molar specific heat at constant pressure for a monoatomic gas is

a) $\frac{3}{2}R$ b) $\frac{5}{2}R$ c) $\frac{7}{2}R$ d) $4\, R$

224. The $r.m.s.$ speed of the molecules of a gas in a vessel is 400 ms^{-1}. If half of the gas leaks out, at constant temperature, the $r.m.s.$ speed of the remaining molecules will be

a) 800 ms^{-1} b) $400\sqrt{2}\, ms^{-1}$ c) 400 ms^{-1} d) 200 ms^{-1}

225. For a gas $\frac{R}{C_V} = 0.67$. This gas is made up of molecules which are

a) Diatomic b) Mixture of diatomic and polyatomic molecules

c) Monoatomic d) Polyatomic

226. At temperature T, the $r.m.s.$ speed of helium molecules is the same as $r.m.s.$ speed of hydrogen molecules at normal temperature and pressure. The value of T is

a) 273°C b) 546°C c) 0°C d) 136.5°C

227. Mean kinetic energy (or average energy) per g molecule of a monoatomic gas is given by

a) $\frac{3}{2}RT$ b) $\frac{1}{2}kT$ c) $\frac{1}{2}RT$ d) $\frac{3}{2}kT$

228. A sealed container with negligible coefficient of volumetric expansion contains helium (a monoatomic gas). When it is heated from 300 K to 600 K, the average K.E. of helium atoms is

a) Halved b) Unchanged

c) Doubled d) Increased by factor $\sqrt{2}$

229. Volume of gas becomes four times if

a) Temperature becomes four times at constant pressure

b) Temperature becomes one fourth at constant pressure

c) Temperature becomes two times at constant pressure

d) Temperature becomes half at constant pressure

230. Which of the following statements is true

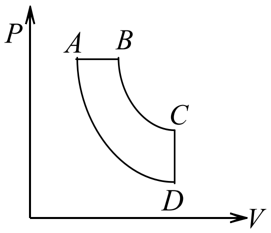
a) Absolute zero degree temperature is not zero energy temperature

b) Two different gases at the same temperature pressure have equal root mean square velocities

c) The root mean square speed of the molecules of different ideal gases, maintained at the same temperature are the same

d) Given sample of 1 cc of hydrogen and 1 cc of oxygen both at NTP; oxygen sample has a large number of molecules

231. In the following pressure-volume diagram, the isochoric, isothermal and isobaric parts, respectively, are



a) BA, AD, DC b) DC, CB, BA c) AB, BC, CD d) CD, DA, AB

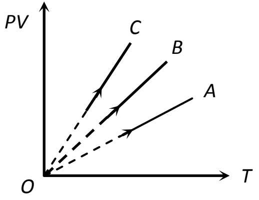
232. Let A and B the two gases and given $\frac{T_B}{M_A} = 4.\frac{T_B}{M_B}$; where T is the temperature and M is molecular mass. If C_A and C_B are the $r.m.s.$ speed, then the ratio $\frac{C_A}{C_B}$ will be equal to

a) 2 b) 4 c) 1 d) 0.5

233. The temperature at which protons in proton gas would have enough energy to overcome. Coulomb barrier of $4.14 \times 10^{-14} J$ is (Boltzman constant $= 1.38 \times 10^{-23} JK^{-1}$)

a) $2 \times 10^9 K$ b) $10^9 K$ c) $6 \times 10^9 K$ d) $3 \times 10^9 K$

234. PV versus T graph of equal masses of H_2, He and O_2 is shown in fig. Choose the correct alternative

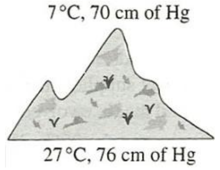


a) C corresponds to H_2, B to He and A to O_2
b) A corresponds to He, B to H_2 and C to O_2
c) A corresponds to He, B to O_2 and C to H_2
d) A corresponds to O_2, B to H_2 and C to He

235. A spherical balloon contains air at temperature T_0 and pressure P_0. The balloon material is such that the instantaneous pressure inside is proportional to the square of the diameter. When the volume of the balloon doubles as a result of heat transfer, the expansion follows the law

a) PV =constant b) $PV^{2/5}$ =constant c) PV^{-1} =constant d) $PV^{-2/3}$ =constant

236. At the top of a mountain a thermometer reads 7°C and a barometer reads 70 cm of Hg. At the bottom of the mountain these read 27°C and 76 cm of Hg, respectively. Ratio of density of air at the top with that of bottom is



a) 75/76 b) 70/76 c) 76/75 d) 76/70

237. Two identical vessels A and B with frictionless pistons conatin the same ideal gas at the same temperature and the same volume V. The masses of gas in A and B are m_A and m_B respectively. The gases are allowed to expand isothermally to same final volume 2 V. The change in pressures of the gas in A and B are found to be Δp and 1.5 Δp respectively. Then

a) $9m_A = 4m_B$ b) $3m_A = 2m_B$ c) $2m_A = 3m_B$ d) $4m_A = 9m_B$

238. 125 ml of gas A at 0.60 atmosphere and 150 ml of gas B at 0.80 atmospheric pressure at same temperature is filled in a vessel of 1 $litre$ volume. What will be the total pressure of mixture at the same temperature

a) 0.140 atmosphere b) 0.120 atmosphere c) 0.195 atmosphere d) 0.212 atmosphere

239. A gaseous mixture contains equal number of hydrogen and nitrogen and nitrogen molecules. Specific heat measurements on this mixture at temperatures below 100 K would indicate that the of γ (ratio specific heats) for this mixture is

a) 3/2 b) 4/3 c) 5/3 d) 7/5

240. A perfect gas at 27°C is heated at constant pressure so as to double its volume. The increase in temperature of the gas will be

a) 300°C b) 54°C c) 327°C d) 600°C

241. The kinetic energy of one mole gas at $300K$ temperature, is E. At 400 K temperature kinetic energy is E'. The value of E'/E is

a) 1.33 b) $\sqrt{\left(\frac{4}{3}\right)}$ c) $\frac{16}{9}$ d) 2

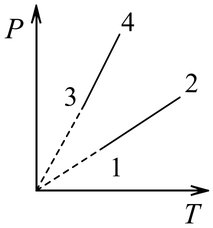
242. An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960J, = -5585\text{J}, Q_3 = -2980\text{J}.Q_4 = 3645$ J, respectively. The corresponding works involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100$ J and W_4, respectively. The value of W_4 is

a) 1315 J b) 275 J c) 765 J d) 675 J

243. A mixture of 2 moles of helium gas (atomic mass = 4 amu), and 1 mole of argon gas (atomic mass = $40amu$) is kept at $300K$ in a container. The ratio of the rms speeds $\left[\frac{V_{rms}(\text{helium})}{V_{rms}(\text{argon})}\right]$ is

a) 0.32 b) 0.45 c) 2.24 d) 3.16

244. Pressures versus temperature graph of an ideal gas of equal number of moles of different volumes is plotted as shown in figure. Choose the correct alternative

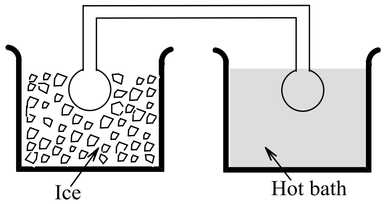


a) $V_1 = V_2, V_3 = V_4$ and $V_2 > V_3$ b) $V_1 = V_2, V_3 = V_4$ and $V_2 < V_3$
c) $V_1 = V_2 = V_3 = V_4$ d) $V_4 > V_3 > V_2 > V_1$

245. The ratio of the molar heat capacities of a diatomic gas at constant pressure to that at constant volume is

a) $\frac{7}{2}$ b) $\frac{3}{2}$ c) $\frac{3}{5}$ d) $\frac{7}{5}$

246. Two identical glass bulbs are interconnected by a thin glass tube. A glass is filled in these bulbs at NTP. If one bulb is placed in ice and another bulb is placed inside hot bath, then the pressure of the gas becomes 1.5 times. The temperature of hot bath will be



a) 100°C b) 182°C c) 256°C d) 546°C

247. Calculate the ratio of rms speeds of oxygen gas molecules to that of hydrogen gas molecules kept at the same temperature.

a) 1:4 b) 1:8 c) 1:2 d) 1:6

248. In a given process on an ideal gas, $dW = 0$ and $dQ < 0$. Then for the gas

a) The temperature will decrease b) The volume will increase
c) The pressure will remain constant d) The temperature will increase

249. A jar contains a gas and few drops of water at T K. The pressure in the jar is 830 mm of mercury. The temperature of jar is reduced by 1%. The saturated vapour pressure of water at the two temperatures are 30 mm and 25 mm of mercury. Then the new pressure in the jar will be

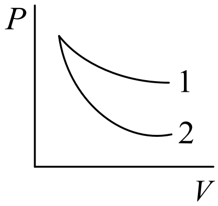
a) 917 mm of Hg b) 717 mm of Hg c) 817 mm of Hg d) None of these

250. If a Vander-Waal's gas expands freely, then final temperature is

a) Less than the initial temperature
b) Equal to the initial temperature
c) More than the initial temperature

d) Less or more than the initial temperature depending on the nature of the gas

251. $P - V$ plots for two gases during adiabatic processes are shown in figure. Plots 1 and 2 should corresponds, respectively, to

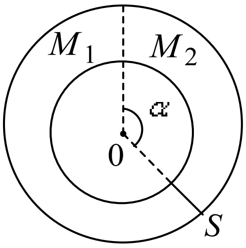


a) He and O_2 b) O_2 and He c) He and Ar d) O_2 and N_2

252. A cylinder contains 10 kg of gas at pressure of 10^7 N/m^2. The quantity of gas taken out of the cylinder, if final pressure is 2.5×10^6 N/m^2, will be (Temperature of gas is constant)

a) 15.2 kg b) 3.7 kg c) Zero d) 7.5 kg

253. A ring-shaped the contains two ideal gases with equal masses and molar masses $M_1 = 32$ and$M_2 = 28$. The gases are separated by one fixed partition and another movable stopper S which can move freely without friction inside the ring. The angle α is

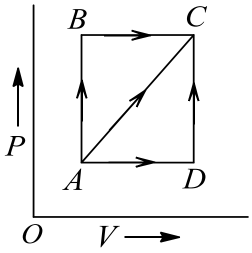


a) 182° b) 170° c) 192° d) 180°

254. Three rods of identical cross-sectional area are made from the same metal and form the sides of an isosceles triangle ABC, right-angled at B. The point A and B are maintained at temperature T and $(\sqrt{2})T$, respectively. In the steady state, the temperature of the point is T_c. Assuming that only heat conduction takes place, T_c/T is

a) $\frac{1}{2(\sqrt{2}-1)}$ b) $\frac{3}{\sqrt{2}+1}$ c) $\frac{1}{\sqrt{3}(\sqrt{2}-1)}$ d) $\frac{1}{\sqrt{2}+1}$

255. A thermodynamic process is shown in figure . The pressures and volumes corresponding to some points in the figure are



$P_A = 3 \times 10^4 \text{Pa} V_A = 2 \times 10^{-3} \text{m}^3$

$P_B = 8 \times 10^4 \text{Pa}\ V_D = 5 \times 10^{-3} \text{m}^3$

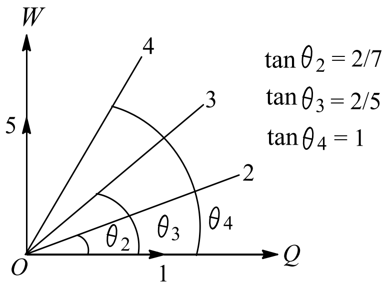
In the process AB, 600 J of heat is added to the system. The change in intermal energy of the system in the process AB would be

a) 560 J b) 800 J c) 60 J d) 640 J

256. The translational kinetic energy of gas molecule for one mole of the gas is equal to

a) $\frac{3}{2}RT$ b) $\frac{2}{3}RT$ c) $\frac{1}{2}RT$ d) $\frac{2}{3}KT$

257. Figure shows an isochore, an isotherm, an adiabatic and two isobars of two gases on a work done versus heat supplied curve. The initial states of both gases are the same and the scales for the two axes are same



Which of the following statements is incorrect?

a) Straight line 1 corresponds to an isochoric process

b) Straight line 2 corresponds to an isobaric process for diatomic gas

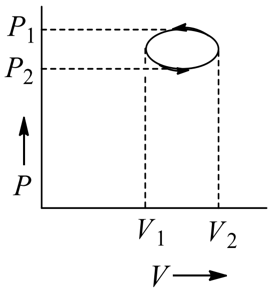
c) Straight line 4 corresponds to an isothermal process

d) Straight line 5 corresponds to an isothermal process

258. In kinetic theory of gases, a molecule of mass m of an ideal gas collides with a wall of vessel with velocity V. The change in the linear momentum of the molecule is

a) $2mV$ b) mV c) $-mV$ d) Zero

259. In the given elliptical $P - V$diagram



a) The work done is positive

b) The change in internal energy is non-zero

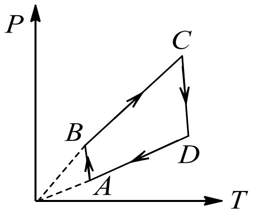
c) The work done $= -(\pi/4)(P_2 - P_1)(V_2 - V_1)$

d) The work done $= \pi(V_1 - V_2)^2 - \pi(P_1 - P_1)^2$

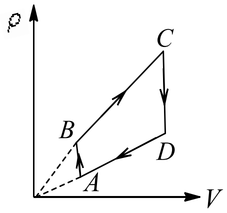
260. At 100°C the volume of 1 kg of water is 10^{-3} and volume of 1 kg of steam at normal pressure is 1.671 m^3. The latent heat of steam is 2.3×10^6 J/kg and the normal pressure is 10^5N/m^2. If 5 kg of water at 100° C is converted into steam, the increase in the internal energy of water in this process will be

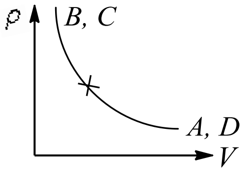
a) 8.35×10^5 J b) 10.66×10^6 J c) 11.5×10^6 J d) Zero

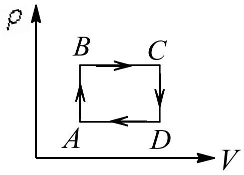
261. Pressure versus temperature graph of an ideal gas is as shown in figure

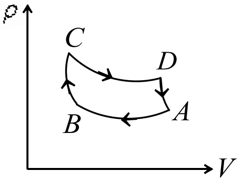


Corresponding density (ρ) versus volume (V) graph will be

a) 

b) 

c) 

d) 

262. A box contains n molecules of a gas. How will the pressure of the gas be effected, if the number of molecules is made $2n$

a) Pressure will decrease

b) Pressure will remain unchanged

c) Pressure will be doubled

d) Pressure will become three times

263. At constant volume the specific heat of a gas is $\frac{3R}{2}$, then the value of $'\gamma'$ will be

a) $\frac{3}{2}$ b) $\frac{5}{2}$ c) $\frac{5}{3}$ d) None of the above

264. Mean free path of gas molecule of constant temperature is inversely proportional to

a) P b) V c) m d) n (number density)

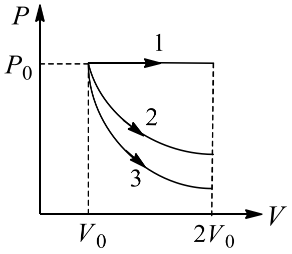
265. A stationary cylinder of oxygen used in a hospital has the following characteristics at room temperature 300 K, gauge pressure 1.38×10^7 Pa, volume 16 L. If the flow area, measured at atmospheric pressure, is constant at 2.4 L/min, the cylinder will last for nearly

a) 5 h b) 10 h c) 15 h d) 20 h

266. One mole of an ideal gas at temperature T_1 expands according to the law $(P/V) =$ constant. Find the work done when the final temperature becomes T_2

a) $R(T_2 - T_1)$ b) $(R/2)(T_2 - T_1)$ c) $(R/4)(T_2 - T_1)$ d) $PV(T_2 - T_1)$

267. A gas is expanded from volume V_0 to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal process and process 3 is adiabatic .Let $\Delta U_1, \Delta U_2$ and ΔU_3 be the change in internal energy of the gas in these three processes. Then



a) $\Delta U_1 > \Delta U_2 > \Delta U_3$ b) $\Delta U_1 < \Delta U_2 < \Delta U_3$ c) $\Delta U_2 < \Delta U_1 < \Delta U_3$ d) $\Delta U_2 < \Delta U_3 < \Delta U_1$

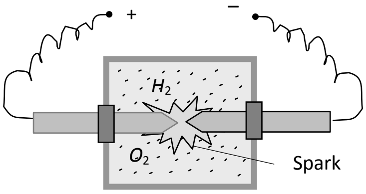
268. The heat capacity per mole of water is (R is universal gas constant)

a) $9R$ b) $\frac{9}{2}R$ c) $6R$ d) $5R$

269. For an ideal gas of diatomic molecules

a) $C_p = \frac{5}{2}R$ b) $C_v = \frac{3}{2}R$ c) $C_p - C_v = 2R$ d) $C_p = \frac{7}{2}R$

270. A vessel contains 14 g (7 moles) of hydrogen and 96 g (9 moles) of oxygen at STP. Chemical reaction is induced by passing electric spark in the vessel till one of the gases is consumed. The temperature is brought back to it's starting value 273 K. The pressure in the vessel is



a) 0.1 atm b) 0.2 atm c) 0.3 atm d) 0.4 atm

271. Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of the gas in A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to the same final volume $2V$. The changes in the pressure in A and B are found to be Δp and $1.5\ \Delta p$, respectively. Then

a) $4\ m_A = 9\ m_B$ b) $2\ m_A = 3\ m_B$ c) $3\ m_A = 3\ m_B$ d) $9\ m_A = 4\ m_B$

272. At what temperature will the rms speed of air molecules be double than that at NTP?

a) 519℃ b) 619℃ c) 719℃ d) 819℃

273. Two thermally insulated vessels 1 and 2 are filled with air at temperatures (T_1, T_2) volume (V_1, V_2) and pressure (P_1, P_2) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be

a) $T_1 + T_2$ b) $(T_1 + T_2)/2$ c) $\frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$ d) $\frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_1 + P_2V_2T_2}$

274. The average kinetic energy of hydrogen molecules at 300 K is E. At the same temperature, the average kinetic energy of oxygen molecules will be

a) $E/4$ b) $E/16$ c) E d) $4E$

275. The gas equation $\frac{PV}{T} =$ constant is true for a constant mass of an ideal gas undergoing

a) Isothermal change b) Adiabatic change c) Isobaric change d) Any type of change

276. Vapour is injected at a uniform rate in a closed vessel which was initially evacuated. The pressure in the

vessel

a) Increases continuously
b) Decreases continuously
c) First increases and then decreases
d) First increases and then becomes constant

277. Root mean square speed of the molecules of ideal gas is v. If pressure is increased two times at constant temperature, the rms speed will become

a) $\frac{v}{2}$
b) v
c) $2v$
d) $4v$

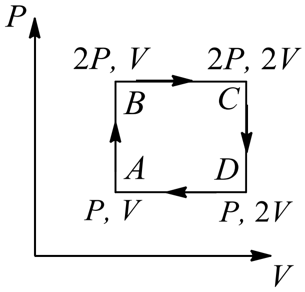
278. It is seen that in proper ventilation of building, windows must be opened near the bottom and the top of the walls, so as to let pass

a) In hot near the roof and cool air out near the bottom
b) Out hot air near the roof
c) In cool air near the bottom and hot air our near the roof
d) In more air

279. A gas under constant pressure of 4.5×10^5 Pa, when subjected to 800 kJ of heat, changes the volume from 0.5 m^3 to 2.0 m^3. The change in internal energy of the gas is

a) 6.75×10^5 J
b) 5.25×10^5 J
c) 3.25×10^5 J
d) 1.25×10^5 J

280. An ideal monatomic gas is taken round the cycle $ABCDA$ as shown in the $P-V$ diagram (see figure). The work done during the cycle is



a) PV
b) $2PV$
c) $1/2$
d) Zero

281. An ideal heat engine has an efficiency η. The coefficient of performance of the engine when driven backward will be

a) $1-(1/\eta)$
b) $\eta/(1-\eta)$
c) $(1/\eta)-1$
d) $1/(1-\eta)$

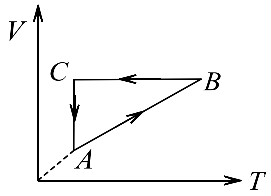
282. For matter to exist simultaneously in gas and liquid phases

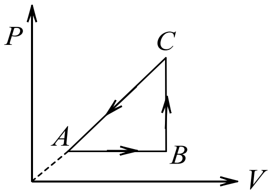
a) The temperature must be 0 K
b) The temperature must be less than 0°C
c) The temperature must be less than the critical temperature
d) The temperature must be less than the reduced temperature

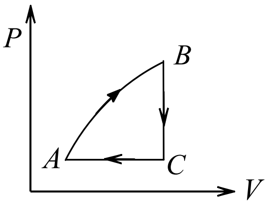
283. Two balloons are filled, one with pure He gas and the other by air, respectively. If the pressure and temperature of these balloons are same, then the number of molecules per unit volume is

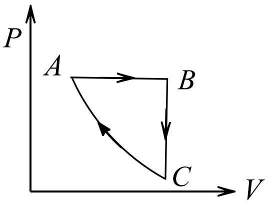
a) More in the He filled balloon
b) Same in both balloons
c) More in air filled balloon
d) In the ratio of 1:4

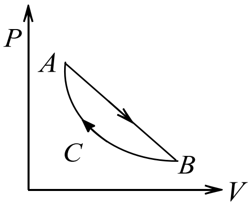
284. A cyclic process $ABCD$ is shown in the $V-T$ diagram. Process on the $P-V$ diagram is



a)


b)


c)


d)


285. Some gas at 300 K is enclosed in a container. Now, the container is placed on a fast moving train. While the train is in motion, the temperature of the gas

a) Rises above 300 K b) Falls below 300 K
c) Remains unchanged d) Become unsteady

286. The rate of diffusion is

a) Faster in solids than in liquids and gases b) Faster in liquids than in solids and gases
c) Equal to solids, liquids and gases d) Faster in gases than in liquids and solids

287. The ratio of the vapour densities of two gases at a given temperature is 9: 8. The ratio of the rms velocities of their molecules is

a) $3: 2\sqrt{2}$ b) $2\sqrt{2}: 3$ c) $9: 8$ d) $8: 9$

288. A vessel is partitioned in two equal halves by a fixed diathermic separator. Two different ideal gases are filled in left (L) and right (R) halves. The rms speed of the molecules in L part is equal to the mean speed of molecules in the R part. Then the ratio of the mass of a molecule in L part to that of a molecule in R part is

a) $\sqrt{\frac{3}{2}}$ b) $\sqrt{\pi/4}$ c) $\sqrt{2/3}$ d) $3\pi/8$

289. The temperature of a given mass is increased from 27°C to 327°C . The rms velocity of the molecules increases

a) $\sqrt{2}$ times b) 2 times c) $2\sqrt{2}$ times d) 4 times

290. The diameter of oxygen atom is 3Å. The fraction of molecular volume to the actual volume occupied by oxygen at STP is

a) 6×10^{-28} b) 8×10^{-4} c) 4×10^{-10} d) 4×10^{-4}

291. Ideal gas and real gas has major difference of

a) Phase transition b) Temperature c) Pressure d) None of them

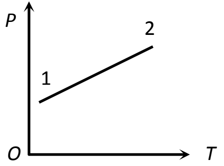
292. At room temperature (27°C) the rms speed of the molecules of a certain diatomic gas is found to be 1920 $\mathrm{m}s^{-1}$. The gas is

a) Cl_2 b) O_2 c) N_2 d) H_2

293. A cylinder of fixed capacity (of 44.8 litres) contains 2 moles of helium gas at STP. What is the amount of heat needed to raise the temperature of the gas in the cylinder by 20°C (Use $R = 8.31\ J\ mol^{-1}K^{-1}$)

a) 996 J b) 831 J c) 498 J d) 374 J

294. A pressure P-absolute temperature T diagram was obtained when a given mass of gas was heated. During the heating process from the state 1 to state 2 the volume



a) Remained constant b) Decreased c) Increased d) Changed erratically

295. At which temperature the velocity of O_2 molecules will be equal to the velocity of N_2 molecules at 0°C

a) 40°C b) 93°C c) 39°C d) Cannot be calculated

296. A certain balloon maintains an internal gas pressure of $P_0 = 100$ kPa until the colume reaches $V_0 = 20\ \mathrm{m}^3$. Beyond a volume of 20 m^3, the internal pressure varies as $P = P_0 + 2k(V - V_0)^2$ where P is in kPa, V is in m^3 and k is a constant ($k = 1\mathrm{kPa/m}^3$). Initially the balloon contains helium gat at 20°C, 100 kPa with a $15\mathrm{m}^3$ volume. The balloon is then heated until the volume becomes 25 m^3 and the pressure is 150 kPa. Assume ideal gas behavior for helium. The work done by the balloon for the centre in kJ is

a) 1256 b) 1414 c) 1083 d) 1512

297. One mole of an ideal monoatomic gas requires 210 J heat to raise the temperature by $10K$, when heated at constant temperature. If the same gas is heated at constant volume to raise the temperature by $10K$ then

heat required is

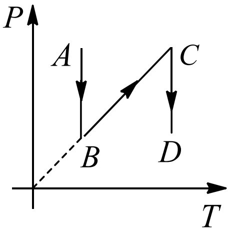
a) 238 J b) 126 J c) 210 J d) 350 J

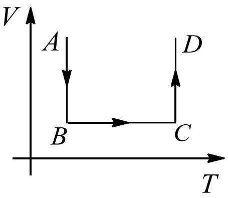
298. If the rms velocity of a gas is v ,then

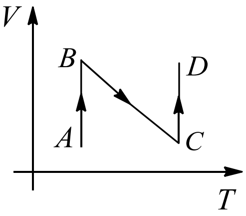
a) v^2T = constant b) v^2/T = constant

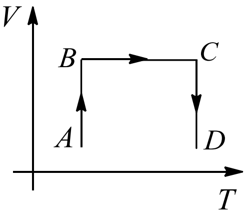
c) vT^2 = constant d) v is independent of T

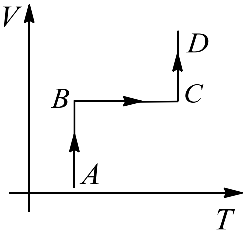
299. $P-T$ diagram is shown in figure. Choose the corresponding $V-T$ diagram



a) 

b) 

c) 

d) 

300. A gas is heated at a constant pressure. The fraction of heat supplied used for external work is

a) $\frac{1}{\gamma}$ b) $\left(1-\frac{1}{\gamma}\right)$ c) $\gamma-1$ d) $\left(1-\frac{1}{\gamma^2}\right)$

301. The specific heat of a gas

a) Has only two values C_P and C_V b) Has a unique value at a given temperature

c) Can have any value between 0 and ∞ d) Depends upon the mass of the gas

302. The translatory kinetic energy of a gas per g is

a) $\frac{3}{2}\frac{RT}{N}$ b) $\frac{3}{2}\frac{RT}{M}$ c) $\frac{3}{2}RT$ d) $\frac{3}{2}NKT$

303. For a gas if $\gamma = 1.4$, then atomicity, C_P and C_V of the gas are respectively

a) Monoatomic, $\frac{5}{2}R, \frac{3}{2}R$ b) Monoatomic, $\frac{7}{2}R, \frac{5}{2}R$ c) Diatomic, $\frac{7}{2}R, \frac{3}{2}R$ d) Triatomic, $\frac{7}{2}R, \frac{5}{2}R$

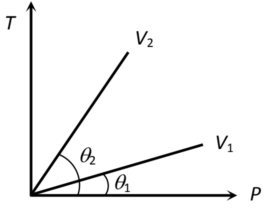
304. O_2 gas is filled in a vessel. If pressure is doubled, temperature becomes four times, how many times its density will become

a) 2 b) 4 c) $\frac{1}{4}$ d) $\frac{1}{2}$

305. Vessel A is filled with hydrogen while vessel B, whose volume is twice that of A, is filled with the same mass of oxygen at the same temperature. The ratio of the mean kinetic energies of hydrogen and oxygen is

a) 16 ∶ 1 b) 1 ∶ 8 c) 8 ∶ 1 d) 1 ∶ 1

306. From the following $P-T$ graph what inference can be drawn



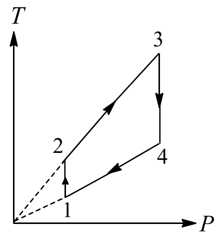
a) $V_2 > V_1$ b) $V_2 < V_1$ c) $V_2 = V_1$ d) None of the above

307. When a vander waal's gas undergoes free expansion then its temperature

a) Decreases b) Increases

c) Does not change d) Depends upon the nature of the gas

308. Two moles of an ideal monatomic gas undergoes a cyclic process as shown in figure. The temperatures in different state are given as $6T_1 = 3T_2 = 2T_4 = T_3 = 1800\text{K}$. Determine the work done by the gas during the cycle



a) −10 kJ b) −20 kJ c) −15 kJ d) −30 kJ

309. The equation of state for 5g of oxygen at a pressure p and temperature T, when occupying a volume V, will be

a) $pV = (5/32)RT$ b) $pV = 5RT$ c) $pV = (5/2)RT$ d) $pV = (5/16)RT$

310. If the internal energy of n_1 moles of He at temperature 10 T is equal to the internal energy of n_2 mole of hydrogen at temperature 6 T. the ratio of $\frac{n_1}{n_2}$ is

a) $\frac{3}{5}$ b) 2 c) 1 d) $\frac{5}{3}$

311. One mole of a diatomic gas undergoes a process $P = P_0/[1 + V/V_0)^3]$ where P_0 and V_0 are constants. The translational kinetic energy of the gas when $V = V_0$ is given by

a) $5P_0V_0/4$ b) $3P_0V_0/4$ c) $3P_0V_0/2$ d) $5P_0V_0/2$

312. At a given temperature the root mean square velocities of oxygen and hydrogen molecules are in the ratio

a) 16 ∶ 1 b) 1 ∶ 16 c) 4 ∶ 1 d) 1 ∶ 4

313. Which of the following cylindrical rods will conduct maximum heat, when their ends are maintained at a constant temperature difference?

a) $l = 1\text{m}, r = 0.2\text{m}$ b) $l = 1\text{m}, r = 0.1\text{m}$ c) $l = 10\text{m}, r = 0.1\text{m}$ d) $l = 0.1\text{m}, r = 0.3\text{m}$

314. The root mean square speed of the molecules of a diatomic gas is v. When the temperature is doubled, the molecules dissociate into two atoms. The new root mean square speed of the atom is

a) $\sqrt{2}v$ b) v c) $2v$ d) $4v$

315. Air inside a closed container is saturated with water vapour. The air pressure is p and the saturated vapour pressure of water is $\bar{p}$. If the mixture is compressed to one half of its volume by maintaining temperature constant, the pressure becomes

a) $2(p + \bar{p})$ b) $(2p + \bar{p})$ c) $(p + \bar{p}/2$ d) $p + 2\bar{p}$

316. A type kept outside in sunlight bursts off after sometime because of

a) Increases in pressure b) Increases in volume c) Both (a) and (b) d) None of these

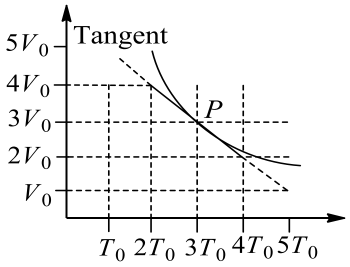
317. The number of translational degrees of freedom for a diatomic gas is

a) 2 b) 3 c) 5 d) 6

318. A cylinder of capacity 20 L is filled with H_2 gas. The total average kinetic energy of translatory motion of its molecules is 1.5×10^5J. The pressure of hydrogen in the cylinder is

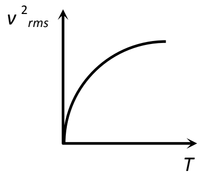
a) $2 \times 10^6 \text{N/m}^2$ b) $3 \times 10^6 \text{N/m}^2$ c) $4 \times 10^6 \text{N/m}^2$ d) $5 \times 10^6 \text{N/m}^2$

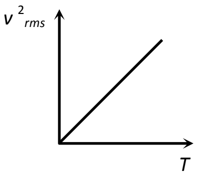
319. Figure shows the adiabatic curve for n moles of an ideal gas; the bulk modulus for the gas corresponding to the point P will be

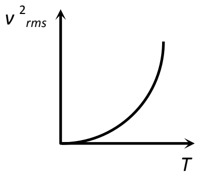


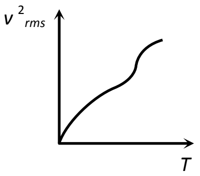
a) $\frac{5nRT_0}{3V_0}$ b) $nR\left(2 + \frac{T_0}{V_0}\right)$ c) $nR\left(1 + \frac{T_0}{V_0}\right)$ d) $\frac{2nRT_0}{V_0}$

320. The curve between absolute temperature and v_{rms}^2 is

a) 

b) 

c) 

d) 

321. The $r.m.s.$ speed of gas molecules is given by

a) $2.5\sqrt{\frac{RT}{M}}$　b) $1.73\sqrt{\frac{RT}{M}}$　c) $2.5\sqrt{\frac{M}{RT}}$　d) $1.73\sqrt{\frac{M}{RT}}$

322. To what temperature should the hydrogen at 327°C be cooled at constant pressure, so that the root mean square velocity of its molecules becomes half of its previous value?

a) -123°C　b) 123°C　c) -100°C　d) 0°C

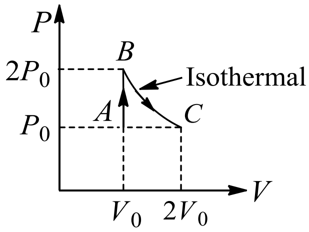
323. The rms velocity of gas molecules is 300 ms^{-1}. The rms velocity of molecules of gas with twice the molecular weight and half the absolute temperature is

a) 300 ms^{-1}　b) 600 ms^{-1}　c) 75 ms^{-1}　d) 150 ms^{-1}

324. At constant pressure, the ratio of increase in volume of an ideal gas per degree rise in kelvin temperature to it's original volume is ($T =$ absolute temperature of the gas)

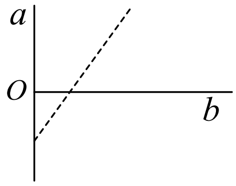
a) T^2　b) T　c) $1/T$　d) $1/T^2$

325. A diatomic ideal gas undergoes a thermodynamic change according to the $P - V$ diagram shown in figure. The total heat given to the gas is nearly



a) $2.5P_0V_0$　b) $1.4P_0V_0$　c) $3.9P_0V_0$　d) $1.1P_0V_0$

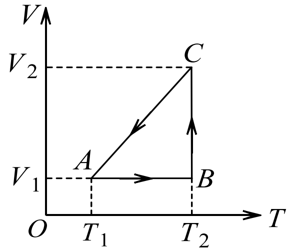
326. The expansion of unit mass of a perfect gas at constant pressure is pressure is shown in figure. Here



a) a =volume, b = °C temperature　b) a =volume, b=K temperature

c) a = °C temperature, b=volume　d) a=K temperature, b= volume

327. A cyclic process for 1 mole of an ideal gas is shown in figure in the $V - T$, diagram. The work done in AB, BC and CA, respectively, is



a) $0, RT_2\text{In}\left(\frac{V_1}{V_2}\right), R(T_1 - T_2)$　b) $R(T_1 - T_2), 0, RT_1 \text{ In } \left(\frac{V_1}{V_2}\right)$

c) $0, RT_2 \text{ In}\left(\frac{V_2}{V_1}\right), R(T_1 - T_2)$　d) $0, RT_2\text{In}\left(\frac{V_2}{V_1}\right), R(T_2 - T_1)$

328. If mass of He atom is 4 times that of hydrogen atom then mean velocity of He is

a) 2 times of H-mean value　b) 1/2 times of H-mean value

c) 4 times of H-mean value　d) Same as H-mean value

329. For a certain gas, the ratio of specific heats is given to be $\gamma = 1.5$. For this gas

a) $C_V = \frac{3R}{J}$ b) $C_P = \frac{3R}{J}$ c) $C_P = \frac{5R}{J}$ d) $C_V = \frac{5R}{J}$

330. The average momentum of a molecule in an ideal gas depends on

a) Temperature b) Volume c) Molecular mass d) None of these

331. Energy of all molecules of a monatomic gas having a volume V and pressure P is $3/2\ PV$. The total translational kinetic energy of all molecules of a diatomic gas at the same volume and pressure is

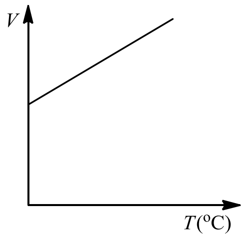
a) $1/2\ PV$ b) $3/2\ PV$ c) $5/2\ PV$ d) $3\ PV$

332. Four moles of hydrogen, 2 moles of helium and 1 mole of water vapour from an ideal gas mixture. What is the molar specific heat at constant pressure of mixture?

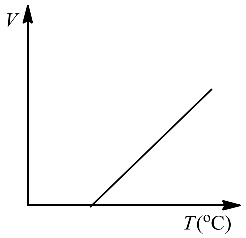
a) $\frac{16}{7}R$ b) $\frac{7R}{16}$ c) R d) $\frac{23}{7}R$

333. Volume-temperature graph at atmospheric pressure for a monoatomic gas (V in m^3, T in °C) is

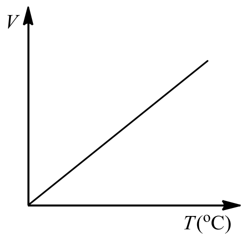
a)



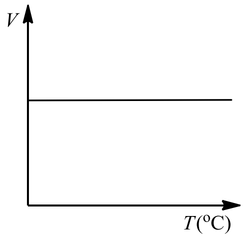
b)



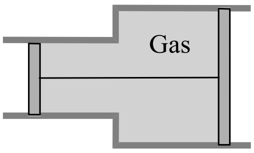
c)



d)



334. A gas is filled in the cylinder shown in figure. The two pistons are joined by a string. If the gas is heated, the right piston will



a) Move towards left b) Move towards right c) Remain stationary d) None of these

335. 70 cal of heat is required to raise the temperature of 2 moles of an ideal gas from 30°C to 35°C while the pressure of the gas is kept constant. The amount of the heat required to raise the temperature of the same gas through the same temperature range at constant volume is (gas constant $R = 2\ \mathrm{cal\ mol^{-1} - K^{-1}}$)

a) 70 cal b) 60 cal c) 50 cal d) 30 cal

336. Six molecules speeds 2 unit, 5 unit, 3 unit, 6 unit, 3 unit, and 5 unit respectively. The rms speed is

a) 4 unit b) 1.7 unit c) 4.2 unit d) 5 unit

337. A wheel is 80.3 cm in circumference. An iron tyre measures 80.0 cm around its inner face. If the coefficient of linear expansion for iron is $12 \times 10^{-6}\,°\mathrm{C}^{-1}$, the temperature of the tyre must be raised by

a) 105°C b) 417°C c) 312°C d) 223°C

338. At what temperature the rms velocity of helium molecules will be equal to that of hydrogen molecules at NTP?

a) 844 K b) 64 K c) 273°C d) 273 K

339. One mole of an ideal gas requires 207 J heat to raise the temperature by 10 K when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by the same 10 K, the heat required is
(Given the gas constant $R = 8.3\ J/mol - K$)

a) 198.7 J b) 29 J c) 215.3 J d) 124 J

340. For hydrogen gas $C_P - C_V = a$ and for oxygen gas $C_P - C_V = b$. So the relation between a and b is given by

a) $a = 16b$ b) $b = 16a$ c) $a = 4b$ d) $a = b$

341. Air is filled in a bottle at atmospheric pressure and it is corked at 35°C. If the cork can come out at 3 atmospheric pressure than upto what temperature should the bottle be heated in order to remove the cork

a) 325.5°C b) 851°C c) 651°C d) None of these

342. The value of densities of two diatomic gases at constant temperature and pressure are d_1 and d_2, then the ratio of speed of sound in these gases will be

a) $d_1 d_2$ b) $\sqrt{d_2/d_1}$ c) $\sqrt{d_1/d_2}$ d) $\sqrt{d_1 d_2}$

343. The identical square rods of metal are welded end to end as shown in figure, Q cal of heat flow through this combination in 4 min. If the rods were welded as shown in figure, the same amount of heat will flow through the combination in


(a)


(b)

a) 16 min b) 12 min c) 1 min d) 4 min

344. A diatomic gas is heated at constant pressure. What fraction of the heat energy is used to increase the thermal energy

a) 3/5 b) 3/7 c) 5/7 d) 5/9

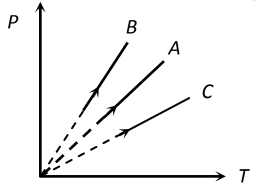
345. When the temperature of a gas increases by 1°C, its pressure increases 0.4%. What is its initial temperature?

a) 250 K b) 125 K c) 195 K d) 329 K

346. $CO_2(O - C - O)$ is a triatomic gas. Mean kinetic energy of one gram gas will be (If N-Avogadro's number, k-Boltzmann's constant and molecular weight of $CO_2 = 44$)

a) $(3/88)NkT$ b) $(5/88)NkT$ c) $(6/88)NkT$ d) $(7/88)NkT$

347. Pressure versus temperature graph of an ideal gas at constant volume V of an ideal gas is shown by the straight line A. Now mass of the gas is doubled and the volume is halved, then the corresponding pressure versus temperature graph will be shown by the line

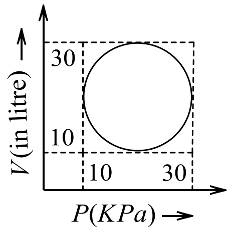


a) A b) B c) C d) None of these

348. Two moles of an ideal gas is contained in a cylinder fitted with a frictionless movable piston. Exposed to the atmosphere at an initial temperature T_0 the gas is slowly heated so that its volume becomes four time the initial value. The work done by the gas is

a) Zero b) $2RT_0$ c) $4RT_0$ d) $6RT_0$

349. Heat energy absorbed by a system in going through a cyclic process shown in figure is



a) $10^7\pi$ J b) $10^4\pi$ J c) $10^2\pi$ J d) $10^{-3}\pi$ J

350. The molar heat capacity varies as $C = C_v + \beta V$. Then the equation of the process for an ideal gas is given as

a) $T^{\frac{\beta}{RV}}$ =constant b) $V^{\frac{\beta T}{R}}$ =constant c) $T^{\frac{R}{\beta V}}$ =constant d) $T^{\frac{R}{\beta T}}$ =constant

351. In an adiabatic process pressure is increased by 2/3% if $C_p/C_v = 3/2$. Then the volume decreases by

about

a) $\frac{4}{9}\%$ b) $\frac{2}{3}\%$ c) 4% d) $\frac{9}{4}\%$

352. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of the gas in B is

a) 30 K b) 18 K c) 50 K d) 42 K

353. Twenty –two grams of CO_2 at 27°C is mixed with 16 g of O_2at 37°C. The temperature of the mixture is about

a) 31.5°C b) 27°C c) 37°C d) 30.5°C

354. If temperature of gas increases from 27°C to 927°C the $K.E.$ will be

a) Double b) Half c) One fourth d) Four times

355. Suppose ideal gas equation follows $VP^3 =$ constant. Initial temperature and volume of the gas are T and V respectively. If gas expands to 27 V then its temperature will become

a) T b) $9T$ c) $27\,T$ d) $T/9$

356. In the absence of intermolecular forces of attraction, the observed pressure p will be

a) p b) $< p$ c) $> p$ d) Zero

357. At a given temperature the ratio of $r.m.s.$ velocities of hydrogen molecule and helium atom will be

a) $\sqrt{2} : 1$ b) $1 : \sqrt{2}$ c) $1 : 2$ d) $2 : 1$

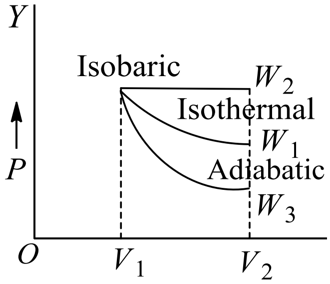
358. The speeds of 5 molecules of a gas (in arbitrary units) are as follows: 2,3,4,5,6. The root mean square speed for these molecules is

a) 2.91 b) 3.52 c) 4.00 d) 4.24

359. An ideal gas ($\gamma = 1.5$) is expanded adiabatically. How many times has the gas to be expanded to reduce the root mean square velocity of molecules 2.0 times?

a) 4 times b) 16 times c) 8 times d) 2 times

360. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic. Then



a) $W_2 > W_1 > W_3$ b) $W_2 > W_3 > W_1$ c) $W_1 > W_2 > W_3$ d) $W_1 > W_3 > W_2$

361. Saturated vapour is compressed to half is volume without any change in temperature, then the pressure will be

a) Doubled b) Halved c) The same d) Zero

362. At what temperature the molecule of nitrogen will have same rms velocity as the molecule of oxygen at 127°C ?

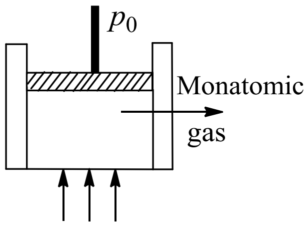
a) 457°C b) 273°C c) 350°C d) 77°C

363. Simple behaviour under all conditions of real gas is governed by the equation

a) $Pv = \mu RT$ b) $\left(P + \frac{a}{v^2}\right)(v - b) = \mu RT$

c) $Pv =$ constant d) $Pv^\gamma =$ constant

364. If 50 cal of heat is supplied to the system containing 2 mol of an ideal monatomic gas, the rise in temperature is ($R = 2$ cal/mol-K)



a) 50 K b) 5 K c) 10 K d) 30 K

365. If one mole of a monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of γ for the mixture is

a) 1.40 b) 1.50 c) 1.53 d) 3.07

366. At what temperature, the mean kinetic energy of O_2 will be the same for H_2 molecules at −73°C

a) 127°C b) 527°C c) −73°C d) −173°C

367. Oxygen and hydrogen are at the same temperature T. The ratio of the mean kinetic energy of oxygen molecules to that of the hydrogen molecules will be

a) 16: 1 b) 1: 1 c) 4: 1 d) 1: 4

368. For a gas molecule with 6 degrees of freedom the law of equipartition of energy gives the following relation between the molecular specific heat (C_V) and gas constant (R)

a) $C_V = \frac{R}{2}$ b) $C_V = R$ c) $C_V = 2R$ d) $C_V = 3R$

369. Root mean square velocity of a particle is v at pressure P. If pressure is increased two times, then the $r.m.s.$ velocity becomes

a) 2 v b) 3 v c) 0.5 v d) v

370. Molecules of a gas behave like

a) Inelastic rigid sphere b) Perfectly elastic non-rigid sphere
c) Perfectly elastic rigid sphere d) Inelastic non-rigid sphere

371. A diatomic ideal is heated at constant volume until the pressure is doubled and again heated at constant pressure until the volume is doubled. The average molar heat capacity for the whole process is

a) $\frac{13R}{6}$ b) $\frac{19R}{6}$ c) $\frac{23R}{6}$ d) $\frac{17R}{6}$

372. The coefficiency of apparent expansion of a liquid when determined using two different vessels A and B are λ_1 and λ_2, respectively. If the coefficient of linear expansion of the vessel A is α, the coefficient of linear expansion of vassel B is

a) $\frac{\alpha\gamma_1\gamma_2}{\gamma_1+\gamma_2}$ b) $\frac{\gamma_1-\gamma_2}{2\alpha}$ c) $\frac{\gamma_1-\gamma_2+\alpha}{3\alpha}$ d) $\frac{\gamma_1-\gamma_2}{3}+\alpha$

373. A closed vessel is maintained at a constant temperature. It is first evacuated and then vapour is injected into it continuously. The pressure of the vapour in the vessel

a) Increases continuously b) First increases and then remains constant
c) First increases and then decreases d) None of the above

374. 8 g of O_2, 14 g of N_2 and 22 g of CO_2 is mixed in a container of 10 L capacity at 27°C. The pressure exerted by the mixture in terms of atmospheric pressure is
($R = 0.082$ L atm K^{-1} mol^{-1})

a) 1.4 atm b) 2.5 atm c) 3.7 atm d) 8.7 atm

375. An ideal gas at 27°C is compressed adiabatically to 8/27 of its original volume. If $\gamma = 5/3$, then the rise in temperature is

a) 450 K b) 375 K c) 225 K d) 405 K

376. A bubble of 8 mole of helium is submerged at a certain depth in water. The temperature of water increases by 30°C. How much heat is added approximately to helium during expansion?

a) 4000 J b) 3000 J c) 3500 J d) 4500 J

377. A vessel contains 32 g of O_2 at a temperature T. The pressure of the gas is p. An identical vessel

containing 4 g of H_2 at a temperature $2T$ has a pressure of

a) $8\,p$ b) $4\,p$ c) p d) $\frac{p}{8}$

378. On colliding in a closed container the gas molecules

a) Transfer momentum to the walls b) Momentum becomes zero
c) Move in opposite directions d) Perform Brownian motion

379. Kinetic theory of gases provide a base for

a) Charle's law b) Boyle's law
c) Charle's law and Boyle's law d) None of these

380. 22 g of carbon dioxide at 27°C is mixed in a closed container with 16 g of oxygen at 37°C. If both gases are considered as ideal gases, then the temperature of the mixture is

a) 24.2°C b) 28.5°C c) 31.5°C d) 33.5°C

381. A sample of an ideal gas occupies a volume V at a pressure P and absolute temperature T, the mass of each molecule is m. The expression for the density of gas is (k = Boltzmaan's constant)

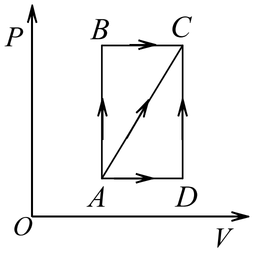
a) mkT b) P/kT c) P/kTV d) Pm/kT

382. The molar specific heat of oxygen at constant pressure $C_p = 7.03$ cal/mol°C and $R = 8.31$ J/mol°C. The amount of heat taken by 5 mol of oxygen when heated at constant volume from 10°C to 20°C will be approximately

a) 25 cal b) 50 cal c) 250 cal d) 500 cal

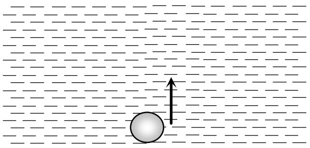
383. A thermodynamic process is shown in figure. The pressures and volumes corresponding to some points in the figure are: $P_A = 3 \times 10^4 \text{Pa}, P_B = 8 \times 10^4 \text{Pa}$ and $V_A = 2 \times 10^{-3} \text{m}^3, V_D = 5 \times 10^{-3} \text{m}^3$

In process AB, 600 J of heat is added to the system and in process BC, 200 J of heat is added to the system. The change in internal energy of the system in process AC would be



a) 560 J b) 800 J c) 600 J d) 640 J

384. An air bubble doubles its radius on raising from the bottom of water reservoir to be the surface of water in it. If the atmospheric pressure is equal to 10 m of water, the height of water in the reservoir is



a) 10 m b) 20 m c) 70 m d) 80 m

385. At what temperature volume of an ideal gas at 0°C becomes triple

a) 546°C b) 182°C c) 819°C d) 646°C

386. Six moles of O_2 gas is heated from 20°C to 35°C at constant volume. If specific heat capacity at constant pressure is 8 cal $\text{mol}^{-1} - \text{K}^{-1}$ and $R = 8.31\ \text{Jmol}^{-1} - \text{K}^{-1}$, what is change in internal energy of gas?

a) 180 cal b) 300 cal c) 360 cal d) 540 cal

387. The value of the gas constant (R) calculated from the perfect gas equation is 8.32 $joules/g$ mole K, whereas its value calculated from the knowledge of C_P and C_V of the gas is 1.98 cal/g mole K. From this data, the value of J is

a) 4.16 J/cal b) 4.18 J/cal c) 4.20 J/cal d) 4.22 J/cal

388. The relation between internal energy U, pressure P and volume V of a gas in an adiabatic process is

$U = a + bPV$

Where a and b are constants. What is the effective value of adiabatic constant γ?

a) $\frac{a}{b}$ b) $\frac{b+1}{b}$ c) $\frac{a+1}{a}$ d) $\frac{b}{a}$

389. The ratio of mean kinetic energy of hydrogen and nitrogen at temperature 300 K and 450 K respectively is

a) 3 : 2 b) 2 : 3 c) 2 : 21 d) 4 : 9

390. The average degrees of freedom per molecule for a gas are 6. The gas performs 25 J of work when it expands at constant pressure. The heat absorbed by gas is

a) 75 J b) 100 J c) 150 J d) 125 J

391. The relation between the internal energy U and adiabatic constant $\gamma$is

a) $U = \frac{PV}{\gamma - 1}$ b) $U = \frac{PV^{\gamma}}{\gamma - 1}$ c) $U = \frac{PV}{\gamma}$ d) $U = \frac{\gamma}{PV}$

392. The gas having average speed four times as that of SO_2 (molecular mass 64) is

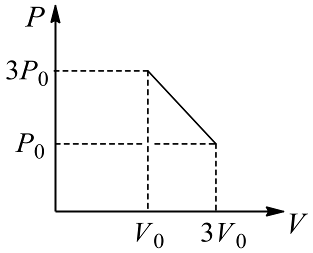
a) He (molecular mass 4) b) O_2 (molecular mass 32)

c) H_2 (molecular mass 2) d) CH_4 (molecular mass 16)

393. The value of C_V for one mole of neon gas is

a) $\frac{1}{2}R$ b) $\frac{3}{2}R$ c) $\frac{5}{2}R$ d) $\frac{7}{2}R$

394. n moles of gas in a cylinder under a piston is transferred infinitely slowly from a state with a volume of V_0 and a pressure $3P_0$ to a state with a volume of $3V_0$ and a pressure P_0 as shown in figure. The maximum temperature that the gas will reach in this process is



a) $\frac{P_0V_0}{nR}$ b) $\frac{3P_0V_0}{nR}$ c) $\frac{4P_0V_0}{nR}$ d) $\frac{2P_0V_0}{nR}$

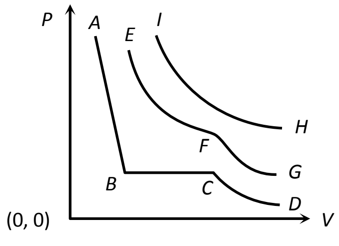
395. A gas at 27°C has a volume V and pressure P. On heating its pressure is doubled and volume becomes three times. The resulting temperature of the gas will be

a) 1800°C b) 162°C c) 1527°C d) 600°C

396. A polyatomic gas with n degrees of freedom has a mean energy per molecule given by
(N is Avogadro's number)

a) $\frac{nkT}{N}$ b) $\frac{nkT}{2N}$ c) $\frac{nkT}{2}$ d) $\frac{3kT}{2}$

397. In the adjoining figure, various isothermals are shown for a real gas. Then

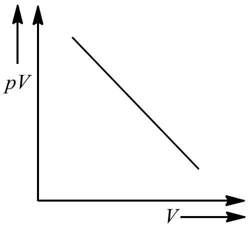


a) EF represents liquification b) CB represents liquification

c) HI represents the critical temperature d) AB represents gas at a high temperature

398. Which one of the following graphs represents the behaviour of an ideal gas?

a)



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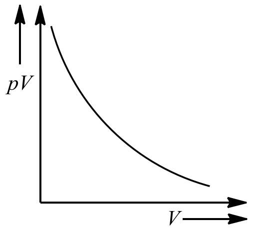
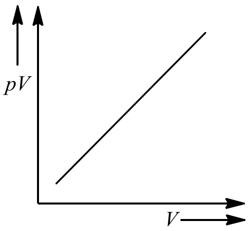
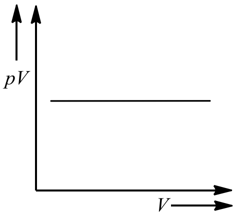


c) 

d) 

399. Equation of gas in terms of pressure (P), absolute temperature (T) and density (d) is

a) $\frac{P_1}{T_1 d_1} = \frac{P_2}{T_2 d_2}$ b) $\frac{P_1 T_1}{d_1} = \frac{P_2 T_2}{d_2}$ c) $\frac{P_1 d_2}{T_1} = \frac{P_2 d_1}{T_1}$ d) $\frac{P_1 d_1}{T_1} = \frac{P_2 d_2}{T_2}$

400. When the pressure on 1200 ml of a gas in increased from 70 cm to 120 cm of mercury at constant temperature, the new volume of the gas will be

a) 700 ml b) 600 ml c) 500 ml d) 400 ml

401. At what temperature is the kinetic energy of a gas molecule double that of its value of 27°C

a) 54°C b) 300 K c) 327°C d) 108°C

402. At room temperature, the rms speed of the molecules of a certain diatomic gas is found to be 1930 m/s. The gas is

a) H_2 b) F_2 c) O_2 d) CI_2

403. The temperature of 5 mol of gas which was held at constant volume was changed from 100°C to 120°C. The change in internal energy was found to be 80 J. The total heat capacity of the gas at constant volume will be equal to

a) 8 JK^{-1} b) 0.8 JK^{-1} c) 4 JK^{-1} d) 0.4 JK^{-1}

404. Four molecules of a gas have speeds 1, 2, 3 and 4 kms^{-1}. The value of rms speed of the gas molecules is

a) $\frac{1}{2}\sqrt{15}\ kms^{-1}$ b) $\frac{1}{2}\ \sqrt{10}\ kms^{-1}$ c) 2.5 kms^{-1} d) $\sqrt{\frac{15}{2}}\ kms^{-1}$

405. A vessel of volume 4 L contains a mixture of 8 g of oxygen, 14 g of nitrogen and 22 g of carbon dioxide at 27°C. The pressure exerted by the mixture is

a) $5.79 \times 10^5\ Nm^{-2}$ b) $6.79 \times 10^5\ Nm^{-2}$ c) $7.79 \times 10^3\ Nm^{-2}$ d) $7.79 \times 10^5\ Nm^{-2}$

406. A steel ball of mass 0.1 kg falls freely from a height of 10 m of 10 m and bounces to a height of 5.4 m from the ground. If the dissipated energy in this process is absorbed by the ball, the rise in its temperature is

a) 0.01°C b) 0.1°C c) 1.1°C d) 1°C

407. A vessel contains 1 mole of O_2 gas (relative molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing 1 mole of He gas (relative molar mass 4) at a temperature $2T$ has a pressure of

a) $P/8$ b) P c) $2P$ d) $8P$

408. The intensity of radiation emitted by the sun has its maximum values at a wavelength of 510 nm and that emitted by the North Star has the maximum value at

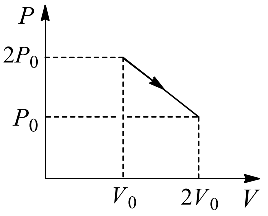
350 nm. If these stars behave like black bodies, the ratio of the surface temperature of the sun and the North Star is

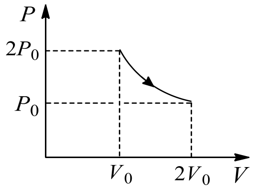
a) 1.46 b) 0.69 c) 1.21 d) 0.83

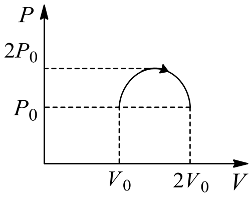
409. The $P - V$ equation for a process of an ideal gas is given as

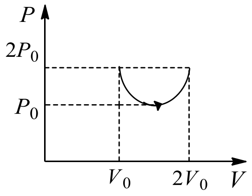
$$P = \frac{12P_0}{V_0}V - \frac{4P_0}{V_0^2}V^2 - 7P_0$$

The graphical representation of the above process is shown as

a) 

b) 

c) 

d) 

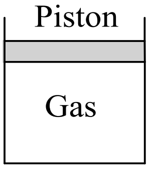
410. At what temperature the kinetic energy of gas molecule is half of the value at 27°C?

a) 13.5°C b) 150°C c) 75 K d) −123°C

411. Two moles of oxygen is mixed with eight moles of helium. The effective specific heat of the mixture at constant volume is

a) 1.3 R b) 1.4 R c) 1.7 R d) 1.9 R

412. A cylinder of ideal gas is closed by an 8 kg movable piston (area 60cm^2) as shown in figure. Atmospheric pressure is 100 kPa. When the gas is heated from 30°C to 100°C, the piston rises by 20 cm. the piston is then fixed in its placed and the gas is cooled back to 30°C. Let ΔQ_1be the heat added in the gas in the heating process and $|\Delta Q_2|$the heat lost during cooling. Then the value of $[\Delta Q_1 - |\Delta Q_2|]$ will be



a) Zero b) 136 J c) −136 J d) −68 J

413. A vessel contains a mixture of 7 g of nitrogen and 11 g of carbon dioxide at temperature $T = 300\text{K}$. If the pressure of the mixture is 1 atm ($1 \times 10^5 \text{N/m}^2$), its density is (gas constant $R = 25/3$ J/mol K)

a) 0.72 kg/m^3 b) 1.44 kg/m^3 c) 2.88 kg/m^3 d) 5.16 kg/m^2

414. At constant pressure, which of the following is true?

a) $v \propto \sqrt{\rho}$ b) $v \propto \frac{1}{\rho}$ c) $v \propto \rho$ d) $v \propto \frac{1}{\sqrt{\rho}}$

415. The temperature at which the $r.m.s.$ speed of hydrogen molecules is equal to escape velocity on earth surface, will be

a) 1060 K b) 5030 K c) 8270 K d) 10063 K

416. In the two vessels of same volume, atomic hydrogen and helium at pressure 1 atm and 2 atm are filled. If temperature of both the samples is same, then average speed of hydrogen atoms $< C_H >$ will be related to that of helium $< C_{He} >$ as

a) $< CH >= \sqrt{2} < C_{He} >$ b) $< C_H >=< C_{He} >$

c) $< C_H >= 2 < C_{He} >$ d) $< C_H >= \frac{< C_{He} >}{2}$

417. A flask is filled with 13 g of an ideal gas at 27°C and its temperature is raised to 52°C. The mass of the gas that has to be released to maintain the temperature of the gas in the flask at 52°C, the pressure remaining the same is

a) 2.5 g b) 2.0 g c) 1.5 g d) 1.0 g

418. The degrees of freedom of a molecule of a triatomic gas are

a) 2 b) 4 c) 6 d) 8

419. A thermally insulated container is divided into two parts by a screen. In one part the pressure and temperature are P and T for an ideal gas filled. In the second part it is vacuum. If now a small hole is created in the screen, then the temperature of the gas will

a) Decrease b) Increase c) Remain same d) None of these

420. As air bubble of volume V_0 is released by a fish at a depth h in a lake. The bubble rises to the surface. Assume constant temperature and standard atmospheric pressure P above the lake. The volume of the bubble just before touching the surface will be (density of water is ρ)

a) V_0 b) $V_0(\rho gh/P)$ c) $\frac{V_0}{\left(1+\frac{\rho gh}{P}\right)}$ d) $V_0\left(1+\frac{\rho gh}{P}\right)$

421. The quantity of heat required to raise one mole through one degree kelvin for a monoatomic gas at constant volume is

a) $\frac{3}{2}R$ b) $\frac{5}{2}R$ c) $\frac{7}{2}R$ d) $4R$

422. A horizontal uniform glass tube of 100 cm length sealed at both ends contains 10 cm mercury

column in the middle. The temperature and pressure of air on either side of mercury column are respectively 31°C and 76 cm of mercury. If the air column at one end is kept at 0°C and the other end at 273°C , the pressure of air which is at 0°C is (in cm of Hg)

a) 76　b) 88.2　c) 102.4　d) 12.2

423. Three closed vessels A, B and C are at the same temperature T and contain gases which obey the Maxwellian distribution of valocities. Vessel A contains only O_2, B only N_2 and C a mixture of equal quantities of O_2 and N_2. If the average speed of the O_2 molecules in vessel A is v_1, that of the N_2 molecules in vessel B is v_2, the average speed of the O_2 molecules in vessels C is

a) $\frac{(v_1+v_2)}{2}$　b) v_1　c) $(v_1 v_2)^{1/2}$　d) $\sqrt{3kT/M}$

424. A cylinder of 5 *litre* capacity, filled with air at N.T.P. is connected with another evacuated cylinder of 30 *litres* of capacity. The resultant air pressure in both the cylinders will be

a) 38.85 cm of Hg　b) 21.85 cm of Hg　c) 10.85 cm of Hg　d) 14.85 cm of Hg

425. The specific heat relation for ideal gas is

a) $C_P + C_V = R$　b) $C_P - C_V = R$　c) $C_P/C_V = R$　d) $C_V/C_P = R$

426. Two moles of monoatomic gas is mixed with three moles of a diatomic gas. The molar specific heat of the mixture at constant volume is

a) 1.55 R　b) 2.10 R　c) 1.63 R　d) 2.20 R

427. The temperature of 5 moles of a gas at constant volume is changed from 100°C to 120°C. The change in internal energy is 80 J. the total heat capacity of the gas at constant volume will be in JK^{-1} is

a) 8　b) 4　c) 0.8　d) 0.4

428. 310 J of heat is required to raise the temperature of 2 mole of an ideal gas at constant pressure from 25°C to 35°C. The amount of heat required to raise the temperature of the gas through the same range at constant volume is

a) 384 J　b) 144 J　c) 276 J　d) 452 J

429. The pressure and temperature of two different gases is P and T having the volume V for each. They are mixed keeping the same volume and temperature, the pressure of the mixture will be

a) $P/2$　b) P　c) $2P$　d) $4P$

430. The mean kinetic energy of one mole of gas per degree of freedom (on the basis of kinetic theory of gases) is

a) $\frac{1}{2}\,k\,T$　b) $\frac{3}{2}\,k\,T$　c) $\frac{3}{2}\,R\,T$　d) $\frac{1}{2}\,R\,T$

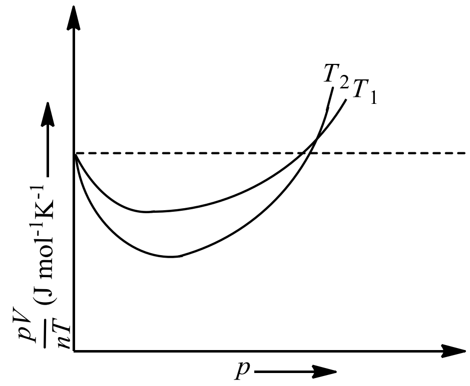
431. Boyle's law holds for an ideal gas during

a) Isobaric changes　b) Isothermal changes　c) Isochoric changes　d) Isotonic changes

432. KE per unit volume is E. The pressure exerted by the gas is given by

a) $\frac{E}{3}$　b) $\frac{2E}{3}$　c) $\frac{3E}{2}$　d) $\frac{E}{2}$

433. The figure below shows the plot of $\frac{pV}{nT}$ *versus* p for oxygen gas at two different temperatures.



Read the following statements concerning the above curves.

I. The dotted line corresponds to the ideal gas behavior

II. $T_1 > T_2$

III. The value of $\frac{pV}{nT}$ at the point where the curves meet on the y-axis is the same for all gases.

a) (i) only　b) (i) and (ii) only　c) All of these　d) None of these

434. What is the mass of 2 L of nitrogen at 22.4 atm pressure and 273 K?

a) 28 g　b) 14×22.4 g　c) 56 g　d) None of these

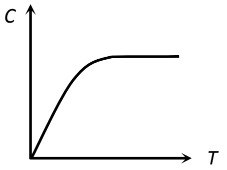
435. The relation between two specific heats of a gas is

a) $C_P - C_V = \frac{R}{J}$　b) $C_V - C_P = \frac{R}{J}$　c) $C_P - C_V = J$　d) $C_V - C_P = J$

436. A metal ball immersed in water weights w_1 at 0°C and w_2 at 50°C. The coefficient of cubical expansion of metal is less than that water. Then

a) $w_1 < w_2$　b) $w_1 > w_2$　c) $w_1 = w_2$　d) Data is not sufficient

437. Graph of specific heat at constant volume for a monoatomic gas is

a)


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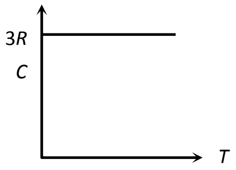

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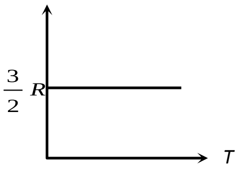

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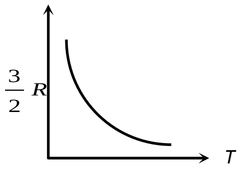


438. Universal gas constant is

a) $\frac{C_p}{C_V}$　b) $C_p - C_V$

c) $C_P + C_V$　d) $\frac{C_V}{C_p}$

439. The temperature of an ideal gas is increased from 27°C to 927°C. The root mean square speed of its molecules becomes

a) Twice　b) Half　c) Four times　d) One-fourth

440. A vertical column 50 cm long at 50°C balances another column of liquid 60 cm long at 100°C. The coefficient of absolute expansion of the liquid is

a) $0.005°\mathrm{C}^{-1}$　b) $0.0005°\mathrm{C}^{-1}$　c) $0.002°\mathrm{C}^{-1}$　d) $0.0002°\mathrm{C}^{-1}$

441. If the ratio of vapour density for hydrogen and oxygen is $\frac{1}{16}$, then under constant pressure the ratio of their *rms* velocities will be

a) $\frac{4}{1}$　b) $\frac{1}{4}$　c) $\frac{1}{16}$　d) $\frac{16}{1}$

442. If the degree of freedom of a gas are f, then the ratio of two specific heats C_P/C_V is given by

a) $\frac{2}{f} + 1$　b) $1 - \frac{2}{f}$　c) $1 + \frac{1}{f}$　d) $1 - \frac{1}{f}$

443. 2 g of O_2 gas is taken at 27°C and pressure 76 $cm.Hg$. Find out volume of gas (in litre)

a) 1.53　b) 2.44　c) 3.08　d) 44.2

444. The temperature of a gas is raised while its volume remains constant, the pressure exerted by the gas on the walls of the container increases because its molecular

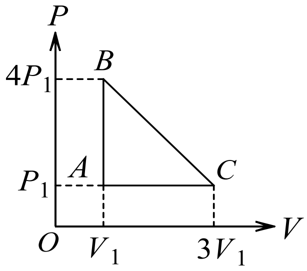
a) Lose more kinetic energy to the wall

b) Are in contact with the wall for a shorter time

c) Strike the wall more often with higher velocities

d) Collide with each other with less frequency

445. An ideal gas is taken around the cycle $ABCA$ shown in $P - V$ diagram. The net work done by gas during the cycle is equal to



a) $12P_1V_1$ b) $6P_1V_1$ c) $3P_1V_1$ d) P_1V_1

446. If masses of all molecules of a gas are halved and their speeds are doubles, then the ratio of initial and final pressures is

a) 1: 2 b) 2: 1 c) 4: 1 d) 1: 4

447. 1 mol of gas occupies a volume of 200 mL at 100 mm pressure. What is the volume occupied by two moles of gas at 400 mm pressure and at same temperature?

a) 50 mL b) 100 mL c) 200 mL d) 400 mL

448. Gas at a pressure P_0 in contained is a vessel. If the masses of all the molecules are halved and their speeds are doubled, the resulting pressure P will be equal to

a) $4P_0$ b) $2P_0$ c) P_0 d) $\frac{P_0}{2}$

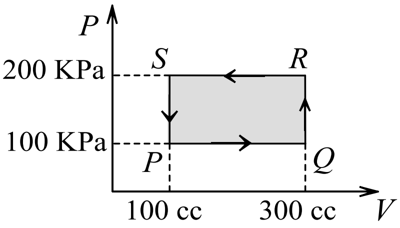
449. Two containers of equal volume contain the same gas at pressures $P_1$and$P_2$and absolute temperatures $T_1$and T_2respectively. On joining the vessel, the gas reaches a common pressure P and common temperature T. The ratio P/T is equal to

a) $\frac{P_1}{T_1}+\frac{P_2}{T_2}$ b) $\frac{P_1T_1+P_2T_2}{(T_1+T_2)^2}$ c) $\frac{P_1T_2+P_2T_1}{(T_1+T_2)^2}$ d) $\frac{P_1}{2T_1}+\frac{P_2}{2T_2}$

450. The vapour of a substance behaves as a gas

a) Below critical temperature b) Above critical temperature
c) At 100°C d) At 1000°C

451. A thermodynamic system is taken through the cyclic $PQRSP$ process. The net work done by the sysyem is



a) 20 J b) −20 J c) 400 J d) −374 J

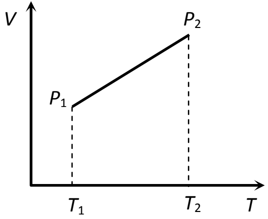
452. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2, molecule to per N_2 molecule is

a) 1:1
b) 1:2
c) 2:1
d) Depends on the moment of inertia of the two molecules

453. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K the root mean square velocity of the gas molecules is v, at 480 K it becomes

a) $4v$ b) $2v$ c) $v/2$ d) $v/4$

454. From the following $V-T$ diagram we can conclude



a) $P_1=P_2$ b) $P_1>P_2$ c) $P_1<P_2$ d) None of these

455. The efficiency of a Carnot engine is 50% and temperature of sink is 500 K. If temperature of source is kept constant and its efficiency raised to 60%, then the required temperature of sink will be

a) 100 K b) 600 K c) 400 K d) 500 K

456. A container of volume 1 m^3 is divided into two equal compartments by a partition. One of these compartments contains an ideal gas at 300K. The other compartment is vaccum. The whole system is thermally isolated from its surroundings. The partition is removed and the gas expands to occupy the whole volume of the container. Its temperature now would be

a) 300 K b) 250 K c) 200 K d) 10 K

457. The root mean square speed of the molecules of a gas is

a) Independent of its pressure but directly proportional to its Kelvin temperature

b) Directly proportional to the square roots of both its pressure and its Kelvin temperature

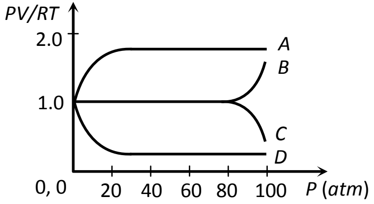
c) Independent of its pressure but directly proportional to the square root of its Kelvin temperature

d) Directly proportional to both its pressure and its kelvin temperature

458. A wall has two layers A and B, each made of different materials. Both the layers have the same thickness. The thermal conductivity of the material of A is twice that of B. Under thermal equilibrium, the temperature difference across the wall is 36°C. the temperature difference across the layer A is

a) 6°C b) 12°C c) 18°C d) 24°C

459. An experiment is carried on a fixed amount of gas at different temperatures and at high pressure such that it deviates from the ideal gas behavior. The variation of $\frac{PV}{RT}$ with P is shown in the diagram. The correct variation will correspond to

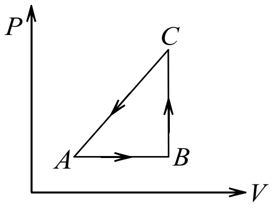


a) Curve A b) Curve B c) Curve C d) Curve D

460. The root mean square speed of hydrogen molecules of an ideal hydrogen gas kept in a gas chamber at 0°C is 3180 $metres/second$. The pressure on the hydrogen gas is (Density of hydrogen gas is $8.99 \times 10^{-2} kg/m^3$, 1 $atmosphere = 1.01 \times 10^5 N/m^2$)

a) 1.0 atm b) 1.5 atm c) 2.0 atm d) 3.0 atm

461. The $P-V$ diagram of a system undergoing thermodynamic transformation is shown in figure. The work done on the system in going from $A \rightarrow B \rightarrow C$ is 50 J and 20 cal heat is given to the system. The change in internal energy between A and C is



a) 34 J b) 70 J c) 84 J d) 134 J

462. A gas mixture consists of molecules of type 1,2 and 3, with molar masses $m_1 > m_2 > m_3$. V_{rms} and $\bar{K}$ are the $r.m.s.$ speed and average kinetic energy of the gases. Which of the following is true

a) $(V_{rms})_1 < (V_{rms})_2 < (V_{rms})_3$ and $(\bar{K})_1 = (\bar{K})_2 = (\bar{K}_3)$

b) $(V_{rms})_1 = (V_{rms})_2 \leq (V_{rms})_3$ and $(\bar{K})_1 = (\bar{K})_2 > (\bar{K})_3$

c) $(V_{rms})_1 > (V_{rms})_2 < (V_{rms})_3$ and $(\bar{K})_1 < (\bar{K})_2 > (\bar{K}_3)$

d) $(V_{rms})_1 > (V_{rms})_2 > (V_{rms})_3$ and $(\bar{K})_1 < (\bar{K})_2 < (\bar{K})_3$

463. On 0°C pressure measured by barometer is 760 mm. What will be pressure at 100°C

a) 760 mm b) 730 mm c) 780 mm d) None of these

464. For a gas, the $r.m.s.$ speed at 800 K is

a) Four times the value at 200 K

b) Half the value at 200 K

c) Twice the value at 200 K

d) Same as at 200 K

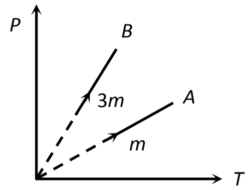
465. A sample of gas is at 0°C. To what temperature it must be raised in order to double the $r.m.s.$ speed of the molecule

a) 270°C b) 819°C c) 1090°C d) 100°C

466. To double the volume of a given mass of an ideal gas at 27°C keeping the pressure constant, one must raise the temperature in degree centigrade to

a) 54^o b) 270^o c) 327^o d) 600^o

467. Two different masses m and $3m$ of an ideal gas are heated separately in a vessel of constant volume, the pressure P and absolute temperature T, graphs for these two cases are shown in the figure as A and B. The ratio of slopes of curves B to A is



a) 3 : 1 b) 1 : 3 c) 9 : 1 d) 1 : 9

468. A perfect gas at 27°C is heated at constant pressure to 327°C. If original volume of gas at 27°C is V then volume at 327°C is

a) V b) $3\,V$ c) $2\,V$ d) $V/2$

469. Two gases occupy two containers A and B; the gas in A, of volume 0.10 m^3, exerts a pressure of 1.41 MPa and that in B, of volume 0.15m^3, exerts a pressure 0.7 MPa. The two containers are joined by a tube os negligible volume and the gases are allowed to intermingle. Then if the temperature remains constant. The final pressure in the container will be (in MPa)

a) 0.70 b) 0.98 c) 1.40 d) 2.10

470. An electron tube was sealed off during manufacture at a pressure of $1.2 \times 10^{-7} mm$ of mercury at 27°C. Its volume is 100 cm^3. The number of molecules that remain in the tube is

a) 2×10^{16} b) 3×10^{15} c) 3.86×10^{11} d) 5×10^{11}

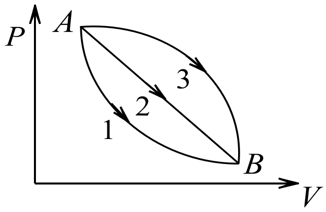
471. Internal energy of n_1 mol of hydrogen of temperature T is equal to the internal energy of n_2 mol of helium at temperature $2T$. The ratio n_1/n_2 is

a) $\frac{3}{5}$ b) $\frac{2}{3}$ c) $\frac{6}{5}$ d) $\frac{3}{7}$

472. A sound wave passing through air at NTP produces a pressure of 0.001 dyne/cm^2 during a compression. The corresponding change in temperature (given $\gamma = 1.5$ ans assume gas to be ideal) is

a) 8.97×10^{-4}K b) 8.97×10^{-6}K c) 8.97×10^{-8}K d) None of these

473. An ideal gas of mass m in a state A goes to another state B via three different processes as shown in figure. If Q_1, Q_2andQ_3 denote the heat absorbed by the gas along the three paths, then



a) $Q_1 < Q_2 < Q_3$ b) $Q_1 < Q_2 = Q_3$ c) $Q_1 = Q_2 > Q_3$ d) $Q_1 > Q_2 > Q_3$

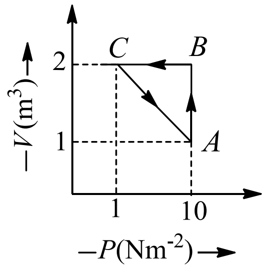
474. The average kinetic energy of a helium atom at 30°C is

a) Less than 1 eV b) A few keV c) $50 - 60\ eV$ d) 13.6 eV

475. The ratio of two specific heats $\frac{C_P}{C_V}$ of CO is

a) 1.33 b) 1.40 c) 1.29 d) 1.66

476. An ideal gas is taken through $A \to B \to C \to A$, as shown in figure. If the net heat supplied to the gas in the cycle is 55 J, the work done by the gas in the process $C \to A$ is

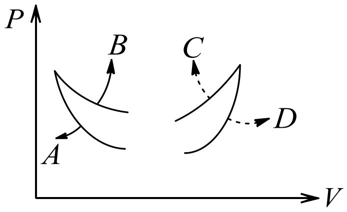


a) −5 J　　b) −10 J　　c) −15 J　　d) −20 J

477. Mean kinetic energy per degree of freedom of gas molecules is

a) $\frac{3}{2}kT$　　b) kT　　c) $\frac{1}{2}kT$　　d) $\frac{3}{2}RT$

478. Four curve A, B, C and D are drawn in figure for a given amount of gas. The curves which represent adiabatic and isothermal changes are



a) C and D, respectively　　b) $D$and C,respectively

c) A and B, respectively　　d) B and A, respectively

479. A monatomic ideal gas, initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L_1 and L_2 are the length of the gas column before and after expansion, respectively, then T_1/T_2 is given by

a) $\left(\frac{L_1}{L_2}\right)^{2/3}$　　b) $\frac{L_1}{L_2}$　　c) $\frac{L_2}{L_1}$　　d) $\left(\frac{L_2}{L_1}\right)^{2/3}$

480. For a gas the difference between the two specific heats is 4150 J/kg K. What is the specific heat at constant volume of gas if the ratio of specific heats is 1.4

a) 8475 J/kg-K　　b) 5186 J/kg-K　　c) 1660 J/kg-K　　d) 10375 J/kg-K

481. The molar specific heat at constant pressure of an ideal gas is (7/2)R. The ratio of specific heat at constant pressure to that at constant volume is

a) 5/7　　b) 9/7　　c) 7/5　　d) 8/7

482. The following sets of values for C_V and C_P of a gas has been reported by different students. The units are $cal/g\text{-}mole\text{-}K$. Which of these sets is most reliable

a) $C_V = 3, C_P = 5$　　b) $C_V = 4, C_P = 6$　　c) $C_V = 3, C_P = 2$　　d) $C_V = 3, C_P = 4.2$

483. Inside a cylinder closed at both ends is a movable piston. On one side of the piston is a mass m of a gas, and on the other side a mass 2 m of the same gas. What fraction of the volume of the cylinder will be occupied by the larger mass of the gas when the piston is in equilibrium? The temperature is the same throughout.

a) $\frac{2}{3}$　　b) $\frac{1}{3}$　　c) $\frac{1}{2}$　　d) $\frac{1}{4}$

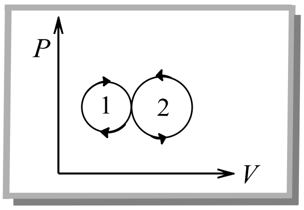
484. ½ mole of helium gas is contained in a container at S.T.P. The heat energy needed to double the pressure of the gas, keeping the volume constant (specific heat of the gas $= 3\ J\ gm^{-1}K^{-1}$) is

a) 3276 J　　b) 1638 J　　c) 819 J　　d) 409.5 J

485. At 0°C the density of a fixed mass of a gas divided by pressure is x. At 100°C, the ratio will be

a) x　　b) $\frac{273}{373}x$　　c) $\frac{373}{273}x$　　d) $\frac{100}{273}x$

486. In the following indicator diagram, the net amount of work done will be



a) Positive b) Negative c) Zero d) Infinity

487. Two samples A and B of a gas initially at the same pressure and temperature are compressed from volume V to $V/2$ (A isothermally and B adiabatically).The final pressure of A is
a) Greater than the final pressure of B
b) Equal to the final pressure of B
c) Less than the final pressure of B
d) Twice the final pressure of B

488. A monoatomic gas molecule has
a) Three degrees of freedom
b) Four degrees of freedom
c) Five degrees of freedom
d) Six degrees of freedom

489. The absolute temperature of a gas is determined by
a) The average momentum of the molecules
b) The velocity of sound in the gas
c) The number of molecules in the gas
d) The mean square velocity of the molecules

490. A pressure cooker contains air at 1 atm and 30°C. If the safety value of the cooler blows when the inside pressure $\geq 3\ atm$, then the maximum temperature of the air, inside the cooker can be
a) 90°C b) 636°C c) 909°C d) 363°C

491. When volume of system is increased two times and temperature is decreased half of its initial temperature, then pressure becomes
a) 2 times b) 4 times c) $\frac{1}{4}$ times d) $\frac{1}{2}$ times

492. Two containers of equal volume contain the same gas at the pressure p_1 and p_2 and absolute temperatures $T_1\ and\ T_2$ respectively. On joining the vessels, the gas reaches a common pressure p and a common temperature T. The ratio p/T is equal to
a) $\frac{p_1T_2+p_2T_1}{T_1\times T_2}$ b) $\frac{p_1T_2+p_2T_1}{T_1+T_2}$ c) $\frac{1}{2}\left[\frac{p_1T_2+p_2T_1}{T_1T_2}\right]$ d) $\frac{p_1T_2-p_2T_1}{T_1\times T_2}$

493. The mean kinetic energy of a gas at 300 K is 100 J. The mean energy of the gas at 450 K is equal to
a) 100 J b) 3000 J c) 450 J d) 150 J

494. The ends of 2 different materials with their thermal conductivities, radii of cross section and length all in the ratio of 1 : 2 maintained at temperature difference. If the rate of the flow of heat in the longer rod is 4 cals^{-1}, that in the shorter rod in cals^{-1} will be
a) 1 b) 2 c) 8 d) 6

495. When temperature of an ideal gas is increased from 27°C to 227°C, its $r.m.s.$ speed changed from 400 $metre/s$ to V_s. The V_s is
a) 516 $metre/s$ b) 450 $metre/s$ c) 310 $metre/s$ d) 746 $metre/s$

496. A cubical box with porous walls containing an equal number of O_2 and H_2 molecules is placed in a large evacuated chamber. The entire system is maintained at constant temperature T. The ratio of v_{rms} of O_2 molecules to that of the v_{rms} of H_2 molecules, found in the chamber outside the box after a short interval is
a) $\frac{1}{2\sqrt{2}}$ b) $\frac{1}{4}$ c) $\frac{1}{\sqrt{2}}$ d) $\sqrt{2}$

497. At what temperature rms speed of air molecules is doubled of that at NTP?
a) 819°C b) 719°C c) 909°C d) None of these

498. Two identical containers A and B have frictionless pistons. They contain the same volume of an ideal gas at the same temperature. The mass of the gas in A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to double the initial volume. The change in the pressure in A and B, respectively, is Δp and 1.5 Δp. Then
a) $4m_A=9m_B$ b) $2m_A=3m_B$ c) $3m_A=2m_B$ d) $9m_A=4m_B$

499. When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which

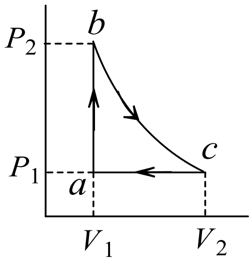
increases the internal energy of the gas is

a) $\frac{2}{5}$ b) $\frac{3}{5}$ c) $\frac{3}{7}$ d) $\frac{5}{7}$

500. A thin copper wire of length l increase in length by 1%, when heated from 0°C to 100°C. If a thin copper plate of area $2l \times l$ is heated from 0°C to 100°C, the percentage increase in its area would be

a) 1% b) 4% c) 3% d) 2%

501. Carbon monoxide is carried around a closed cyclic process abc, in which bc is an isothermal process, as shown in figure. The gas absorvs 7000 J of heat as its temperature is increased from 300 K to 1000 K in going from a to b. The quantity of heat ejected by the gas during the process ca is



a) 4200 J b) 500 J c) 9000 J d) 9800 J

502. An ideal gas has an initial pressure of 3 pressure units and an initial volume of 4 volume units. The table gives the final the final pressure and volume of the gas (in those same units) in four, processes. Which processes start and end on the same isotherm

	A	B	C	D
P	5	4	12	6
V	7	6	1	3

a) A b) B c) C d) D

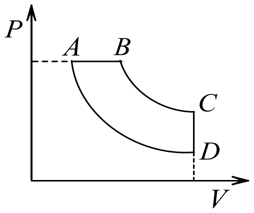
503. One mole of air ($C_v = 5R/2$) is confined at atmospheric pressure in a cylinder with a piston at 0°C. the initial volume occupied by gas is V. After the equivalent of 13200J of heat is transferred to it, the volume of gas V' is nearly ($1 \text{ atm} = 10^5 \text{N/m}^3$)

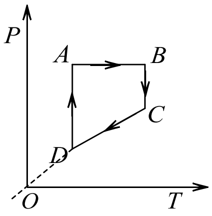
a) 37 L b) 22 L c) 60 L d) 30 L

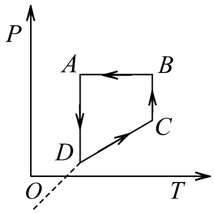
504. Supposing the distance between the atoms of a diatomic gas to be constant, its specific heat at constant volume per mole (gram mole) is

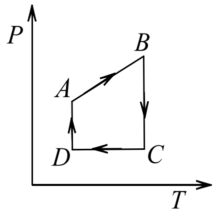
a) $\frac{5}{2}R$ b) $\frac{3}{2}R$ c) R d) $\frac{1}{2}R$

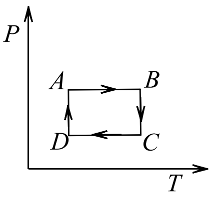
505. A cyclic process $ABCD$ is shown in the following $P - V$ diagram. Which of the following curves represents the same process?



a)


b)


c)


d)


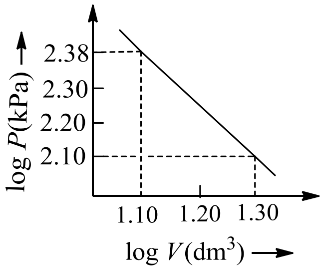
506. A diatomic gas molecule has translational, rotational and vibrational degrees of freedom. The C_P/C_V is

a) 1.67 b) 1.4 c) 1.29 d) 1.33

507. Two metallic spheres S_1 and S_2 are made of the same material and have got identical surface finish. The mass of S_1 is thrice that of S_2. Both the spheres are heates to the same high temperature and placed in the same room having lower temperature but are thermally insulated from each other. The ratio of the initial rate of cooling of S_1 to that of S_2 is

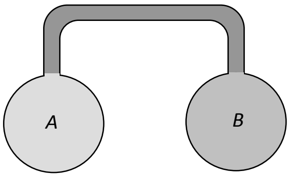
a) $\frac{1}{3}$ b) $\frac{1}{\sqrt{3}}$ c) $\frac{\sqrt{3}}{1}$ d) $\left(\frac{1}{3}\right)^{\frac{1}{3}}$

508. Logarithms of readings of pressure and volume for an ideal gas were plotted on a graph as shown in figure. By measuring the gradient, it can be shown that the gas may be



a) Monatomic and undergoing an adiabatic change
b) Monatomic and undergoing an isothermal change
c) Diatomic and undergoing an adiabatic change
d) Triatomic and undergoing an isothermal change

509. Two spherical vessel of equal volume, are connected by a a narrow tube. The apparatus contains an ideal gas at one atmosphere and $300K$. Now if one vessel is immersed in a bath of constant temperature $600K$ and the other in a bath of constant temperature $300K$. Then the common pressure will be



a) 1 atm b) $\frac{4}{5}atm$ c) $\frac{4}{3}atm$ d) $\frac{3}{4}atm$

510. For a real gas (van der Waal's gas)
a) Boyle temperature is a/Rb
b) Critical temperature is a/Rb
c) Triple temperature is $2a/Rb$
d) Inversion temperature is $a/2Rb$

511. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is
a) $4RT$ b) $15RT$ c) $9RT$ d) $11RT$

512. On any planet, the presence of atmosphere implies (C_{rms} = root mean square velocity of molecules and V_e = escape velocity)
a) $C_{rms} << V_e$ b) $C_{rms} > V_e$ c) $C_{rms} = V_e$ d) $C_{rms} = 0$

513. If the volume of the gas containing n number of molecules is V, then the pressure will decrease due to force of intermolecular attraction in the proportion
a) n/V b) n/V^2 c) $(n/V)^2$ d) $1/V^2$

514. S.I. unit of universal gas constant is
a) $cal/°C$ b) J/mol c) $J\ mol^{-1}K^{-1}$ d) J/kg

515. 70 calories of heat are required to raise the temperature of 2 moles of an ideal diatomic gas at constant pressure from 30°C to 35°C. The amount of heat required (in calorie) to raise the temperature of the same gas through the same range (30°C to 35°C) at constant volume is
a) 30 b) 50 c) 70 d) 90

516. If pressure of CO_2 (real gas) in a container is given by $P = \frac{RT}{2V-b} - \frac{a}{4b^2}$, then mass of the gas in container is
a) 11 g b) 22 g c) 33 g d) 44 g

517. The latent heat of vaporization of water is 2240 J. If the work done in the process of vaporization of 1 g is 168 J, then increase in internal energy is
a) 2072 J b) 1904 J c) 2408 J d) 2240 J

518. The value of $C_p - C_r = 1.00R$ for a gas in state A and $C_p - C_v = 1.06R$ in another state. If $P_A$and P_B denote

the pressure and T_A and T_B denote the temperatures in the two states, then

a) $P_A = P_B, T_A > T_B$ b) $P_A > P_B, T_A = T_B$ c) $P_A < P_B, T_A > T_B$ d) $P_A = P_B, T_A < T_B$

519. A real gas behaves like an ideal gas if its

a) Pressure and temperature are both high b) Pressure and temperature are both low

c) Pressure is high and temperature is low d) Pressure is low and temperature is high

520. The power radiated by a black body is P, and it radiates maximum energy around the wavelength λ_0. If the temperature of black body is now changed so that it radiates maximum energy around a wavelength $\lambda_0/4$, the power radiated by it will increase by a factor of

a) $\frac{4}{3}$ b) $\frac{16}{9}$ c) $\frac{64}{27}$ d) $\frac{256}{81}$

521. According to the kinetic theory of gases, the temperature of a gas is a measure of average

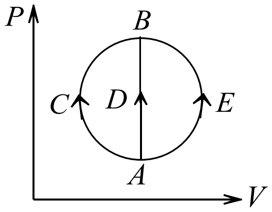
a) Velocities of its molecules b) Linear momenta of its molecules

c) Kinetic energies of its molecules d) Angular momenta of its molecules

522. In gases of diatomic molecules, the ratio of the two specific heats of gases C_P/C_V is

a) 1.66 b) 1.40 c) 1.33 d) 1.00

523. One mole of an ideal gas is taken from state A to state B by three different processes (a) ACB, (b) ADB and (c) AEB as shown in the $P-V$ diagram. The heat absorbed by the gas is



a) Greater in process (b) than in (a) b) The least in process (b)

c) The same in (a) and (c) d) Less in (c) than in (b)

524. Oxygen boils at (−183°C). The temperature on the Fahrenheit scale is

a) −297.4°F b) −253.6°F c) −342.6°F d) −225.3°F

525. The kinetic energy of one g-mole of a gas at normal temperature and pressure is ($R = 8.31\ J/mol-K$)

a) $0.56 \times 10^4 J$ b) $1.3 \times 10^2 J$ c) $2.7 \times 10^2 J$ d) $3.4 \times 10^3 J$

526. Consider a collection of a large number of particles each with speed v. The direction of velocity is randomly distributed in the collection. What is the magnitude of the relative velocity between a pairs in the collection

a) $2V/\pi$ b) V/π c) $8V/\pi$ d) $4V/\pi$

527. A body cools from 50°C to 40°C in 5 min. Its temperature comes down to 33.33°C in next 5 min. The temperature of surroundings is

a) 15°C b) 20°C c) 25°C d) 10°C

528. The temperature of a piece of metal is increased from 27°C to 84°C. The rate at which energy is radiated is increased to

a) Four times b) Two times c) Six times d) Eight times

529. In Boyle's law what remains constant

a) PV b) TV c) $\frac{V}{T}$ d) $\frac{P}{T}$

530. A container with insulating walls is divided into two equal parts by a partition fitted with a value. One part is filled with an ideal gas at a pressure p and temperature T, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be

a) $\frac{p}{2}, T$ b) $\frac{p}{2}, \frac{T}{2}$ c) p, T d) $p, \frac{T}{2}$

531. A monatomic gas expands at constant pressure on heating. The percentage of heat supplied that increases the internal energy of the gas and that is involved in the expansion is

a) 75%, 25% b) 25%, 75% c) 60%, 40% d) 40%, 60%

532. For a diatomic gas change in internal energy for unit change in temperature for constant volume is U_1 and U_2 respectively. $U_1 : U_2$ is

a) 5 : 3 b) 3 : 5 c) 1 : 1 d) 5 : 7

533. What is the ratio of specific heats of constant pressure and constant volume for NH_3

a) 1.33 b) 1.44 c) 1.28 d) 1.67

534. For the specific heat of 1 mole of an ideal gas at constant pressure (C_P) and at constant volume (C_V) which is correct

a) C_P of hydrogen gas is $\frac{5}{2}R$ b) C_V of hydrogen gas is $\frac{7}{2}R$

c) H_2 has very small values of C_P and C_V d) $C_P - C_V = 1.99\ cal/mole - K$ for H_2

535. The specific heats at constant pressure is greater than that of the same gas at constant volume because

a) At constant pressure work is done in expanding the gas

b) At constant volume work is done in expanding the gas

c) The molecular attraction increases more at constant pressure

d) The molecular vibration increases more at constant pressure

536. The specific heat of an ideal gas is

a) Proportional to T b) Proportional to T^2 c) Proportional to T^3 d) Independent of T

537. A body takes 10 min to cool from 60°C to 50°C. If the temperature of surroundings is 25°C and 527°C respectively. The ratio of energy radiated by P and $Q\ is$

a) 48°C b) 46°C c) 49°C d) 42.85°C

538. An air bubble of volume 1.0 cm^3 rises from the bottom of a lake $40m$ deep at a temperature of 12°C. The volume of the bubble when it reaches the surface, which is at a temperature of 35°C, will be

a) 5.4 cm^3 b) 4.9 cm^3 c) 2.0 cm^3 d) 10.0 cm^3

539. Three containers of the same volume contain three different gases. The masses of the molecules are m_1, m_2 and m_3 and the number of molecules in their respective containers are N_1, N_2 and N_3. The gas pressure in the containers are P_1, P_2 and P_3 respectively. All the gases are now mixed and put in one of the containers. The pressure P of mixture will be

a) $P < (P_1 + P_2 + P_3)$ b) $P = \frac{P_1 + P_2 + P_3}{3}$ c) $P = P_1 + P_2 + P_3$ d) $P > (P_1 + P_2 + P_3)$

540. The time average of the kinetic energy of one molecule of a gas taken over a long period of time

a) Is proportional to the square root of the absolute temperature of the gas

b) Is proportional to the absolute temperature of the gas

c) Is proportional to the square of the absolute temperature of the gas

d) Does not depend upon the absolute temperature of the gas

541. The kinetic energy per $g\ mol$ for a diatomic gas at room temperature is

a) 3 RT b) $\frac{5}{2}RT$ c) $\frac{3}{2}RT$ d) $\frac{1}{2}RT$

542. The equation of state for a gas is given by $PV = \eta RT + \alpha V$, where η is the number of moles and α positive constant.The initial pressure and temperature of 1 mol of the gas containes in a cylinder is P_0 and T_0, respectively the work done by the gas when its temoperature doubles isobarically will be

a) $\frac{P_0 T_0 R}{P_0 - \alpha}$ b) $\frac{P_0 T_0 R}{P_0 + \alpha}$ c) $P_0 T_0 R$ In 2 d) None of this

543. At what temperature is the root mean square velocity of gaseous hydrogen molecules equal to that of oxygen molecules at 47°C

a) 20 K b) 80 K c) $-73\ K$ d) 3 K

544. The temperature of an ideal gas is reduced from 927°C to 27°C. The $r.m.s.$ velocity of the molecules becomes

a) Double the initial value b) Half of the initial value

c) Four times the initial value d) Ten times the initial value

545. At constant temperature on increasing the pressure of a gas by 5% its volume will decrease by

a) 5% b) 5.26% c) 4.26% d) 4.76%

546. Mean free path of a gas molecule is

a) Inversely proportional to number of molecules per unit volume

b) Inversely proportional to diameter of the molecule

c) Directly proportional to the square root of the absolute temperature

d) Directly proportional to the molecular mass

547. A solid whose volume does not change with temperature floats in liquid. For two different temperaturest_1 and t_2, the fractions f_1 and f_2 of volume of solid remain submerged. What is the coefficient of volume expansion of liquid?

a) $\frac{f_1 - f_2}{f_2 t_1 - f_1 t_2}$ b) $\frac{f_1 - f_2}{f_1 t_1 - f_2 t_2}$ c) $\frac{f_1 + f_2}{f_2 t_1 - f_1 t_2}$ d) $\frac{f_1 + f_2}{f_1 t_1 - f_2 t_2}$

548. Certain amount of an ideal gas is contained in a closed vessel. The vessel is moving with a constant velocity v. The molecular mass of gas is M. The rise in temperature of the gas is M. The rise in temperature of the gas when the vessel is suddenly stopped is ($\gamma = C_p/C_v$)

a) $\frac{Mv^2(\gamma-1)}{2R(\gamma+1)}$ b) $\frac{Mv^2(\gamma-1)}{2R}$ c) $\frac{Mv^2}{2R(\gamma+1)}$ d) $\frac{Mv^2}{2R(\gamma-1)}$

549. If universal gas constant is R, the essential heat to increase from 273 K to 473 K at constant volume for ideal gas of 4 mol is

a) 200 R b) 400 R c) 800 R d) 1200 R

550. At NTP, sample of equal volume of chlorine and oxygen is taken. Now ratio of no. of molecules is

a) 1 : 1 b) 32 : 27 c) 2 : 1 d) 16 : 14

Multiple Correct Answers Type

551. Let $\bar{v}$, v_{rms} and v_p, respectively, denote the mean speed root mean square speed and most probable speed of the molecules in an ideal monatomic gas at absolute temperature T. The mass of a molecule is m. Then

a) No molecule can have a speed greater than $\sqrt{2}v_{\text{rms}}$

b) No molecule can have speed less then $v_p/\sqrt{2}$

c) $v_p < \bar{v} < v_{\text{rms}}$

d) The average kinetic energy of a molecule is $3/4mv_p^2$

552. A bimetallic strip is formed out of two identical strips one of copper and the other of brass. The coefficients of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then R is

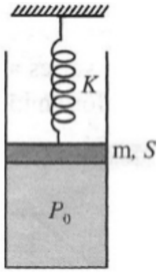
a) Proportional to ΔT

b) Inversely proportional to ΔT

c) Proportional to $|\alpha_B - \alpha_C|$

d) Inversely proportional to $|\alpha_B - \alpha_C|$

553. In the arrangement shown in figure, gas is thermally insulated. An ideal gas is filled in the cylinder having pressure P_0(> atmospheric pressure P_a). The spring of force constant K is initially unstretched. The piston of mass m and area S is frictionless. In equilibrium, the piston rises up by distance x_0, Then



a) Final pressure of the gas is $P_0 + \frac{Kx_0}{S} + \frac{mg}{S}$

b) Work done by the gas is $\frac{1}{2}Kx_0^2 + mgx_0$

c) Decrease in internal energy of the gas is

$\frac{1}{2}Kx_0^2 + mgx_0 \ + P_0Sx_0$

d) All of the above

554. In steady state

a) Temperature does not change with time

b) There is no absorption of heat

c) There is no flow of heat

d) All parts of the body are at same temperature

555. Two bodies A and B have thermal emissivities of 0.01 and 0.81, respectively. The outer surface areas of the two bodies are the same. The two bodies emit total radiant power of the same rate. Wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A, by 1.00 μm. If the temperature of A is 5802 K

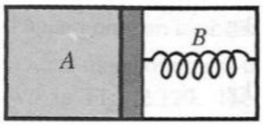
a) The temperature of B is 1934 K

b) $\lambda_B = 1.5\mu$m

c) The temperature of B is 11604 K

d) The temperature of B is 2901 K

556. A thermally insulated chamber of volume $2V_0$is divided by a frictionless piston of area S into two equal parts $A$and B. Part A has an ideal gas at pressure P_0 and temperature $T_0$and part B is vaccum. A massless spring of force constant K is connected with the piston and the wall of the container as shown. Initially the spring is unstretched. The gas inside chamber A is allowed to expand. Let in equilibrium the spring be compressed by x_0.Then



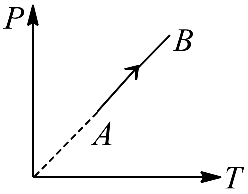
a) Final pressure of the gas is $\frac{Kx_0}{S}$

b) Work done by the gas is $\frac{1}{2}Kx_0^2$

c) Change the internal energy of the gas is $\frac{1}{2}Kx_0^2$

d) Temperature of the gas is decreased

557. During the process AB of an ideal gas



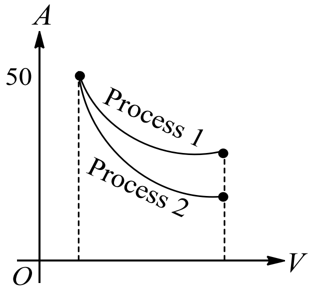
a) Work done on the gas is zero

b) Density of the gas is constant

c) Slope of line AB from the T-axis is inversely proportional to the number of moles of the gas

d) Slope of line AB from the T —axisis directly proportional to the number of moles of the gas

558. The indicator diagram for two processes 1 and 2 carrying on an ideal gas is shown in figure .If $m_1$andm_2 be the slope (dP/dV) for Process 1 and Process 2, respectively then



a) $m_1 = m_2$

b) $m_1 > m_2$

c) $m_1 < m_2$

d) $m_2C_v = m_1C_p$

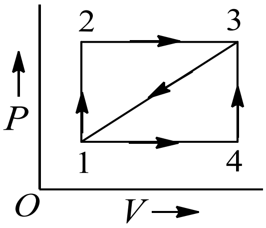
559. A spherical body of radius r radiates power P and its rate of cooling is R.

a) $P \propto r$ b) $P \propto r^2$ c) $R \propto r^2$ d) $R \propto \frac{1}{r}$

560. During the melting of a slab of ice at 273 K at atmosphere pressure
    a) Positive work is done by the ice-water system on the atmosphere
    b) Positive work is done on the ice-water system by the atmosphere
    c) The internal energy of the ice-water system increases
    d) The internal energy of the ice-water system decreases

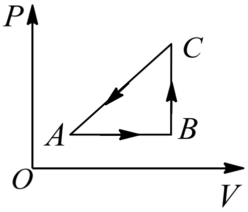
561. An ideal gas is taken from the state A (pressure P, volume V) to the state B (pressure $P/2$, volume $2V$) along a straight line path in the $P-V$ diagram. Select the correct statement(s) from the following:
    a) The work done by the gas in process A to B exceeds the work that would be done by it if the system were taken from A to B along the isotherm
    b) In the $T-V$ diagram, the path AB become a part of a parabola
    c) In the $P-T$ diagram, the path AB becomes a part of a hyperbola
    d) In going from A to B, the temperature T of the gas first increases to a maximum value and then decreases

562. Figure shows an indicator diagram. During path $1-2-3$, 100 is given to the system and 40 cal worth work is done. During path $1-4-3$, the work done is 10 cal Then



    a) Heat given to the system during path $1-4-3$ is 70 cal
    b) If the system is brought from 3 to 1 along straight line path $3-1$, work done is worth 25 cal
    c) Along straight line path $3-1$, the heat ejected by the system is 85 J
    d) The internal energy of the system in state 3 is 140 cal above that in state 1

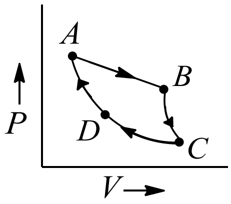
563. An ideal gas undergoes a thermodynamic cycle as shown in figure. Which of the following statements are correct?



    a) Straight line AB cannot pass through O
    b) During process AB, temperature decreases while during process BC it increases
    c) During process BC, work is done by the gas against external pressure and temperature of the gas increases
    d) During process CA, work is done by the gas against external pressure and heat supplied to the gas is exactly equal to this work

564. Which of the following statements are correct?
    a) Two bodies at different temperatures T_1andT_2 are brought in thermal contact. When thermal equilibrium is attained, the temperature of each body is $(T_1+T_2)/2$
    b) The coolant used in a car or a chemical or nuclear plant should have high specific heat
    c) Vapour in equilibrium with its liquid at a constant temperature does not obey Boyle's law
    d) Two vessels $A$and B of equal capacity are connected to each other by a stop cock. Vessel A contains a gas at 0°C and 1 atm pressure. Vessel B is completely evacuated. When the stop cock is opened, the final pressure of gas in each vessel will be 0.5 atm

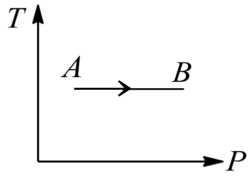
565. Figure shows the $P-V$ diagram for a Carnot cycle in this diagram



a) Curve AB represents isothermal process and BC adiabatic process
b) Curve AB represents adiabatic process and BC isothermal process
c) Curve CD represents isothermal process and DA adiabatic process
d) Curve CD represents adiabatic process and DA isothermal process

566. Under which of the following conditions, the law $pV = RT$ is not obeyed by a real gas?
a) High pressure and high temperature
b) Low pressure and low temperature
c) Low pressure and high temperature
d) High pressure and low temperature

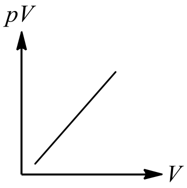
567. Temperature versus pressure graph of an ideal gas is shown in figure. During the process AB

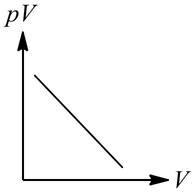


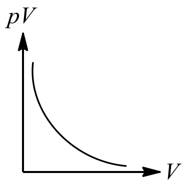
a) Internal energy of the gas remains constant
b) Volume of the gas is increased
c) Work done by the atmosphere on the gas is positive
d) Pressure is inversely proportional to volume

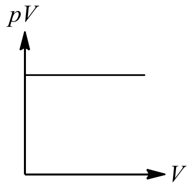
568. From the following statements concerning ideal gas at any given temperature T, select the correct one(s)
a) The coefficient of volume expansion at constant pressure is the same for all ideal gases
b) The average translation kinetic energy per molecule of oxygen gas is $3kT$, k being the Boltzmann constant
c) The mean free path of molecules increases with decreases on pressure
d) In a gaseous mixture, the average translational kinetic energy of the molecules of each component is different

569. Which of the following graphs do/does not represent the behaviour of an ideal gas?

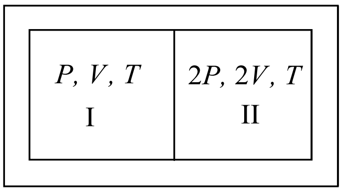
a) 

b) 

c) 

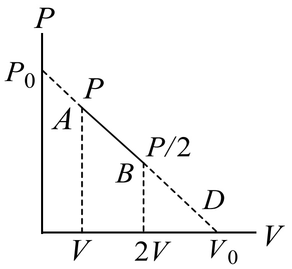
d) 

570. A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statements is/are correct, with reference to the final equilibrium position?



a) The pressures in the two compartments are equal
b) Volume of compartment I is $3V/5$
c) Volume of compartment II is $12V/5$
d) Final pressure in compartment I is $5P/3$

571. An ideal gas is taken from the state A (pressure P, volume V) to the state B (pressure $P/2$, volume $2V_0$) along a straight line path in the $P - V$ diagram. Select the correct statement (s) from the following



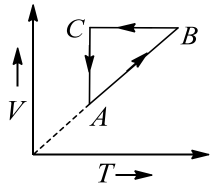
a) The work done by the gas in process AB is greater than the work that would be done if the system were taken from A to B along the isotherm

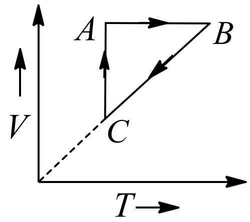
b) In the $T-V$ diagram, the path AB becomes a part of parabole

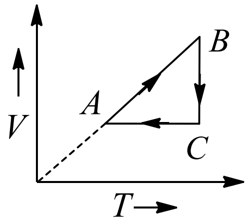
c) In the $P-T$ diagram, the path AB becomes a part of hyperbola

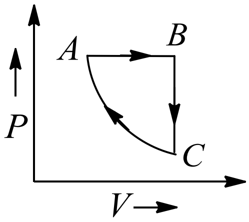
d) In going from A to B, the temperature T of the gas first increases to a maximum value and then decreases

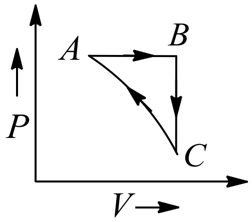
572. An ideal gas undergoes a thermodynamic cycle as shown in figure. Which of the following graphs represent the same cycle?



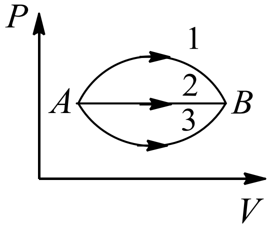
a) 

b) 

c) 

d) 

573. A gas undergoes change in its state position A to position B via three different paths as shown in figure. Select the correct alternatives:



a) Change in internal energy in all the three paths is equal

b) In all three paths heat is absorbed by the gas

c) Heat absorbed/released by the gas is maximum in path (1)

d) Temperature of the a gas first increase and then decreases continuously in path (1)

574. An ideal gas is taken from state A (pressure P,volume V) to state B (pressure $P/2$, volume $2V$) along a straight line path in the $P-V$ diagram. Select the correct statements from the following:

a) The work done by the gas in the process A to$B$ exceeds the work done that would be done by it if the system were taken from A to B along isotherm

b) In the $T-V$ diagram, the path AB becomes a part of a parabola

c) In the $P-T$ diagram, the path AB becomes a part of hyperbola

d) In going from A to B, the temperature T of the gas first increases to a maximum value and then decreases

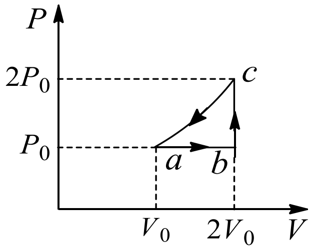
575. At ordinary temperatures, the molecules of an ideal gas have only translational and rotational kinetic energies. At high temperature they may also have vibrational energy. As a result of this, at higher temperature

a) $C_v=\frac{3R}{2}$ for a monatomic gas

b) $C_v>\frac{3R}{2}$ for a monatomic gas

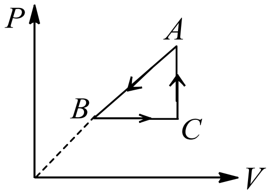
c) $C_v < \frac{5R}{2}$ for a diatomic gas   d) $C_v > \frac{5R}{2}$ for a diatomic gas

576. One mole of an ideal monatomic gas has initial temperature T_0, is made to go through the cycle $abca$ shown in figure. If U denotes the internal energy, then choose the correct alternative



a) $U_c > U_b > U_a$ b) $U_c - U_b = 3RT_0$ c) $U_c - U_a = \frac{9RT_0}{2}$ d) $U_b - U_a = \frac{3RT_0}{2}$

577. $P - V$ diagram of a cyclic process $ABCA$ is as shown in figure. Choose the correct alternative



a) $\Delta Q_{A \rightarrow B}$ is negative   b) $\Delta U_{B \rightarrow C}$ is positive   c) $\Delta U_{C \rightarrow A}$ is negative   d) ΔW_{CAB} is negative

578. Pick the correct statement (s):

a) The rms translational speed for all ideal gas molecules at the same temperature is not the same but it depends on the mass

Each particle in a gas has average translational kinetic energy and the equation $1/2\ mv_{\max}^2 = 3/2kT$

b) establishes the relationship between the average translational kinetic energy per particle and temperature of an ideal gas

c) If the temperature of an ideal gas is doubled from 100°C to 200°C, the average kinetic energy of each particle is also doubled

d) It is possible for both pressure and volume of a monatomic ideal gas to change simultaneously without causing the internal energy of the gas to change

579. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then

a) $C_p - C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

b) $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

c) C_p/C_v is larger for a diatomic ideal gas than for a monoatomic ideal gas

d) $C_p . C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

580. Select the correct alternatives for an ideal gas:

The change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to

a) $nC_v(T_2 - T_1)$, where C_v, is the molar specific heat at constant volume and n the number of moles of the gas

b) The change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process

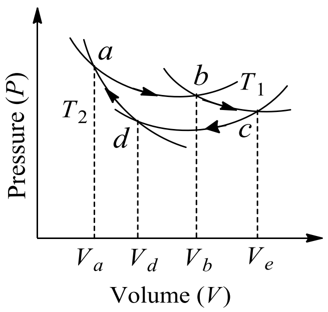
c) The internal energy does not change in an isothermal process

d) No heat is added or removed in an adiabatic process

581. A gas in container A is in thermal equilibrium with another gas in container B. Both contain equal masses of the two gases. Which of the following can be true?

a) $P_A V_A = P_B V_B$ b) $P_A = P_B, V_A \neq V_B$ c) $P_A \neq P_B, V_A = V_B$ d) $\frac{P_A}{V_A} = \frac{P_B}{V_B}$

582. An ideal gas undergoes the cyclic process show in a graph below:



a) $T_1 = T_2$ b) $T_1 > T_2$ c) $V_aV_c = V_bV_d$ d) $V_aV_b = V_cV_d$

583. In accordance with Kirchhoff's law

a) Bad absorber is bad emitter b) Bad emitter is good absorber

c) Bad reflector is good emitter d) Bad absorber is good reflector

584. During an experiment, an ideal gas is found to obey a condition $P^2/\rho =$ constant (ρ =density of the gas). The gas is initially at temperature T, pressure $P$and density ρ. The gas expands such that density changes to $\rho/2$

a) The pressure of the gas changes to $\sqrt{2}P$

b) The temperature of the gas changes to $\sqrt{2}T$

c) The graph of the above process on the $P - T$ diagram is parabola

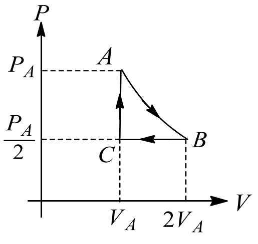
d) The graph of the above process on the $P - T$ diagram is hyperbola

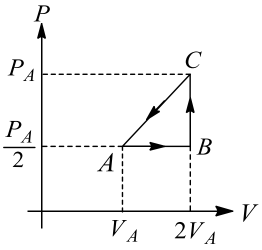
585. The molar heat capacity for an ideal gas cannot

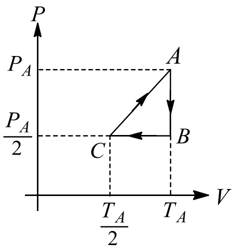
a) Be negative b) Be equal to either $C_v$or C_p

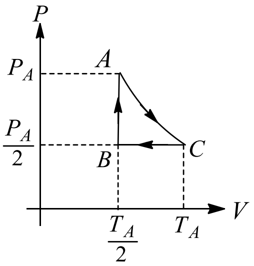
c) Lie in the range $C_v \leq C \leq C_p$ d) It may have any value between $-\infty$and $+\infty$

586. Three moles of an ideal gas $C_p = 7/2R$ at pressure P_A and temperature T_A is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original volume. Finally the gas is compressed at constant volume to the original pressure P_A. The correct $P - V$ and $P - T$ diagrams indicating the process are

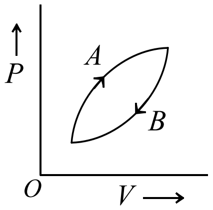
a)


b)


c)


d)


587. In the cyclic process shown in figure $\Delta U_1$and ΔU_2 represents the change in internal energy in process A and B, respectively. If ΔQ be the net heat given to the system in the process and ΔW be the work done by the system in the process, then



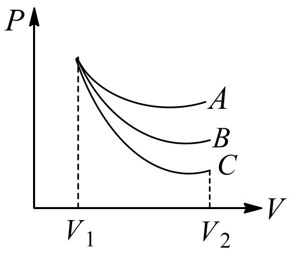
a) $\Delta U_1 + \Delta U_2 = 0$ b) $\Delta U_1 + \Delta U_2 = 0$ c) $\Delta Q - \Delta W = 0$ d) $\Delta Q + \Delta W = 0$

588. At a given volume, the pressure of a gas

a) Varies linearly as its mass b) Varies linearly as its temperature

c) Varies inversely at its mass d) Is independent of its temperature

589. An ideal gas undergoes an expansion from a state with temperature T_1 and volume V_1 through three different polytropic processes A, B and C as shown in the $P - V$ diagram. If $|\Delta E_A|, |\Delta E_B|and|\Delta E_c|$ be the magnitude of changes in internal energy along the three paths respectively, then:



a) $|\Delta E_A| < |\Delta E_B| < |\Delta E_C|$ if temperature in every process decreases
b) $|\Delta E_A| > |\Delta E_B| > |\Delta E_C|$ if temperature in every process decreases
c) $|\Delta E_A| > |\Delta E_B| > |\Delta E_C|$ if temperature in every process increases
d) $|\Delta E_B| < |\Delta E_A| < |\Delta E_C|$ if temperature in every process increases

590. If α and λ are coefficients of linear, superficial and volume expansion respectively, then
a) $\frac{\beta}{\alpha} = \frac{1}{2}$ b) $\frac{\beta}{\gamma} = \frac{2}{3}$ c) $\frac{\gamma}{\alpha} = \frac{3}{1}$ d) $\frac{\beta}{\alpha} = \frac{\gamma}{\beta}$

591. A box contains a mixture of H_2 and He gases. Which of the following statements are correct
a) The average translational kinetic energies of H_2 molecules and He atoms are same
b) The average energies of H_2 molecules and He atoms are same
c) H_2 molecules have greater average energy than that of He atoms
d) The average speed of H_2 molecules and He atoms are same

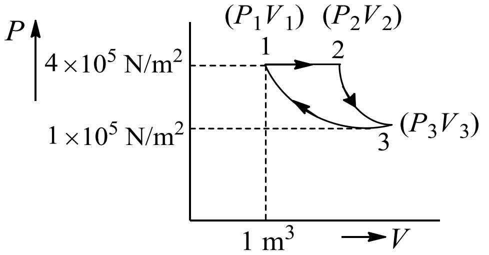
592. A closed vessel contains a mixture of two diatomic gases $A$and B. Molar mass of A is 16 times that of B and mass of gas A contained in the vessel is 2 times that of B. Which of the following statements are correct?
a) Average kinetic energy per molecule of A is equal to that of B
b) Root-mean-square value of translation velocity of B is four times that of A
c) Pressure exerted by B is eight times of that exerted by A
d) Number of molecules of B, in the cylinder, is eight times that of A

593. Choose the wrong statement (s) from the followings
a) The average KE of a molecule of any gas is the same at the same temperature
b) The average KE of a molecule of a gas is independent of its temperature
c) The average KE of 1 g of any gas is the same at the same temperature
d) The average KE of 1 g of any gas is independent of its temperature

594. An insulated 0.2 m^3 tank contains helium at 1200 kPa and 47°C. A valve is now opened, allowing some helium to escape. The valve is closed when one-half of the initial mass has escaped. The temperature of the gas is$\left(\sqrt[3]{4} = 1.6\right)$
a) 100K b) 200K c) 73°C d) −73°C

595. For an ideal gas:
The change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to
a) $nCv(T_2 - T_1)$ where Cv is the molar specific heat at constant volume and n the number of moles of the gas
b) The change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process
c) The internal energy does not change in an isothermal process
d) No heat is added or removed in an adiabatic process

596. A system undergoes three quasi-static processes sequentially as indicated in figure $1 - 2$ is an isobaric process, $2 - 3$ is a polytropic process with $\gamma = 4/3$ and $3 - 1$ is a process in which PV=constant $P_2 = P_1 = 4 \times 10^5 \mathrm{N/m^2}, P_3 = 1 \times 10^5 \mathrm{N/m^2}$and $V_1 = 1\ \mathrm{m^3}$. The heat transfer for the cycle is ΔQ, the change in internal energy is ΔU and the work done is ΔW. Then



a) $\Delta W = 0$ b) $\Delta Q = 1.08 \times 10^5 \mathrm{J}$ c) $\Delta U = 0$ d) $\Delta Q > \Delta W$

: ANSWER KEY :

1)	d	2)	a	3)	c	4)	c	189)	b	190)	d	191)	c	192)	c
5)	c	6)	d	7)	a	8)	a	193)	a	194)	d	195)	a	196)	d
9)	a	10)	b	11)	c	12)	b	197)	b	198)	d	199)	a	200)	b
13)	b	14)	c	15)	a	16)	d	201)	a	202)	c	203)	d	204)	a
17)	b	18)	c	19)	a	20)	c	205)	b	206)	c	207)	b	208)	d
21)	b	22)	d	23)	d	24)	a	209)	a	210)	b	211)	d	212)	c
25)	b	26)	a	27)	c	28)	b	213)	c	214)	d	215)	c	216)	c
29)	c	30)	c	31)	c	32)	a	217)	d	218)	a	219)	d	220)	b
33)	a	34)	d	35)	c	36)	b	221)	b	222)	d	223)	b	224)	c
37)	a	38)	d	39)	c	40)	a	225)	c	226)	a	227)	a	228)	c
41)	c	42)	a	43)	a	44)	b	229)	a	230)	a	231)	d	232)	a
45)	a	46)	c	47)	d	48)	a	233)	a	234)	a	235)	d	236)	a
49)	c	50)	d	51)	a	52)	b	237)	a	238)	c	239)	c	240)	a
53)	d	54)	d	55)	c	56)	c	241)	a	242)	c	243)	d	244)	a
57)	d	58)	a	59)	b	60)	c	245)	d	246)	d	247)	a	248)	a
61)	c	62)	a	63)	d	64)	a	249)	c	250)	a	251)	b	252)	d
65)	c	66)	b	67)	b	68)	c	253)	c	254)	b	255)	a	256)	a
69)	c	70)	b	71)	b	72)	d	257)	d	258)	a	259)	c	260)	b
73)	b	74)	c	75)	a	76)	c	261)	b	262)	c	263)	c	264)	d
77)	b	78)	c	79)	b	80)	b	265)	c	266)	b	267)	a	268)	a
81)	a	82)	a	83)	b	84)	d	269)	d	270)	a	271)	c	272)	d
85)	c	86)	c	87)	c	88)	b	273)	c	274)	c	275)	d	276)	c
89)	c	90)	c	91)	c	92)	c	277)	b	278)	c	279)	d	280)	a
93)	a	94)	d	95)	c	96)	a	281)	c	282)	c	283)	b	284)	c
97)	c	98)	d	99)	a	100)	a	285)	a	286)	d	287)	b	288)	d
101)	c	102)	b	103)	b	104)	a	289)	a	290)	b	291)	a	292)	d
105)	d	106)	a	107)	c	108)	b	293)	c	294)	c	295)	c	296)	c
109)	c	110)	d	111)	d	112)	d	297)	b	298)	b	299)	d	300)	b
113)	d	114)	b	115)	b	116)	b	301)	c	302)	b	303)	c	304)	d
117)	b	118)	c	119)	d	120)	b	305)	d	306)	a	307)	a	308)	a
121)	c	122)	d	123)	a	124)	c	309)	a	310)	c	311)	b	312)	d
125)	d	126)	a	127)	b	128)	a	313)	d	314)	c	315)	b	316)	a
129)	a	130)	a	131)	a	132)	a	317)	b	318)	d	319)	d	320)	b
133)	c	134)	d	135)	b	136)	c	321)	b	322)	a	323)	d	324)	c
137)	d	138)	d	139)	a	140)	d	325)	c	326)	c	327)	c	328)	b
141)	c	142)	d	143)	b	144)	d	329)	b	330)	d	331)	b	332)	d
145)	d	146)	b	147)	b	148)	a	333)	c	334)	b	335)	c	336)	c
149)	a	150)	a	151)	c	152)	c	337)	c	338)	c	339)	d	340)	d
153)	c	154)	c	155)	c	156)	d	341)	c	342)	b	343)	c	344)	c
157)	b	158)	d	159)	a	160)	a	345)	a	346)	d	347)	b	348)	d
161)	a	162)	d	163)	d	164)	d	349)	c	350)	a	351)	a	352)	d
165)	a	166)	a	167)	a	168)	c	353)	a	354)	d	355)	b	356)	c
169)	a	170)	d	171)	c	172)	c	357)	a	358)	d	359)	b	360)	a
173)	a	174)	c	175)	b	176)	c	361)	c	362)	d	363)	b	364)	b
177)	d	178)	b	179)	a	180)	a	365)	c	366)	c	367)	b	368)	d
181)	b	182)	a	183)	b	184)	a	369)	d	370)	c	371)	b	372)	d
185)	b	186)	b	187)	a	188)	c	373)	b	374)	c	375)	b	376)	b

377)	b	378)	a	379)	c	380)	c
381)	d	382)	c	383)	a	384)	c
385)	a	386)	d	387)	c	388)	b
389)	b	390)	b	391)	a	392)	a
393)	b	394)	c	395)	c	396)	c
397)	b	398)	d	399)	a	400)	a
401)	c	402)	a	403)	c	404)	d
405)	d	406)	b	407)	c	408)	b
409)	c	410)	d	411)	c	412)	b
413)	b	414)	d	415)	d	416)	c
417)	d	418)	c	419)	c	420)	d
421)	a	422)	c	423)	b	424)	c
425)	b	426)	b	427)	b	428)	b
429)	c	430)	d	431)	b	432)	b
433)	c	434)	a	435)	a	436)	a
437)	c	438)	b	439)	a	440)	a
441)	a	442)	a	443)	a	444)	c
445)	c	446)	b	447)	b	448)	b
449)	d	450)	b	451)	b	452)	a
453)	b	454)	b	455)	c	456)	a
457)	c	458)	b	459)	b	460)	d
461)	d	462)	a	463)	d	464)	c
465)	b	466)	c	467)	a	468)	c
469)	b	470)	c	471)	c	472)	c
473)	a	474)	a	475)	b	476)	a
477)	c	478)	c	479)	d	480)	d
481)	c	482)	a	483)	a	484)	b
485)	b	486)	b	487)	c	488)	a
489)	d	490)	b	491)	c	492)	c
493)	d	494)	a	495)	a	496)	b
497)	a	498)	c	499)	d	500)	d
501)	d	502)	c	503)	c	504)	a
505)	a	506)	d	507)	d	508)	c
509)	c	510)	b	511)	d	512)	a
513)	c	514)	c	515)	b	516)	b
517)	a	518)	c	519)	c	520)	d
521)	c	522)	b	523)	d	524)	a
525)	d	526)	d	527)	b	528)	b
529)	a	530)	a	531)	c	532)	c
533)	a	534)	d	535)	a	536)	d
537)	d	538)	a	539)	c	540)	b
541)	b	542)	a	543)	a	544)	b
545)	d	546)	a	547)	a	548)	b
549)	d	550)	a	1)	c,d	2)	b,d
3)	a,c	4)	a,b				
5)	a,b	6)	a,b,c,d	7)	a,b,d	8)	c,d
9)	b,d	10)	b,c	11)	a,b,d	12)	a,b,c
13)	b,d	14)	b,c,d	15)	a,c	16)	a,b,d
17)	a,c,d	18)	a,c	19)	a,b,c	20)	a,b,c,d
21)	a,b,d	22)	a,c	23)	a,b,c	24)	a,b,d
25)	a,d	26)	a,b,c,d	27)	a,b,d	28)	a,d
29)	b,d	30)	a,b,c,d	31)	b,c	32)	b,c
33)	a,c,d	34)	b,d	35)	a,b,c	36)	a,c
37)	a,c	38)	a,b	39)	a,c	40)	b,c
41)	a,c	42)	a,b,c,d	43)	b,c,d	44)	b,d
45)	a,b,c,d	46)	a,b,c				

: HINTS AND SOLUTIONS :

1 **(d)**

Oxygen being a diatomic gas possesses 5 degrees of freedom, 3 translational and 2 rotational.

Argon being monoatomic has 3 translational degrees of freedom.

Total energy of the system

$$= E_{\text{oxygen}} + E_{\text{argon}}$$

$$= n_1 f_1 \left(\frac{1}{2}RT\right) + n_2 f_2 (\frac{1}{2}RT)$$

$$= 2 \times 5 \times \frac{1}{2}RT + 4 \times 3 \times \frac{1}{2}RT$$

$$= 5RT + 6RT = 11RT$$

2 **(a)**

$$P \propto T \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{P_2 - P_1}{P_1} = \frac{T_2 - T_1}{T_1}$$

$$\Rightarrow \left(\frac{\Delta P}{P}\right)\% = \left(\frac{251 - 250}{250}\right) \times 100 = 0.4\%$$

3 **(c)**

Mean kinetic energy of gas molecule

$$E = \frac{f}{2}kT = \frac{f}{2}k(t + 273) = \left(\frac{f}{2}k\right)t + \frac{f}{2} \times 273k;$$

Comparing it with standard equation of straight line

$y = mx + c$. We get $m = \frac{f}{2}k$ and $c = \frac{f}{2}273k$

So the graph between E and t will be straight line with positive intercept on E-axis and positive slope with t-axis

4 **(c)**

$$PV = \mu RT = \frac{m}{M}RT \Rightarrow P \propto mT$$

$$\Rightarrow \frac{P_2}{P_1} = \frac{m_2}{m_1}\frac{T_2}{T_1} = \frac{1}{2} \times \frac{(273 + 27 + 50)}{(273 + 27)} = \frac{7}{12}$$

$$\Rightarrow P_2 = \frac{7}{12}P_1 = \frac{7}{12} \times 20 = 11.67 atm. \approx 11.7 atm$$

5 **(c)**

For ideal gas, on free expansion there is no change in temperature. Hence $C_a = C_b$

6 **(d)**

$$P = \frac{2}{3}E$$

7 **(a)**

Let T be the temperature of the mixture

Then $U = U_1 + U_2$

or

$$\frac{f}{2}(n_1 + n_2)RT = \frac{f}{2}(n_1)(R)(T_0) + \frac{f}{2}(n_2)(R)(2T_0)$$

or $(2 + 4)T = 2T_0 + 8T_0$

$(\because n_1 = 2, n_2 = 4)$

$$\therefore T = \frac{5}{3}T_0$$

8 **(a)**

As the steel tape is calibrated at 10°C, therefore, adjacent centimeter marks on the steel tape will be separated by a distance of

$l_t = l_{10}(1 + \alpha_s \Delta T) = (1 + \alpha_s 20)$ cm

Length of copper rod at 30°C

$= 90(1 + \alpha_c 20)$cm

Therefore, number of centimeters read on the tape will be

$$= \frac{90(1+\alpha_c 20)}{1(1+\alpha_s 20)} = \frac{90(1+1.7\times10^{-5}\times20)}{1(1+1.2\times10^{-5}\times20)}$$

$$= \frac{90\times1.00034}{1.00024} = 90.01 \text{ cm}$$

9 **(a)**

$$c_p - c_v = \frac{R}{M} = \frac{PV}{TM} = \frac{P}{Td}$$

$$\therefore d = \frac{P}{T(c_p - c_v)}$$

$$= \frac{1.013 \times 10^5}{273(525 - 315)} = 1.77 \text{ kg/m}^3$$

10 **(b)**

Kinetic energy of N molecules of gas,

$$E = \frac{3}{2}NkT$$

Initially

$$E_1 = \frac{3}{2}N_1kT_1$$

and finally

$$E_2 = \frac{3}{2}N_2kT_2$$

But according to the problem $E_1 = E_2$and$N_2 = 2N_1$

$$\frac{3}{2}N_1kT_1 = \frac{3}{2}(2N_1)kT_2$$

$$\Rightarrow T_2 = \frac{T_1}{2}$$

Since the kinetic energy is constant

$$\frac{3}{2}N_1kT_1 = \frac{3}{2}N_2kT_2$$

$$\Rightarrow N_1T_1 = N_2T_2$$

$\therefore$ NT =constant

From ideal gas equation of N molecules

$$PV = NkT$$

$$\Rightarrow P_1V_1 = P_2V_2$$

$$\therefore P_1 = P_2$$

(as $V_1 = V_2$ and NT = constant)

11 **(c)**

$$\gamma_{poly} = \frac{(4 + f_{vib})}{(3 + f_{vib})}$$

f_{vib} = degree of freedom due to vibration

$\Rightarrow \gamma_{poly} < \frac{4}{3}$

Or $\gamma_{poly} < 1.33$

Also you can remember that as the atomicity of gas increases the value of γ-decreases

12 **(b)**

$V_1 = 2.4 \times 10^{-3} \mathrm{m}^3, P_1 = P_0 = 10^5 \mathrm{N/m}^2$

and $T_1 = 300$ K (given)

If area of cross section of piston is A and it moves through distance x, then increment in volume of the gas $= Ax$

If force constant of a spring is k, then force $F = kx$ and pressure $= F/A = kx/A$

$$V_2 = V_1 + Ax = 2.4 \times 10^{-3} + 8 \times 10^{-3} \times 0.1$$
$$= 3.2 \times 10^{-3}$$

and $P_2 = P_0 + \frac{kx}{A} = 10^5 + \frac{8000 \times 0.1}{8 \times 10^{-3}} = 2 \times 10^5$

From ideal gas equation

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\Rightarrow \frac{10^5 \times 2.4 \times 10^{-3}}{300} = \frac{2 \times 10^5 \times 3.2 \times 10^{-3}}{T_2}$$

$\Rightarrow T_2 = 800$ K

13 **(b)**

$$v_{\mathrm{rms}} = \sqrt{\frac{3RT}{M}}$$

or $v_{\mathrm{rms}} \propto \sqrt{T}$

Since v_{rms} becomes half, so temperature is reduced to one-fourth of its previous value

$$\frac{T'}{T} = \frac{1}{4}$$

During adiabatic process,

$TV^{\gamma-1} = T'V'^{\gamma-1}$

or $\frac{V'}{V} = \left(\frac{T}{T'}\right)^{\frac{1}{\gamma-1}}$

$= (4)^{\frac{1}{1.5-1}} = 4^2 = 16$

$\therefore V' = 16V$

14 **(c)**

$$v_{av} = \sqrt{\frac{8RT}{\pi M}} \Rightarrow T \propto M \quad [\because v_{av}, R \rightarrow \text{constant}]$$

$$\Rightarrow \frac{T_{H_2}}{T_{O_2}} = \frac{M_{H_2}}{M_{O_2}} \Rightarrow \frac{T_{H_2}}{(273 + 31)} = \frac{2}{32}$$

$\Rightarrow T_{H_2} = 19\,K = -254$°C

15 **(a)**

At $T = 0K, v_{rms} = 0$

16 **(d)**

$$v_{rms} = \sqrt{\frac{3kT}{m}} = v_{rms} \propto \frac{1}{\sqrt{m}}$$

17 **(b)**

$$(C_P)_{mix} = \frac{\mu_1 C_{P_1} + \mu_2 C_{P_2}}{\mu_1 + \mu_2} (C_{P_1}(He)$$
$$= \frac{5}{2}R \text{ and } C_{P_2}(H_2) = \frac{7}{2}R)$$

$$= \frac{1 \times \frac{5}{2}R + 1 \times \frac{7}{2}R}{1 + 1} = 3R = 3 \times 2 = 6 cal/mol.{}^\circ\mathrm{C}$$

$\therefore$ Amount of heat needed to raise the temperature from 0°C to 100°C

$(\Delta Q)_P = \mu C_P \Delta T = 2 \times 6 \times 100 = 1200\, cal$

18 **(c)**

$$\rho = \frac{PM}{RT}$$

Density ρ remains constant when P/T or volume remains constant.

In graph (i) Pressure is increasing at constant temperature hence volume is decreasing so density is increasing. Graphs (ii) and (iii) volume is increasing hence, density is decreasing. Note that volume would had been constant in case the straight line the graph (iii) had passed through origin

19 **(a)**

$\because \theta_1 < \theta_2 \Rightarrow \tan\theta_1 < \tan\theta_2 \Rightarrow \left(\frac{V}{T}\right)_1 < \left(\frac{V}{T}\right)_2$

Form $PV = \mu RT; \frac{V}{T} \propto \frac{1}{P}$

Hence $\left(\frac{1}{P}\right)_1 < \left(\frac{1}{P}\right)_2 \Rightarrow P_1 > P_2$

21 **(b)**

$v_{rms} \propto \sqrt{T}$

22 **(d)**

$$\frac{3}{2}kT = 1\, eV \Rightarrow T = \frac{2}{3}\frac{eV}{k} = \frac{\frac{2}{3} \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23}}$$
$$= 7.7 \times 10^3 K$$

23 **(d)**

The value of $\frac{pV}{T}$ for one mole of an ideal gas

= gas constant

$= 2$ cal mol^{-1}K^{-1}

24 **(a)**

At constant pressure $(\Delta Q)_P = \mu C_P \Delta T = 1 \times C_P \times (30 - 20) = 40$

$\Rightarrow C_P = 4$ cal/mol – K

$\therefore C_v = C_p - R = 4 - 2 = 2$ cal/mol-K

Now $(\Delta Q)_v = \mu C_v \Delta T = 1 \times 2 \times (30 - 20) =$ 20 cal

25 **(b)**

For path abc:

$\Delta Q = \Delta U + \Delta W$
$\Rightarrow 84 = \Delta U + 32 \Rightarrow \Delta U = 52$ kJ
Hence $\Delta U_{abc} = \Delta U_{ab} = \Delta U_{adb} = 52$ kJ
For path adb:
$\Delta Q = \Delta U + \Delta W$
$= 52 + 10.5 = 62.5$ kJ
So option (a) is correct
For process ba, system will release the heat. So option (b) is wrong
For path ad:
$\Delta W_{adb} = \Delta W_{ad} + \Delta W_{db}$
$\Rightarrow 10.5 = \Delta W_{ad} + 0$
$\Rightarrow \Delta W_{ad} = 10.5$ kJ
$\Delta Q_{ad} = \Delta U_{ad} + \Delta W_{ad}$
$= (42 - 0) + 10.5$
$= 52.5$ kJ
So option (C) is correct
$\Delta Q_{adb} = 52 + 10.5 = 62.5$ kJ
$\Delta Q_{db} = \Delta Q_{adb} - \Delta Q_{ad}$
$= 62.5 - 52.5$
$= 10$ kJ
So option (d) is correct
Hence answer of these question is (b)

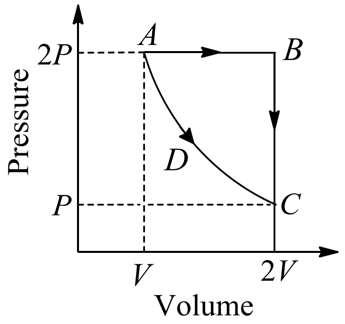
26 **(a)**
When gas is filled in a closed container, it exerts pressure on the walls of the vessel. According to kinetic theory this pressure is developed due to the collisions of the moving molecules on the walls of the vessels. Whenever a molecules collides with the wall, it return with changed momentum and an equal momentum is transferred to the wall. According to Newton's law of motion, the rate of change of momentum of the ball is equal to the force exerted on the wall. Since, the gas contains a large number of molecules which are colliding with the walls of the vessel, they exert a steady force on the walls. This force measured per unit area gives pressure, which is same as the molecules are moving in horizontal direction with constant acceleration.

27 **(c)**
Average translational kinetic energy of an ideal gas molecule is $3/2KT$ which depends on temperature only. Therefore if the temperature is same, translational kinetic energy of O_2 and N_2 both will be equal

28 **(b)**
According to Wien's law, $\lambda T =$ constant. From the graph
$\lambda_1 < \lambda_3 < \lambda_2$
$\therefore\ T_1 > T_3 > T_2$

29 **(c)**
$$V_{rms} = \sqrt{\frac{3P}{\rho}} \text{ or } P = \frac{\rho V_{rms}^2}{3}$$
$$= \frac{8.99 \times 10^{-2} \times 1840 \times 1840}{3} = 1.01 \times 10^5 N/m^2$$

30 **(c)**
$\Delta W_{ABC} = 2P(2V - V) = 2PV$
$\Delta W_{ADC} = nRT \text{ In } (2V/V)$
$= 2PV \text{ In } 2$



$\therefore$ The required factor will be
$$= \frac{2\ PV \text{ In } 2}{2PV} = \text{In}2$$

31 **(c)**
$$\left(\frac{\Delta Q}{\Delta t}\right)_{\text{inner}} + \left(\frac{\Delta Q}{\Delta t}\right)_{\text{outer}} = \left(\frac{\Delta Q}{\Delta t}\right)_{\text{total}}$$
$$\frac{K_1 \pi r^2 (T_2 - T_1)}{l} + \frac{K_2 \pi [(2r)^2 - r^2](T_2 - T_1)}{l}$$
$$= \frac{K\pi (2r)^2 (T_2 - T_1)}{l}$$
$$\text{or } (K_1 + 3K_2)\frac{\pi r^2 (T_2 - T_1)}{l} = \frac{K\pi\, 4\, r^2 (T_2 - T_1)}{l}$$
$$\therefore\ K = \frac{K_1 + 3K_2}{4}$$

32 **(a)**
Mayer Formula

33 **(a)**

Rate of cooling proportional to $(T^4 - T_0^4)$, as per Stefan's Law.

$$\therefore \quad \frac{R'}{R} = \frac{(900)^4 - (300)^4}{(600)^4 - (300)^4}$$

$$= \frac{9^4 - 3^4}{6^4 - 3^4} = \frac{3^4(3^4 - 1)}{3^4(2^4 - 1)}$$

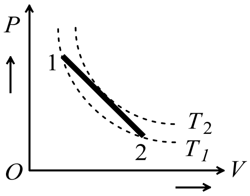
$$= \frac{80}{15} = \frac{16}{3}$$

$$R' = \frac{16}{3} R$$

34 **(d)**

Vander waal's equation is followed by real gases

35 **(c)**



Draw two isothermals one passing through points 1 and 2 the other through mid point of straight line joining 1 and 2

$T_2 > T_1$, at point 1 temperature is T_1 and that at mid point is T_2 and then at point 2 again it is T_1

$\therefore$ The gas is first heated and then cooled towards end

36 **(b)**

As the temperature increases, the average velocity increases. So the collisions are faster

37 **(a)**

The gases carbon monoxide (CO) and nitrogen (N_2) are diatomic, so both have equal kinetic energy $\frac{5}{2}kT, ie. E_1 = E_2$.

38 **(d)**

Mean kinetic energy of any ideal gas is given by $E = \frac{f}{2}RT$ which is different gases. (f is not same for all gases)

39 **(c)**

Pressure, $P = \frac{F}{A} = \frac{1}{A}.\frac{\Delta p}{\Delta t}$ [Δp = change in momentum]

40 **(a)**

$$V \propto T \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2} \Rightarrow \frac{200}{V_2} = \frac{(273 + 20)}{(273 - 20)} = \frac{293}{253}$$

$$\Rightarrow V_2 = \frac{200 \times 253}{293} = 172.6ml$$

41 **(c)**

The average kinetic energy of monoatomic gas molecule is $K = \frac{3}{2}k_BT$

Where k_B is the Boltzmann constant and T is the temperature of the gas in kelvin

$$K = \frac{3}{2} \times (1.38 \times 10^{-23} JK^{-1}) \times (300K)$$

$$= \frac{3 \times (1.38 \times 10^{-23} JK^{-1}) \times (300K)}{2 \times (1.6 \times 10^{-19} J/eV)}$$

$$= 3.9 \times 10^{-2} eV = 0.039eV$$

42 **(a)**

In elastic collision kinetic energy is conserved

44 **(b)**

Given that, $T = 27°\text{C} = 300\text{ K}$

$$v_{\text{rms}} = 1365\text{ ms}^{-1}$$

We know that

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$\text{or} \quad v_{rms}^2 = \frac{3RT}{M}$$

$$\text{or} \quad M = \frac{3RT}{v_{\text{rms}}^2}$$

$$\Rightarrow \quad M = \frac{3 \times 8.31 \times 300}{1365 \times 1365}\text{ kg}$$

$$= \frac{3 \times 8.31 \times 300}{1365 \times 1365} \times 1000\text{ g} = 4\text{ g}$$

The molecular weight of helium is 4.

45 **(a)**

$$\mu = \frac{\text{Mass of water}}{\text{Molecular wt. of water}} = \frac{4.5\text{kg}}{18 \times 10^{-3}\text{kg}} = 250$$

$T = 273\text{K}$ and $P = 10^5\text{N/m}^2$ (STP)

From $PV = \mu\, RT$,

$$\Rightarrow V = \frac{\mu RT}{P} = \frac{250 \times 8.3 \times 273}{10^5} = 5.66\text{ m}^3$$

46 **(c)**

According to Boyle's law

$$p_1V_1 = p_2V_2$$

As the pressure is decreased by 20%, so

$$p_2 = \frac{80}{100}p_1$$

$$p_1V_1 = \frac{80}{100}p_1V_2$$

$$V_1 = \frac{80}{100}V_2$$

Percentage increase in volume

$$= \frac{V_2 - V_1}{V_1} \times 100$$

$$= \frac{100-80}{80} \times 100 = 25\%$$

47 **(d)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow v_{rms} \propto \frac{1}{\sqrt{M}}$$

48 **(a)**

According to Gay Lussac's law $p \propto T$

$$\therefore \quad \frac{dp}{p} \times 100 = \frac{dT}{T} \times 100$$

$$1 = \frac{1}{T} \times 100$$

$\Rightarrow \qquad T = 100\text{ K}$

49 **(c)**

$$PV = \mu RT \Rightarrow \mu = \frac{PV}{RT} = \frac{21 \times 10^4 \times 83 \times 10^{-3}}{8.3 \times 300}$$
$$= 7$$

50 **(d)**

Average kinetic energy

$$E = \frac{3}{2}kT \Rightarrow \frac{E_1}{E_2} = \frac{T_1}{T_2} = \frac{(273 - 23)}{(273 + 227)} = \frac{250}{500} = \frac{1}{2}$$

$$\Rightarrow E_2 = 2E_1 = 2 \times 5 \times 10^{-14} = 10 \times 10^{-14} erg$$

51 **(a)**

Heat required

$$Q = (1.1 + 0.02) \times 10^3 \times 1 \times (80 - 15)$$
$$= 72800\text{ cal}$$

Let m gram of steam is condensed, then heat loss

$= m \times 540 + m \times 1 \times 20$

$= 560\text{ m}$

Heat loss = Heat gain

$\Rightarrow 560\text{ m} = 72800$

$\Rightarrow m = 130\text{ g} = 0.130\text{ kg}$

52 **(b)**

The collision of molecules of ideal gas is elastic collision

53 **(d)**

The difference of C_P and C_V is equal to R, not $2R$

54 **(d)**

$PV = nRT$

$$\Rightarrow PV = \frac{\omega}{M}RT$$

$$\frac{PM}{RT} = \frac{\omega}{V} = e$$

$$\Rightarrow e = \frac{PM}{RT} = \frac{P \times m \times N_A}{RT} = \frac{Pm}{\left(\frac{R}{N_A}\right)T} = \frac{Pm}{kT}$$

55 **(c)**

We know that V/T = constant

$$\frac{V + \Delta V}{T + \Delta T} = \frac{V}{T} \text{ or } VT + T\Delta V = VT + V\Delta T$$

or $T\Delta V = V\Delta T$ or $\frac{\Delta V}{V\Delta T} = \frac{1}{T}$

This is represented by graph (c)

56 **(c)**

The given equation is for 1 $g\ mol$ gas

57 **(d)**

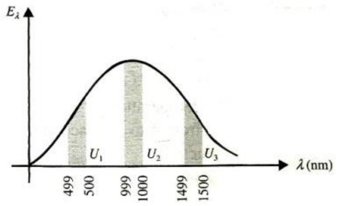
Wien's displacement law is

$\lambda_m T = b \quad$ (b =Wien's constant)

$$\lambda_m = \frac{b}{T} = \frac{2.88 \times 10^6\text{nm} - \text{K}}{2880\text{ K}}$$

$\lambda = 1000$ nm

Energy distribution with wavelength will be as follows:



From the graph it is clear that

$U_2 > U_1$ (in fact $U_2$is maximum)

58 **(a)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{(273 + 90)}{(273 + 27)}} = 1.1$$

% increase $= \left(\frac{v_2}{v_1} - 1\right) \times 100 = 0.1 \times 100 = 10\%$

59 **(b)**

Mean free path $\lambda \propto \frac{1}{P}$; If λ is doubled then P becomes half

60 **(c)**

Using pressure or Gay-Lussac's law $\frac{P_1}{P_2} = \frac{T_1}{T_2}$

or $P_2 = \frac{P_1 T_2}{T_1} = \frac{P(273+927)}{(273+27)} = 4P$

61 **(c)**

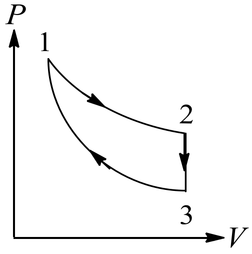
C_p is always greater than C_V

$ie, \qquad C_P > C_V$

63 **(d)**

Work done on the system is negative

For the process 1 → 2



Process	ΔQ	ΔW	ΔU
1 – 2			
2 – 3			−20 J
3 – 1		−20 J	
Cycle		10 J	

$\Delta U_{1\to 2} = 0$

$\therefore \Delta Q_{1\to 2} = \Delta W_{12}$

For the process 2 → 3

$\Delta W_{2\to 3} = 0$

$\Delta Q_{2\to 3} = -20\text{ J}$

For the process 3 → 1

$\Delta Q_{3\to 1} = 20\text{ J}$

$\Delta U = \Delta U_{1\to 2} + \Delta U_{2\to 3} + \Delta U_{3\to 1} = 0$

$\Delta W = \Delta W_{1\to 2} + \Delta W_{2\to 3} + \Delta W_{3\to 1}$

$= \Delta W_{1+2} + 0 - 20\text{ J} = 10\text{ J}$

Work done in the process 1 → 2 = 30 J

$$\Delta Q = \Delta Q_{1\to 2} + \Delta Q_{2\to 3} + \Delta Q_{3\to 1} = 30\text{ J} - 20\text{ J}$$
$$= 10\text{ J}$$

For the process $1 \rightarrow 2$, work is positive, i.e., work is done by the system

64 **(a)**

Ratio of specific heat for a monoatomic gas is $\frac{5}{3}$ and for diatomic gas is $\frac{7}{5}$.

Given, $n_1 = 1, n_2 = 3, n = 4$

$$\therefore \quad \frac{n}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

$$\frac{4}{\gamma - 1} = \frac{1}{\frac{5}{3} - 1} + \frac{3}{\frac{7}{5} - 1}$$

$$\Rightarrow \quad \frac{4}{\gamma - 1} = \frac{3}{2} + \frac{15}{2} = 9$$

$$\therefore \quad 4 = 9\gamma - 9$$

$$\Rightarrow \quad 9\gamma = 13 \quad \Rightarrow \gamma = \frac{13}{9}$$

Now, $\quad C_V(\gamma - 1) = R$

or $\quad C_V = \frac{R}{\gamma - 1} = \frac{8.3}{\frac{13}{9} - 1} = \frac{8.3 \times 9}{4}$

$$\Rightarrow \quad C_V = 18.7 \text{ J mol}^{-1} - \text{K}^{-1}$$

66 **(b)**

$P_1 = 720 kPa, T_1 = 40°\text{C} = 273 + 40 = 313K$

$$P \propto mT \Rightarrow \frac{P_2}{P_1} = \frac{m_2}{m_1}\frac{T_2}{T_1} = \frac{3}{4} \times \frac{626}{313} = 1.5$$

$\Rightarrow P_2 = 1.5P_1 = 1.5 \times 720 = 1080 kPa$

67 **(b)**

Since $P - V$ graph of the process is a straight line and two point $(V_0 . 2P_0)$ and $(2V_0, P_0)$ are known, its equation will be

$$(P - P_0) = \frac{(2P_0 - P_0)}{(V_0 - 2V_0)}(V - 2V_0) = \frac{P_0}{V_0}(2V_0 - V)$$

$$\therefore P = 3P_0 - \frac{P_0 V}{V_0}$$

According to equation for ideal gas

$$T = \frac{pV}{nR}$$

$$= \left(3P_0 - \frac{P_0 V}{V_0}\right)\frac{V}{nR}$$

$$= \frac{3P_0 V_0 V - P_0 V^2}{nRV_0} \quad \text{(i)}$$

For T to be maximum, $\frac{dT}{dV} = 0$

$3P_0 V_0 - 2P_0 V = 0$

or $V = \frac{3V_0}{2} \quad$ (ii)

Putting this value in Eq.(i), we get

$$T_{\max} = \frac{3P_0 V_0\left(\frac{3V_0}{2}\right) - P_0\left(\frac{9}{4}V_0^2\right)}{nRV_0} = \frac{9P_0 V_0}{4nR}$$

68 **(c)**

At constant temperature; $PV =$ constant

$\Rightarrow P \times \left(\frac{m}{D}\right) =$ constant

$\Rightarrow \frac{P}{D} = \text{constant} = K.$ $[D = \text{Density}]$

69 **(c)**

$$(\Delta Q)_P = \mu C_p \Delta T = \mu\left(\frac{\gamma}{\gamma - 1}\right)R\Delta T$$

$$\therefore (\Delta Q)_p = 5 \times \left(\frac{\frac{7}{5}}{\frac{7}{5} - 1}\right) \times 2 \times 30$$

$$= 5 \times 2 \times \frac{7}{5} \times \frac{5}{2} \times 30 = 1050 \text{ cal}$$

(as $\mu = 5$ mol and $\gamma = 7/5$ for H_2)

70 **(b)**

At critical temperature the horizontal portion in $P - V$ curve almost vanishes as at temperature T_2. Hence the correct answer will be (b)

71 **(b)**

Work done, $W = \int_{v_1}^{v_2} \alpha V^2 dV$

where $\alpha = 3 \times 10^5 \text{Pa/m}^6$

$$\Rightarrow W = \left[\frac{\alpha V^3}{3}\right]_{V_1 = 1\text{m}^3}^{V_2 = 2\text{m}^3} = \left[\frac{3 \times 10^5 V^3}{3}\right]_{V_1}^{V_2}$$

$\Rightarrow W = 10^5(V_2^3 - V_1^3)$

$V_1 = 1\text{m}^3 V_2 = 2 \text{ m}^3$

$W = 10^5(8 - 1) = 7 \times 10^5$ J

72 **(d)**

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\% \text{ increase in } V_{rms} = \frac{\sqrt{\frac{3RT_2}{M}} - \sqrt{\frac{3RT_1}{M}}}{\sqrt{\frac{3RT_1}{M}}} \times 100\%$$

$$= \frac{20 - 17.32}{17.32} \times 100 = 15.5\%$$

73 **(b)**

$$\frac{E_1}{E_2} = \frac{A_1}{A_2} . \left(\frac{T_1}{T_2}\right)^4 = \frac{4\pi r_1^2}{4\pi r_2^2} \times 1 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

74 **(c)**

$C_p - C_v =$ m, for hydrogen $(M_1 = 2)$

$C_p - C_v =$ n, for nitrogen $(M_2 = 14)$

For hydrogen, $C_p - C_v = \frac{1}{M_1}\frac{dQ}{dT} = m$

For nitrogen, $C_p - C_v = \frac{1}{M_2}\frac{dQ}{dT} = n$

$$\therefore \frac{m}{n} = \frac{\frac{1}{M_1}\frac{dQ}{dT}}{\frac{1}{M_2}\frac{dQ}{dT}} = \frac{M_2}{M_1} = \frac{14}{2} = 7$$

$\therefore m = 7n$

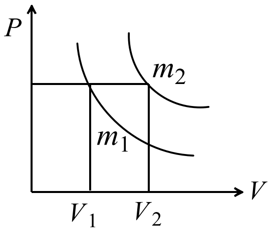
75 **(a)**

$$\frac{\Delta W}{\Delta Q} = \frac{\Delta Q - \Delta U}{\Delta Q}$$

$$= \frac{C_p - C_v}{C_p} = 1 - \frac{1}{\gamma} = 1 - \frac{1}{1 - \frac{5}{3}} = \frac{2}{5}$$

i.e., percentage energy utilized in doing external work $= \frac{2}{5} \times 100 = 40\%$

76 **(c)**



$PV = \mu RT = \dfrac{m}{M} RT$

For 1st graph,

$P = \frac{m_1}{M}\frac{RT}{V_1}$ ...(i)

For 2nd graph,

$P = \frac{m_2}{M}\frac{RT}{V_2}$ ...(ii)

Equating the two, we get, $\frac{m_1}{m_2} = \frac{V_1}{V_2} \Rightarrow m \propto V$

As $V_2 > V_1 \Rightarrow m_1 < m_2$

77 **(b)**

$$V_t = V_0(1 + \alpha t) = 0.5\left(1 + \frac{1}{273} \times 819\right) = 2\ litre$$
$$= 2 \times 10^{-3} m^3$$

78 **(c)**

$$E_{av} = \frac{f}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 273$$
$$= 0.56 \times 10^{-20} J$$

79 **(b)**

At $x = \infty, C = \frac{3}{2}R$

From $PV^x =$ constant

$\Rightarrow P^{1/x}V =$another constant

So at $x = \infty, V =$constant

hence $C = C_v = \frac{3}{2}R$

and then $C_p = C_v + R = \frac{5}{2}R$

at $x = 0, P =$constant and $C = C'$

hence $C' = C_p = \frac{5}{2}R$

at $x = x', C = 0$, so the process is adiabatic, hence

$x' = \dfrac{C_p}{C_v} = \dfrac{5}{3}$

80 **(b)**

Let the initial pressure as of the three samples be P_A, P_B and P_C, then

$P_A(V)^{3/2} = (2V)^{3/2}P (\because P_B = P)$

or $P_A = P(2)^{3/2}$

$P_C(V) = P(2V)$

or $P_C = 2P$

$P_A : P : P_C$

$= (2)^{3/2} : 1 : 2 = 2\sqrt{2} : 1 : 2$

81 **(a)**

As $\rho - \rho_0(1 - \gamma\Delta T)$

$\therefore\ 9.7 = 10(1 - \gamma \times 100)$

$\dfrac{9.7}{10} = 1 - \gamma \times 100$

$\gamma \times 100 = 1 - \dfrac{9.7}{10} = \dfrac{0.3}{10} = 3 \times 10^{-2}$

$\gamma = 3 \times 10^{-4}\ \therefore\ \alpha = \dfrac{1}{3}\gamma = 10^{-4}{}^\circ C^{-1}$.

82 **(a)**

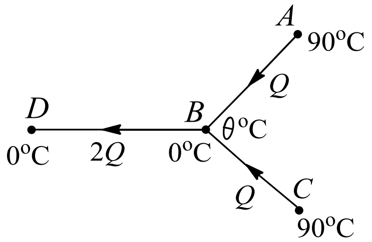
$PV = \mu RT \Rightarrow PV \propto T$

If P and V are doubled then T becomes four times, $i.e.$,

$T_2 = 4T_1 = 4 \times 100 = 400K$

83 **(b)**

Let θ°C be the temperature at B. Let Q be the heat flowing per second from A to B on account of temperature difference by conductivity



$\therefore\ Q = \dfrac{KA(90 - \theta)}{l}$ (i)

Where $k =$ thermal conductivity of the rod, $A =$ Area of cross section of the rod, $l =$ length of the rod. By symmetry, the same will be the case for heat flow from C to B

$\therefore$ The heat flowing per second from B to D will be

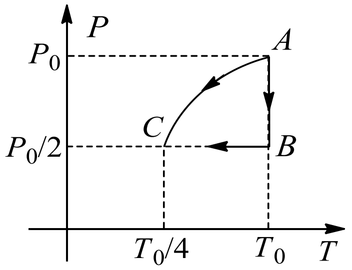
$2Q = \dfrac{KA(\theta - 0)}{l}$ (ii)

Dividing Eq. (ii) by Eq. (i)

$2 = \dfrac{\theta}{90 - \theta} \Rightarrow \theta = 60°C$

85 **(c)**

Process AB is isothermal expansion, BC is isobaric compression and in process CA



$P \propto \dfrac{nRT}{P} \Rightarrow P^2 \propto T$

86 **(c)**

$\Delta Q = \Delta U$

$$= \mu C_v \Delta T = \mu\left(\frac{R}{\gamma - 1}\right)\Delta T = 2 \times \frac{R}{\frac{5}{3} - 1}[373 - 273]$$
$$= 300R$$

(as for monatomic gas $\gamma = 5/3$)

87 **(c)**

Energy spent in overcoming inter-molecular forces, $\Delta U = \Delta Q - \Delta W$

$= \Delta Q - P(V_2 - V_1)$

$$= 540 - \frac{1.013 \times 10^5 (1671 - 1) \times 10^{-6}}{4.2}$$

≈ 500 cal

88 **(b)**

Ideal gas equation for m garms of gas is

$PV = mrT$ (where r =specific gas constant)

or $P = \frac{m}{V} rT = \rho rT$

$$\Rightarrow r = \frac{P}{\rho T} = \frac{1.013 \times 10^5}{0.795 \times 273} = 466.7$$

Specific heat at constant volume

$c_V = \frac{r}{\gamma - 1} = \frac{466.7}{\frac{4}{3} - 1} = 1400$ J/kg-K

(γ =4/3 for polyatomic gas)

89 **(c)**

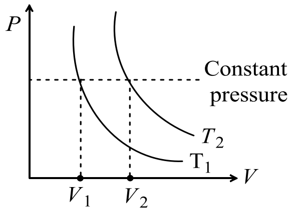
Kinetic energy ∝ Temperature

90 **(c)**

$$\frac{R}{C_P} = \frac{R}{7/2R} = \frac{2}{7} \quad \left[\because C_P = \frac{7}{2}R\right]$$

91 **(c)**

For a given pressure, volume will be more if temperature is more [Charle's law]



From the graph it is clear that $V_2 > V_1 \Rightarrow T_2 > T_1$

92 **(c)**

In Vander Waal's equation $\left(P + \frac{a}{V_2}\right)(V - b) = RT$

a represents intermolecular attractive force and b represents volume correction

94 **(d)**

$n_1 C_v \Delta T_1 = n_2 C_v \Delta T_2$

$10 \times (T - 10) = 20(20 - T)$

$T - 10 = 40 - 2T$

$3T = 50 \Rightarrow T = 16.6°\text{C}$

95 **(c)**

Along path AB

$\Delta Q = \Delta U + \Delta W = U_B - U_A + \Delta W$

or $-50 = U_B - U_A = U_B - 1500$

or $U_B = 1450$ J

Along path BC

or $\Delta Q = U_C - U_B + \Delta W$

or $0 = U_C - U_B + \Delta W = U_C - U_B + (-40)$

or $0 = U_C - 1450 - 40$ or $U_C = 1490$ J

96 **(a)**

$$v_{average} = \sqrt{\frac{8RT}{\pi M}} \Rightarrow v_{av} \propto \sqrt{T}$$

97 **(c)**

For an adiabatic process,

PV^γ = constant

$TV^{\gamma-1}$=constant

and $T^\gamma P^{1-\gamma}$ =constant

Putting, γ=5/3 (argon being a monatomic gas), the equation become:

$PV^{5/3}$ =constant

$TV^{-2/3}$=constant

$T^{5/3}P^{-2/3}$= constant ⇒ $TP^{-2/5}$ =constant

98 **(d)**

$1 \to 2$: isothermal, $\Delta U_{12} = 0$

$2 \to 3$: isochoric, $\Delta W = 0$

$\Rightarrow \Delta Q_{23} = \Delta U_{23} \Rightarrow -40 = \Delta U_{23}$

For a cyclic process, $\Delta U = 0$

$\Delta U_{12} + \Delta U_{23} + \Delta U_{31} = 0$

$0 + (-40) + \Delta U_{31} = 0$

$0 + (-40) + \Delta U_{31} = 0$

$\Delta U_{31} = +40$ J

99 **(a)**

$A \to B$ is an isobaric process,

$V \propto T$

So, $\Delta W_{AB} = nR\Delta T = 2 \times R \times (750 - 250) = 1000R$

$B \to C$ is an isochoric process

$\therefore \Delta W_{BC} = 0$ and

$C \to D$ is an isothermal process

$$\Delta W_{CD} = nRT \text{ In}\left(\frac{V_f}{V_i}\right)$$

$$= 2 \times R \times 1000 \text{ In}\left(\frac{20}{15}\right) = 2000R \text{ In}\left(\frac{4}{3}\right)$$

Total work done, $\Delta W = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CD}$

100 **(a)**

K.E. is function of temperature. So $\frac{E_{H_2}}{E_{O_2}} = \frac{1}{1}$

101 **(c)**

$\mu_1 = 1, \gamma_1 = 5/3$ (for monatomic gas) and

$\mu_2 = 2, \gamma_2 = 7/5$ (for diatomic gas)

From formula

$$\gamma_{\text{mixture}} = \frac{\frac{\mu_1\gamma_1}{\gamma_1 - 1} + \frac{\mu_2\gamma_2}{\gamma_2 - 1}}{\frac{\mu_1}{\gamma_1 - 1} + \frac{\mu_2}{\gamma_2 - 1}}$$

$$= \frac{\frac{1\times\frac{5}{3}}{\frac{5}{3}-1} + \frac{2\times\frac{7}{5}}{\frac{7}{5}-1}}{\frac{1}{\frac{5}{3}-1} + \frac{2}{\frac{7}{5}-1}} = \frac{\frac{5}{2} + 7}{\frac{3}{2} + 5} = \frac{19}{13}$$

102 **(b)**

$\gamma_1 = 5/3$ means gas is monatomic or $C_{V_1} = \frac{3}{2}R$

$\gamma_2 = 7/5$ means gas is diatomic or $C_{V_2} = 5/2R$

C_V (of the mixture)

$$= \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2} = \frac{(1)\left(\frac{3}{2}R\right) + (1)\left(\frac{5}{2}\right)R}{1+1} = 2R$$

C_P(of the mixture) $= C_V + R = 3R$

$$\gamma_{\text{mixture}} = \frac{C_P}{C_V} = \frac{3R}{2R} = 1.5$$

103 **(b)**

In a given mass of the gas

$$n = \frac{pV}{kT}$$

k being Boltzmann's constant.

104 **(a)**

Work done by the gas at constant pressure

$\Delta W = P\Delta V$

$= (1 \times 10^5 \text{Nm}^{-2})(1000 - 800) \times 10^{-6}\text{m}^3 = 20 \text{ J}$

$\Delta U = \Delta Q - \Delta W$

$\Delta U = 100 \text{ J} - 20 \text{ J} = 80 \text{ J}$

105 **(d)**

$M_1 = M, T_1 = 60 + 273 = 333\text{K}$

$$M_2 = M - \frac{M}{4} = \frac{3M}{4}$$

(as 1/4th part of air escapes)

If pressure and volume of the gas remain constant, then MT=constant

$$\therefore \frac{T_2}{T_1} = \frac{M_1}{M_2} = \left(\frac{M}{3M/4}\right) = \frac{4}{3}$$

$$\Rightarrow T_2 = \frac{4}{3} \times T_1 = \frac{4}{3} \times 333 = 444 \text{ K} = 171°\text{C}$$

106 **(a)**

As degree of freedom is defined as the number of independent variables required to define body's motion completely. Here $f = 2$ (1 Translational + 1 Rotational)

107 **(c)**

Ideal gas equation is given by

$$pV = nRT$$

...(i)

For oxygen, $p = 1$ atm, $V = 1$ L, $n = n_{O_2}$

Therefore, Eq. (i) becomes

$\therefore \quad 1 \times 1 = n_{O_2}RT$

$$\Rightarrow \quad n_{O_2} = \frac{1}{RT}$$

For nitrogen p =0.5 atm, V =2 L, $n = n_N$

$\therefore \quad 0.5 \times 2 = n_{N_2}RT$

$$\Rightarrow \quad n_{N_2} = \frac{1}{RT}$$

For mixture of gas

$$p_{\text{mix}}V_{\text{mix}} = n_{\text{mix}}RT$$

Here, $\quad n_{\text{mix}} = n_{O_2} + n_{N_2}$

$$\therefore \quad \frac{p_{\text{mix}}V_{\text{mix}}}{RT} = \frac{1}{RT} + \frac{1}{RT}$$

$\Rightarrow \quad p_{\text{mix}}V_{\text{mix}} = 2 \qquad (V_{\text{mix}} =$
$1)$

108 **(b)**

$$C_v = \frac{3\text{R}}{2}\text{J/mol K} = \frac{3R}{2M}\text{ J/kg K}$$

$$= \frac{3R}{2M \times 4.2}\text{cal/kg K} = 0.075 \text{ kcal/kg K}$$

Molecular weight of argon atom

$$M = \frac{3R}{2M \times 4.2 \times 0.075 \times 10^3}$$

$$= \frac{3 \times \frac{25}{3}}{2 \times 4.2 \times 75} = 40 \times 10^{-3} \text{ kg}$$

109 **(c)**

According to Boyle's law

$(P_1V_1)_{\text{At top of the lake}} = (P_2V_2)_{\text{At the bottom of the lake}}$

$$\Rightarrow P_1V_1 = (P_1 + h)V_2 \Rightarrow 10 \times \frac{4}{3}\pi\left(\frac{5r}{4}\right)^3$$

$$\Rightarrow (10 + h) \times \frac{4}{3}\pi r^3 \Rightarrow h = \frac{610}{64} = 9.53m$$

110 **(d)**

Total pressure (P) of gas = Actual pressure of gas P_a + aqueous vapour pressure (P_V)

$\Rightarrow P_a = P - P_V = 735 - 23.8 = 711.2mm$

111 **(d)**

Suppose there are n_1 moles of hydrogen and $n_2$moles of helium in the given mixture. Then the pressure of the mixture will be

$$P = \frac{n_1RT}{V} + \frac{n_2RT}{V} = (n_1 + n_2)\frac{RT}{V}$$

$$2 \times 101.3 \times 10^3 = (n_1 + n_2)\frac{(8.3)(300)}{20 \times 10^{-3}}$$

$$(n_1 + n_2) = \frac{2 \times 101.3 \times 10^3 \times 20 \times 10^{-3}}{(8.3)(300)} = 1.62$$

The mass of the mixture is (in grams):

$n_1 \times 2 + n_2 \times 4 = 5$

$(n_1 + 2n_2) = 2.5$

Solving Eqs.(i) and (ii), $n_1 = 0.74, n_2 = 0.88$

Hence $\frac{m_{\text{H}}}{m_{\text{He}}} = \frac{0.74 \times 2}{0.88 \times 4} = \frac{1.48}{3.52} \rightarrow 2:5$

112 **(d)**

The energy radiated per second by a black body is given by Stefan's law,

$$\frac{E}{t} = \sigma T^4 \times A$$

Where A is the surface of the black body

$$\frac{E}{t} = \sigma T^4 \times 4\pi r^2$$

Since black body is a sphere, $A = 4\pi r^2$

$\boldsymbol{Case\ (i)}$

$\frac{E}{t} = 450, T = 500K,\ \ r = 0.12\text{m},$

$\therefore 450 = 4\pi\sigma(500)^4(0.12)^2$ (i)

$\boldsymbol{Case\ (ii)}$

$\frac{E}{t} = ?, T = 1000\text{K}, r = 0.06\text{m}$ (ii)

Dividing Eq. (ii) by Eq. (i), we get

$$\frac{E/t}{450} = \frac{(1000)^4(0.06)^2}{(500)^4(0.12)^2} = \frac{2^4}{2^2} = 4$$

$$\Rightarrow \frac{E}{t} = 450 \times 4 = 1800\text{ W}$$

113 **(d)**

As we know 1 mol of any ideal gas at STP occupies a volume of 22.4 $litres$.

Hence number of moles of gas $\mu = \frac{44.8}{22.4} = 2$

Since the volume of cylinder is fixed,

Hence $(\Delta Q)_V = \mu C_V\,\Delta T$

$= 2 \times \frac{3}{2}R \times 10 = 30R\ \left[\because (C_V)_{mono} = \frac{3}{2}R\right]$

114 **(b)**

The ideal gas law is the equation of state of an ideal gas. The state of an amount of gas is determined by its pressure, volume and temperature. The equation has the form

$$pV = nRT$$

where, p is pressure, V the volume, n the number of moles, R the gas constant and T the temperature.

$$\therefore \quad \frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

Given, $p_1 = 200\text{ kPa}, V_1 = V, T_1 = 273 + 22 = 295\text{ K}, V_2 = V + 0.02\,V$

$$T_2 = 273 + 42 = 315\text{ K}$$

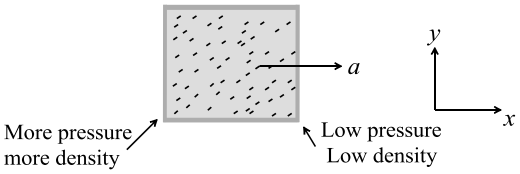
$$\frac{200\times V}{295} = \frac{p_2\times 1.02V}{315}$$

$$\Rightarrow \quad p_2 = \frac{200 \times 315}{295 \times 1.02}$$

$$p_2 = 209\text{ kPa}$$

115 **(b)**

Pressure will be less in front portion of the compartment because in accelerated frame molecules will feel pseudo force in backward direction. Also density of gas will be more in the back portion



116 **(b)**

An ideal gas is a gas which satisfying the assumptions of the kinetic energy.

117 **(b)**

Average speed or mean speed of gas molecules

$$\bar{v} = \sqrt{\frac{8RT}{\pi M}} \quad \text{or} \quad \bar{v} \propto \frac{1}{\sqrt{M}}$$

or $\quad \frac{\bar{v}_{\text{H}}}{\bar{v}_{\text{He}}} = \sqrt{\frac{M_{\text{He}}}{M_{\text{H}}}}$

Here, $\quad M_{\text{He}} = 4\,M_{\text{H}}$

$$\therefore \quad \frac{\bar{v}_{\text{H}}}{\bar{v}_{\text{He}}} = \sqrt{\frac{4}{1}} = 2 \quad \text{or} \quad \bar{v}_{\text{He}} = \frac{1}{2}\bar{v}_{\text{H}}$$

118 **(c)**

A diatomic molecule has three translational and two rotational degrees of freedom

Hence total degrees of freedom $f = 3 + 2 = 5$

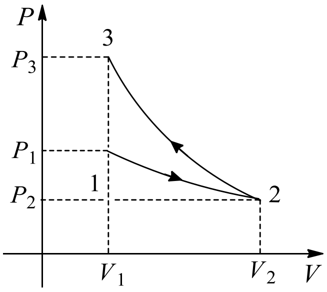
120 **(b)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.3 \times 300}{28 \times 10^{-3}}} = 517m/s$$

121 **(c)**

The two processes are shown in the following $P - V$

Diagram:



For isothermal process:

$P_1V_1 = P_2V_2$

i.e., $P_1 = \left(\frac{V_2}{V_1}\right)P_2$

For adiabatic process:

$P_3V_1^\gamma = P_2V_2^\gamma$

i.e., $P_3 = \left(\frac{V_2}{V_1}\right)^\gamma P_2$

As $\gamma > 1$, hence $P_3 > P_1$

Further, as slope of adiabatic is greater than that of isothermal process curve, adiabatic curve will lie above the isothermal curve. That is, area under adiabatic curve > area under isothermal curve

i.e., Negative work > Positive work

i.e., $W < 0$

122 **(d)**

From Maxwell's velocity distribution law, we infer that

$$v_{\text{rms}} > v > v_{\text{mp}}$$

ie, most probable velocity is less than the root mean square velocity.

123 **(a)**

According to ideal gas equation

$PV = nRT$ or $\frac{V}{T} = \frac{nR}{P}$

At constant pressure

$\frac{V}{T} =$ constant

Hence graph (a) is correct

124 **(c)**

$$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{v_{O_2}}{v_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} \Rightarrow \frac{C}{v_{H_2}} = \sqrt{\frac{2}{32}} = \frac{1}{4}$$

$\Rightarrow v_{H_2} = 4C\ cm/s$

125 **(d)**

Vander Waal's gas constant $b = 4 \times$ total volume of all the molecules of the gas in the enclosure

Or $b = 4 \times N \times \frac{4}{3}\pi\left(\frac{d}{2}\right)^3 = \frac{2}{3}\pi N d^3$

$$= \frac{2}{3} \times 3.14 \times 6.02 \times 10^{23} \times (2.94 \times 10^{-10})^3$$

$$= 32 \times 10^{-6}\frac{m^3}{mol}$$

126 **(a)**

As $V \propto T$

$\therefore \frac{V_2}{V_1} = \frac{T_2}{T_1}$

$\Rightarrow V_2 = \left(\frac{313}{293}\right)V_1$

Friction of gas that comes out

$$= \frac{V_2 - V_1}{V_1} = \frac{\left(\frac{313}{293}\right)V_1 - V_1}{V_1} = \frac{20}{293} = 0.07$$

127 **(b)**

$$V_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow \frac{(V_{rms})_{O_2}}{(V_{rms})_{H_2}} = \sqrt{\frac{T_{O_2}}{T_{H_2}} \times \frac{M_{H_2}}{M_{O_2}}}$$

$$\Rightarrow \frac{(V_{rms})_{O_2}}{(V_{rms})_{H_2}} = \sqrt{\frac{900}{300} \times \frac{2}{32}} = \frac{\sqrt{3}}{4}$$

$\Rightarrow (v_{rms})_{O_2} = 836 m/s$

128 **(a)**

The rms velocity of an ideal gas is

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

Where T is the absolute temperature and M is the molar mass of an ideal gas

Since M remains the same

$\therefore v_{rms} \propto \sqrt{T}$

$$\frac{v'_{rms}}{v_{rms}} = \sqrt{\frac{T'}{T}} = \sqrt{\frac{3T}{T}}$$

$\Rightarrow v'rms = \sqrt{3}v_{rms}$

129 **(a)**

Work done= area enclosed by triangle ABC

$$= \frac{1}{2}AC \times BC = \frac{1}{2} \times (3V - V) \times (3P - P) = 2PV$$

130 **(a)**

$PV = \mu RT \Rightarrow P \propto \frac{T}{V}$. If T and V both doubled then pressure remains same, $i.e., P_2 = P_1 = 1\ atm = 1 \times 10^5 N/m^2$

131 **(a)**

Average kinetic theory of one molecule is

$$E = \frac{3}{2}kT$$

where k is Boltzmann constant and T the absolute temperature.

Given, $T_1 = -68°\text{C} = 273 - 68 = 205\ \text{K}$,

$E_1 = E, \quad E_2 = 2E$

$\therefore \quad \frac{E_1}{E_2} = \frac{T_1}{T_2}$

$\Rightarrow \quad T_2 = \frac{T_1 E_2}{E_1}$

$\therefore \quad T_2 = \frac{205 \times 2E}{E} = 410\ \text{K}$

132 **(a)**

From Boyle's law

$$pV = \text{constant}$$

$\therefore \quad p_1 V_1 = p_2 V_2$

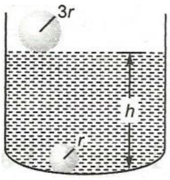
Here, $p_1 = (h + l),\ V_1 = \frac{4}{3}\pi r^3$

$p_2 = l,\ V_2 = \frac{4}{3}\pi(3r)^3$

$\therefore \quad (h + l)\frac{4}{3}\pi r^3 = l \times \frac{4}{3}\pi(3r)^3$

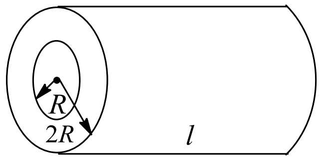
or $\quad h + l = 27l$

$\therefore \quad h = 26l$



133 **(c)**

Let R_1 and R_2 be the thermal resistances of inner and outer portions. Since temperature difference at both ends is same, the resistances are in parallel. Hence,



$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{K(4\pi R^2)}{l} = \frac{K_1(\pi R^2)}{l} + \frac{K_2(3\pi R^2)}{l} \Rightarrow K$$

$$= \frac{3K_2 + K_1}{4}$$

134 **(d)**

$$PV = NkT \Rightarrow \frac{N_A}{N_B} = \frac{P_A V_A}{P_B V_B} \times \frac{T_B}{T_A}$$

$$\Rightarrow \frac{N_A}{N_B} = \frac{P \times V \times (2T)}{2P \times \frac{V}{4} \times T} = \frac{4}{1}$$

135 **(b)**

For an isothermal process, $PV =$ constant and for the given process

$PV^2 =$constant

Therefore the gas is cooled because volume expands by a greater exponent than in an isothermal process

136 **(c)**

Kinetic energy of ideal gas depends only on its temperature. Hence, it remains constant whether its pressure is increased or decreased.

137 **(d)**

Kinetic energy is function of temperature

138 **(d)**

Let initial conditions $= V, T$

And final conditions $= V', T'$

By Charle's law $V \propto T$ [P remains constant]

$$\frac{V}{T} = \frac{V'}{T'} \Rightarrow \frac{V}{T} = \frac{V'}{1.2T'} \Rightarrow V' = 1.2V$$

But as per question, volume is reduced by 10% means

$V' = 0.9V$

So percentage of volume leaked out

$$= \frac{(1.2 - 0.9)V}{1.2V} \times 100 = 25\%$$

139 **(a)**

By Dalton's law

$$P = P_1 + P_2 + P_3 = \frac{\mu_1 RT}{V} + \frac{\mu_2 RT}{V} + \frac{\mu_3 RT}{V}$$

$$= \frac{RT}{V}[\mu_1 + \mu_2 + \mu_3] = \frac{RT}{V}\left[\frac{m_1}{M_1} + \frac{m_2}{M_2} + \frac{m_3}{M_3}\right]$$

$$= \frac{8.31 \times 300}{3 \times 10^{-3}}\left[\frac{6}{32} + \frac{8}{28} + \frac{5}{44}\right]$$

$$= 498 \times 10^3 = 500 \times 10^3 = 5 \times 10^5 \mathrm{N/m^2}$$

140 **(d)**

The formula for average kinetic energy is

$$\overline{(KE)} = \frac{3}{2}KT$$

$$\therefore \frac{\overline{(KE)}_{600\mathrm{K}}}{\overline{(KE)}_{300\mathrm{K}}} = \frac{600}{300}$$

$$\Rightarrow \overline{(KE)}_{600\mathrm{K}} = 2 \times 6.21 \times 10^{-21}\mathrm{J}$$

$$= 12.42 \times 10^{-21}\mathrm{J}$$

Also the formula for rms velocity is

$$C_{\mathrm{rms}} = \sqrt{\frac{3KT}{m}}$$

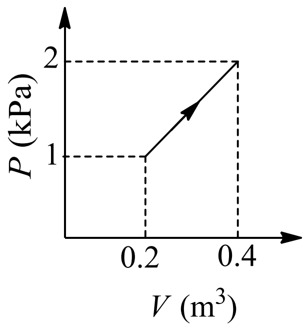
$$\therefore \frac{(C_{\mathrm{rms}})_{600\mathrm{K}}}{(C_{\mathrm{rms}})_{300\mathrm{K}}} = \sqrt{\frac{600}{300}}$$

$$\Rightarrow (C_{\mathrm{rms}})_{600\mathrm{K}} = \sqrt{2} \times 484 = 684 \mathrm{~m/s}$$

141 **(c)**

$$\Delta W = \frac{1}{2}(1+2) \times 10^3 \frac{\mathrm{N}}{\mathrm{m}^2} \times (0.4 - 0.2)\mathrm{m}^3 = 300\mathrm{J}$$

$$\Delta U = nC_v\Delta T = \frac{(P_2V_2 - P_1V_1)}{\gamma - 1}$$



$$= (3/2)(0.4 \times 2 - 0.2 \times 1) \times 103 \text{ J} = 900 \text{ J}$$

$$\Delta Q = \Delta W + \Delta U = 1200 \text{ J}$$

142 **(d)**

Total internal energy of system

$$U_{\mathrm{oxygen}} + U_{\mathrm{argon}} = \mu_1 \frac{f_1}{2}RT + \mu_2 \frac{f_2}{2}RT$$

$$= 2\frac{5}{2}RT + 4\frac{3}{2}RT = 5RT + 6RT = 11RT$$

(As $f_2 = 5$(for oxygen) and $f_2 = 3$(for argon))

143 **(b)**

Since PV^n =constant and also $PV = RT$, taking 1 mol of the gas for simplicity, $dU = C_v dT$

Where $C_v \rightarrow$molar specific heat at constant volume

Now the molar specific heat in a polytropic process PV^n =constant is given by

$$C_V = \left(\frac{R}{\gamma-1}\right) - \left(\frac{R}{n-1}\right) = \frac{(n-\gamma)R}{(n-1)(\gamma-1)} \quad \text{(i)}$$

From this equation we see that C_v will be negative when $n < y$ and $n > 1$, simultaneously, i.e., $1 < n < \gamma$. Since γ for all ideal gases is greater than 1, if $n > \gamma$ or $n < 1$, then C_v will be positive

144 **(d)**

From Dalton's law, final pressure of the mixture of nitrogen and oxygen is

$P = P_1 + P_2$

$= \frac{\mu_1 RT}{V} + \frac{\mu_2 RT}{V} = \frac{m_1}{M_1}\frac{RT}{V} + \frac{m_2}{M_2}\frac{RT}{V}$

$= \frac{8}{32}\frac{RT}{V} + \frac{7}{28}\frac{RT}{V} = \frac{RT}{2V} \Rightarrow 10 = \frac{RT}{2V}$ (i)

When oxygen is absorbed then for nitrogen let pressure is

$P = \frac{7}{28}\frac{RT}{V}$

$\Rightarrow P = \frac{RT}{4V}$ (ii)

From Eqs. (i) and (ii), we get pressure of the nitrogen $P = 5$ atm

145 **(d)**

Root mean square velocity of gas molecules

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

or $$v_{\text{rms}} \propto \frac{1}{\sqrt{M}}$$

or $$\frac{v_{O_3}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{O_3}}}$$

Here, $M_{O_2} = 32, \quad M_{O_3} = 48$

$$\therefore \quad \frac{v_{O_3}}{v_{O_2}} = \sqrt{\frac{32}{48}} = \frac{\sqrt{2}}{\sqrt{3}}$$

146 **(b)**

Saturated water vapour do not obey gas laws

147 **(b)**

Thermal capacity = Mass × Specific heat

Due to same material both spheres will have same specific heat.

Also mass = Volume (V) × Density (ρ)

∴ Ratio of thermal capacity

$= \frac{m_1}{m_2} = \frac{V_1\rho}{V_2\rho} = \frac{\frac{4}{3}\pi r_1^3}{\frac{3}{4}\pi r_2^3} = \left(\frac{r_1}{r_2}\right)^3$

$= \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

148 **(a)**

$PV = mrT = m\left(\frac{R}{M}\right)T$

$\Rightarrow V = \left(\frac{m}{M}\right)\frac{RT}{P} = \left(\frac{2.2}{44}\right) \times \frac{8.31 \times (273 + 0)}{2 \times (1 \times 10^5)}$

$= 5.67 \times 10^{-4} m^3 = 0.56$ litre

149 **(a)**

22 g of CO_2 is half mole of CO_2 *ie*, $n_1 = 0.5$

16 g of O_2 is half mole of O_2 *ie*, $n_2 = 0.5$

$\therefore \; T = \frac{n_1 T_1 + n_2 T_2}{n_1 + n_2}$

$= \frac{0.5 \times (27+273) + 0.5(37+273)}{0.5+0.5}$

$= 305$ K

$= 305 - 273 = 32$°C

150 **(a)**

$\left(P + \frac{aT^2}{V}\right)V^c = (RT + b) \Rightarrow P$

$= (RT + b)V^{-c} - (aT^2)V^{-1}$

Comparing this equation with $P = AV^m - BV^n$

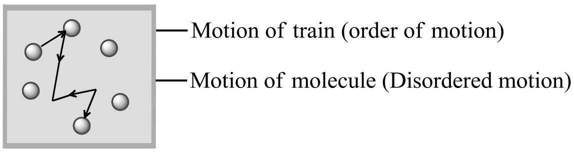
We get $m = -c$ and $n = -1$

151 **(c)**

No change, because *rms* velocity of gas depends upon temperature only

152 **(c)**

Temperature of the gas is concerned only with it's disordered motion. It is no way concerned with it's ordered motion



153 **(c)**

The average velocity

$$v_{\text{av}} = \frac{v_1 + v_2 + v_3 + \ldots + v_n}{N}$$

$$= \frac{1+3+5+7}{4} = 4 \text{ km/s}$$

Root mean square velocity

$$v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 + \ldots + v_n^2}{N}}$$

$$= \sqrt{\frac{1 + (3)^2 + (5)^2 + (7)^2}{4}}$$

$$= \sqrt{21} = 4.583 \text{ km/s}$$

Difference between average velocity and root mean square velocity

=4.583-4

=0.583 km/s

154 **(c)**

$PV = \frac{m}{M}RT \Rightarrow V \propto mT \Rightarrow \frac{V_1}{V_2} = \frac{m_1}{m_2}.\frac{T_1}{T_2}$

$= \frac{2V}{V} = \frac{m}{m_2} \times \frac{100}{200} \Rightarrow m_2 = \frac{m}{4}$

155 **(c)**

$C = C_V + W'$

where W' is the work done by the gas per unit mole per unit rise in temperature. So

$W' = \alpha T - C_V = \alpha T - (5R/2)$

$\Delta W = \int W' dT = \int_{T_0}^{2T_0} \left(\alpha T - \frac{5R}{2}\right) dT$

$$= (3\alpha T_0 - 5R)\frac{T_0}{2}$$

156 **(d)**

Since $U\rho =$constant,

$$\frac{P}{\rho} = \frac{RT}{M}$$

$P =$constant since ρ is increasing, therefore V is decreasing

157 **(b)**

$$v_{rms} \propto \sqrt{T} \Rightarrow \frac{(v_{rms})_2}{(v_{rms})_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\Rightarrow 2 = \sqrt{\frac{T_2}{300}} \Rightarrow T_2 = 1200K = 927°\text{C}$$

158 **(d)**

For A: As piston is free to move, the process is isobaric

$\Delta Q = \mu C_p(\Delta T)_1$

For B: As piston is held fixed, the process is isochoric

$\therefore \Delta Q = \mu C_v(\Delta T)_2$

Now $C_p(\Delta T)_1 = C_v(\Delta T)_2$

$$\frac{7R}{2} \times 30 = \frac{5R}{2}(\Delta T)_2$$

$\therefore T_2 = 42\text{ K}$

159 **(a)**

Given $P \propto T^3$. But for adiabatic process

$P \propto T^{\gamma/\gamma-1}$. So,

$$\frac{\gamma}{\gamma - 1} = 3 \Rightarrow \gamma = \frac{3}{2} \Rightarrow \frac{C_p}{C_v} = \frac{3}{2}$$

160 **(a)**

For 1 g gas $PV = rT = \left(\frac{R}{M}\right)T$

Since P and V are constant $\Rightarrow T \propto M \Rightarrow \frac{T_{N_2}}{T_{O_2}} = \frac{M_{N_2}}{M_{O_2}}$

$$\Rightarrow \frac{T_{N_2}}{(273 + 15)} = \frac{28}{32} \Rightarrow T_{N_2} = 252K = -21°\text{C}$$

161 **(a)**

Kinetic energy for m g gas $E = \frac{f}{2}mrT$

If only translational degree of freedom is considered

Then $f = 3 \Rightarrow E_{\text{Trans}} = \frac{3}{2}mrT = \frac{3}{2}m\left(\frac{R}{M}\right)T$

$$= \frac{3}{2} \times 20 \times \frac{8.3}{32} \times (273 + 47) = 2490J$$

162 **(d)**

10 g of ice at −10°C to ice at 0°C

$Q_1 = \text{cm}, \Delta\theta = 0.5 \times 10 \times 10 = 50\text{ cal}$

10 g of ice 0°C to water at 0°C

$Q_2 = mL = 10 \times 80 = 800\text{ cal}$

10 g of water at 0°C to water at 100°C

$Q_3 = \text{cm}, \Delta\theta = 1 \times 10 \times 100 = 1000\text{ cal}$

10 g water at 100°C to steam at 100°C

$Q_4 = mL = 10 \times 540 = 5400\text{ cal}$

Total heat required, $Q + Q_1 + Q_2 + Q_3 + Q_4$

$= 50+800+1000+5400 = 7250\text{ cal}$

163 **(d)**

$$\gamma_{\text{mixture}} = \frac{\frac{\mu_1\gamma_1}{\gamma_1-1} + \frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1} + \frac{\mu_2}{\gamma_2-1}}$$

$\mu_1 = \text{moles of helium} = \frac{16}{4} = 4$

$\mu_2 = \text{moles of oxygen} = \frac{16}{32} = \frac{1}{2}$

$$\Rightarrow \gamma_{\text{mix}} = \frac{\frac{4\times5/3}{\frac{5}{3}-1} + \frac{1/2\times7/5}{\frac{7}{5}-1}}{\frac{4}{\frac{5}{3}-1} + \frac{1/2}{\frac{7}{5}-1}} = 1.62$$

164 **(d)**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow T_2 = \frac{P_2V_2}{P_1V_1} \times T_1$$

$$= T_2 = \frac{1}{30} \times \frac{10}{1} \times 300 = 100K = -173°\text{C}$$

165 **(a)**

Since the piston is moved slowly we assume isothermal condition for both gases as thermal equilibrium is maintained throughout

Let the total volume of chamber be V. Then volume of gas in X increases (expands) from $V/3$ to $2V/3$. The work done is positive and given (for 1 mol of monatomic gas) by

$$W_x = +RT\ \log_e \frac{2V/3}{V/3} = RT\log_e 2$$

The volume of gas in Y decreases (compressed) from $2V/3$ to $V/3$

The work done (isothermally) is negative and given (for 2 mol of diatomic gas) by

$$W_Y = 2RT\log_e \frac{V/3}{2V/3} = -2RT\log_e 2$$

Hence the total work done on the system is

$W = W_X + W_Y = -RT\log_e 2$

Substituting $R = 8.3, \log_e 2 = 0.6996$ and simplifying $W = -5.8\,T$

166 **(a)**

For $\gamma = \frac{7}{5}, C_v = \frac{R}{\gamma-1} = \frac{R}{\frac{7}{5}-1} = \frac{5R}{2}$

$$C_P = \frac{\gamma R}{\gamma - 1} = \frac{(7/5)R}{\frac{7}{5} - 1} = \frac{7R}{2}$$

For $\gamma = \frac{4}{3}, C_v = 3R, C_p = 4R$

$$\therefore \gamma_{\text{mix}} = \frac{\frac{7}{2} + 4}{\frac{5}{2} + 3} = \frac{15}{11}$$

167 **(a)**

Molar specific heat= molecular weight × gram specific heat

$C_V = M \times c_v$

2.98 cal/mol-K= $M \times 0.075$ kcal/kg –K

$= M \times \frac{0.075\times10^3}{10^3}$ cal/g-K

∴ Molecular weight of argon

$$M = \frac{2.98}{0.075} = 39.7\text{g}$$

i.e., mass of 6.023×10^{23}atom = 39.7g

Therefore, mass of single atom

$$= \frac{39.7}{6.023\times10^{23}} = 6.60\times10^{-23}\text{g}$$

168 **(c)**

Given, pT^2=constant

∴ $\left(\frac{nRT}{V}\right)T^2$ =constant

or T^3V^{-1} = constant

Differentiating the equation, we get

$$\frac{3T^2}{V}.dT - \frac{T^3}{V^2}.dV = 0$$

or $3.dT = \frac{T}{V}.dV$

From the equation, $dV = V_\gamma.dT$

γ = coefficient of volume expansion of gas

$$= \frac{dV}{V.dT}$$

$$\therefore \quad \gamma = \frac{dV}{V.dT} = \frac{3}{T}$$

169 **(a)**

$$\frac{F}{2}n_1kT_1 + \frac{F}{2}n_2kT_2 + \frac{F}{2}n_3kT_3$$

$$= \frac{F}{2}(n_1 + n_2 + n_3)kT$$

$$T = \frac{n_1T_1+n_2T_2+n_3T_3}{n_1+n_2+n_3}$$

170 **(d)**

Argon is a monoatomic gas so it has only translational energy

171 **(c)**

RMS velocity doesn't depend upon pressure, it depends upon temperature only,

ie., $v_{\text{rms}} \propto \sqrt{T}$.

$$\Rightarrow \quad \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} \Rightarrow \frac{200}{v_2}$$

$$= \sqrt{\frac{(273+27)}{(273+127)}} = \sqrt{\frac{300}{400}}$$

$$\Rightarrow \quad v_2 = \frac{400}{\sqrt{3}}\text{ m/s}$$

172 **(c)**

Here, $m = 10$ g $=10^{-2}$ kg

$v = 300$ ms^{-1}, θ =? C, = 150 J-kg^{-1}K^{-1}

$Q = \frac{50}{100}\left(\frac{1}{2}mv^2\right) = \frac{1}{4}\times10^{-2}(300)^2 = 225$ J

From $Q = cm\,\theta$

$$\theta = \frac{Q}{cm} = \frac{225}{150\times10^{-2}} = 150°\text{C}$$

173 **(a)**

Most probable speed $v_{mp} = \sqrt{\frac{2kT}{m}} \Rightarrow \frac{1}{2}mv_{mp}^2 = kT$

174 **(c)**

$$C_V = \frac{n_1C_{v_1} + n_2C_{V_2}}{n_1 + n_2}$$

$$= \frac{1\times\frac{3}{2}R + 1\times\frac{5}{2}R}{1+1} = 2R$$

175 **(b)**

According to ideal gas equation $PV = nRT$

$PV = \frac{m}{M}RT, P = \frac{\rho}{M}RT$ or $\frac{\rho}{P} = \frac{M}{RT}$or $\frac{\rho}{P} \propto \frac{1}{T}$

Here, $\frac{\rho}{P}$ represent the slope of graph

Hence $T_2 > T_1$

176 **(c)**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{1\times500}{300} = \frac{0.5\times V_2}{270} \Rightarrow V_2 = 900m^3$$

177 **(d)**

Here, $\frac{D_1}{D_2} = \frac{1}{2}$

$$\frac{A_1}{A_2} = \frac{D_1^2}{D_2^2} = \frac{1}{4}$$

$$\frac{dx_1}{dx_2} = \frac{2}{1}$$

$$\frac{dQ_1}{dt} = KA_1\frac{dT}{dx_1} : \frac{dQ_2}{dt} = KA_2\frac{dT}{dx_2}$$

$$\frac{dQ_1/dt}{dQ_2/dt} = \frac{A_1}{dx_1}.\frac{dx_2}{A_2} = \frac{1}{4}\times\frac{1}{2} = \frac{1}{8}$$

178 **(b)**

$$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow V_H > V_N > V_O \ [\because M_H < M_N < M_O]$$

179 **(a)**

Pressure of the gas will not be affected by motion of the system, hence by

$$v_{rms} = \sqrt{\frac{3P}{\rho}} \Rightarrow \bar{c}^2 = \frac{3P}{\rho} \Rightarrow P = \frac{1}{3}\rho\bar{c}^2$$

180 **(a)**

According to Boyle's law, $pV = k$ (a constant)

Or $p\frac{m}{p} = k$ or $p = \frac{pm}{k}$

Or $p = \frac{p}{k}$ (where, $\frac{k}{m} = k$ a constant)

So, $\rho_1 = \frac{p_1}{k}$ and $V_1\frac{p_1}{k} = \frac{m_1}{p_1} = \frac{m_1}{p_1/k} = \frac{km_1}{\rho_1}$

Similarly , $V_2 = \frac{km_2}{p_2}$

Total volume $= V_1 + V_2 = k\left(\frac{m_1}{p_1}+\frac{m_2}{p_2}\right)$

Let p be the common pressure and ρ be the common density of mixture. Then

$$\rho = \frac{m_1+m_2}{V_1+V_2} = \frac{m_1+m_2}{k\left(\frac{m_1}{P_1}+\frac{m_2}{P_2}\right)}$$

$$\therefore\ p = k\rho = \frac{m_1+m_2}{\frac{m_1}{P_1}+\frac{m_2}{P_2}} = \frac{P_1P_2(m_1+m_2)}{(m_1P_2+m_2P_1)}$$

181 **(b)**

Average kinetic energy ∝ Temperature

183 **(b)**

Temperature at state $P = T_0$, since P lies on the isothermal of temperature T_0. If T be the temperature at Q, then for the adiabatic process B, we have, $T_0V_0^{\gamma-1} = T(2V_0)^{\gamma-1}$

$$T = \frac{T}{2^{\gamma-1}} = \frac{T_0}{2^{2/3}}$$

Change in the internal energy of the gas is

$$\Delta U = C_V(T-T_0) = \left(\frac{R}{\gamma-1}\right)\left(\frac{T_0}{2^{2/3}}-T_0\right)$$

$$= \frac{3RT_0(1-2^{2/3})}{2\times 2^{2/3}} = -4.6\,T_0$$

184 **(a)**

Temperatures $T_1 = 15°\text{C} = 15+273 = 288\text{ K}$

$T_2 = 35°\text{C} = 35+273 = 308\text{ K}$

Volume remains constant.

So, $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$$\frac{p_1}{p_2} = \frac{T_1}{T_2} \quad\Rightarrow \frac{p_1}{p_2} = \frac{288}{308}$$

$$\frac{p_2}{p_1} = \frac{308}{288}$$

% increases in pressure$=\frac{p_2-p_1}{p_1}\times 100$

$$= \frac{308-288}{288}\times 100$$

$$\approx 7\%$$

185 **(b)**

Let the temperature of junction be$Q$. In equilibrium, rate of flow of heat through rod 1= sum of rate of flow of heat through rods 2 and 3.

$$\left(\frac{dQ}{dt}\right)_1 = \left(\frac{dQ}{dt}\right)_2 + \left(\frac{dQ}{dt}\right)_3$$

$$KA\frac{(\theta-0)}{l} = \frac{KA(90°-\theta)}{l} + \frac{KA(90°-\theta)}{l}$$

$$\theta\ = 2(90°-\theta)$$

$3\theta = 180°, \theta = \frac{180°}{3} = 60°$

186 **(b)**

$$\frac{C_P}{C_v} = \gamma = \frac{7}{5}$$

Work done $= \frac{\mu R}{\gamma-1}\times\Delta T$

$$= \frac{8.3\times 400\times 5}{\frac{7}{5}-1} = 41.5\text{ J}$$

Work done = change in internal energy

($\because \Delta Q = 0$ for adiabatic process)

Therefore, change in internal energy =41.5kJ

187 **(a)**

The total pressure exerted by a mixture of non-reacting gases occupying a vessel is equal to the sum of the individual pressure which each gas exert if it alone occupied the same volume at a given temperature.

For two gases,

$$p = p_1 + p_2 = p + p = 2p$$

188 **(c)**

At constant temperature PV = constant $\Rightarrow P \propto \frac{1}{V}$

189 **(b)**

$\gamma = 7/5$ for a diatomic gas

190 **(d)**

We know $v_s = \sqrt{\frac{\gamma P}{\rho}}$ and $v_{rms} = \sqrt{\frac{3P}{\rho}}$

$$\therefore \frac{v_{rms}}{v_s} = \sqrt{\frac{\gamma}{3}}$$

191 **(c)**

$W_{AB} = -P_0V_0$

$W_{BC} = 0$

and $W_{CD} = 4P_0V_0$

$\therefore W_{ABCD} = -P_0V_0 + 0 + 4P_0V_0$

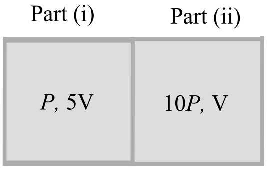
$= 3P_0V_0$

192 **(c)**

$$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$$

$\therefore \frac{1}{\sqrt{2}} = \sqrt{\frac{M_2}{32}} \Rightarrow M_2 = 16$. Hence the gas is CH_4

193 **(a)**



When the piston is allowed to move the gases are kept separated but the pressure has to be equal. ($P_1 = P_2$) and final volume x and $(6V-x)$, the no of moles are same in initial and final position at each parts.

$\because P_1 = P_2 \qquad P_V = n_1RT$

$$\frac{n_1RT}{x} = \frac{n_2RT}{6V-x} \quad n_1 = \frac{5PV}{RT}$$

$$\frac{n_1}{x} = \frac{n_2}{6V - x} \qquad n_2 = \frac{10PV}{RT}$$

$$\Rightarrow \frac{5PV}{xRT} = \frac{10PV}{(6V - x)RT} \Rightarrow \frac{1}{x} = \frac{2}{6V - x}$$

$\Rightarrow 6V - x = 2x \Rightarrow x2V$ and $6V - x \Rightarrow 6V - 2V = 4V$

$\therefore (2V, 4V)$

194 **(d)**

$$v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\frac{5}{3} \times 10^3}{2.6}} = 25 m/s$$

195 **(a)**

$$(\Delta Q)_V = C_V \Delta T = \frac{f}{2} R\Delta T$$

$$\Rightarrow \Delta T \propto \frac{1}{f}$$

Also $f_{Mono} < f_{Dia} \Rightarrow (\Delta T)_{Mono} > (\Delta T)_{Dia}$

196 **(d)**

Average kinetic energy $E = \frac{3}{2}kT$

$\Rightarrow \qquad E \propto T$

Thus, average kinetic energy of a gas molecule is directly proportional to the absolute temperature of gas.

197 **(b)**

As $dQ = C_p m\Delta T$

$\therefore\ 70 = C_p \times 2(35 - 30)$

$C_V = C_p - R$

$= 7 - 1.99 = 5.01$ calmol^{-1}°C^{-1}

$\therefore\ dQ' = C_V m\Delta T$

$= 5.01 \times 2 \times (35 - 30) = 50.1$ cal

198 **(d)**

$v_{rms} = \sqrt{\frac{3P}{\rho}} = P \propto \rho$ [v_{rms} is constant for fixed temperature]

199 **(a)**

$PV = RT$ for 1 mol

$$W = \int PdV = \int \frac{RT}{V} dV$$

$$V = CT^{2/3}$$

$$dV = \frac{2}{3} CT^{-1/3} dT \text{ or } \frac{dV}{V} = \frac{2}{3}\frac{dT}{T}$$

$$W = \int_{T_1}^{T_2} RT \left(\frac{2}{3}\right) = \frac{dT}{T} = \frac{2}{3} R(T_2 - T_1) = 166.2 \text{ J}$$

200 **(b)**

For 1 mol of gas,

$\Delta Q = C_v \Delta T + P\Delta T$

At constant volume, $\Delta T = 0$

For 2 moles of gas,

$\Delta = 2C_v \Delta T$

From $PV = nRT = 2R \times 300$

and $\frac{P}{2}V = 2RT_f$

$\therefore T_f = 150$K

$\therefore \Delta Q = 2C_v(T_f - T_i) = 2C_v(150 - 300)$

$= -300C_v$ J

In the next process,

$\Delta Q = 2C_p \Delta T = 2C_p(300 - 150)$

$= 300C_P$J

$\therefore$ Net heat absorbed $= -300C_v + 300C_p$

$= 300(C_p - C_v) = 300R$ J

201 **(a)**

From ideal gas equation

$$pV = nkT$$

$$p = \frac{n}{V}kT$$

Here, $\frac{n}{V} = 5/\text{cm}^3 = 5 \times 10^6/\text{m}^3$

$\therefore \quad p$

$= (5 \times 10^6/\text{m}^3)(1.38 \times 10^{-23}/\text{JK}^{-1}) \times 3\text{K}$

$$p = 20.7 \times 10^{-17} \text{ Nm}^{-2}$$

202 **(c)**

From the Mayer's formula

$$C_p - C_V = R$$

...(i)

and $\quad \gamma = \frac{C_p}{C_V}$

$\Rightarrow \quad \gamma C_V = C_p$

...(ii)

Substituting Eq. (ii) in Eq. (i) we get

$\Rightarrow \quad \gamma C_V - C_V = R$

$$C_V(\gamma - 1) = R$$

$$C_V = \frac{R}{\gamma - 1}$$

203 **(d)**

$\Delta Q = KA\left(\frac{\Delta T}{\Delta x}\right)\Delta t, \qquad$ where $A = 4\pi r^2$

$= 0.008 \times 4 \times \frac{22}{7}(6 \times 10^8)^2 \times \left(\frac{32}{10^5}\right) \times 86400$

$= 10^{18}$ cal

204 **(a)**

For paths 1, 2, 3 and 4, initial temperature of the gas is T_1 and final temperature of the gas is T_2

i.e., $\Delta U_1 = \Delta U_2 = \Delta U_3 = \Delta U_4$

$= nC_V \Delta T = nC_v(T_2 - T_1)$

$T_3 > T_2 > T_1$

For path 5, $(T_3 - T_1) > (T_2 - T_1)$

$\Delta U_5 > \Delta U_3$

205 **(b)**

$v_{rms} > v_{av} > v_{mp}$

206 **(c)**

Since P and V are not changing, so temperature remains same

208 **(d)**

$PV \propto MT$ or $\dfrac{V}{T} \propto \dfrac{M}{P}$

Here (M/P) represents the slope of curve drawn on volume and temperature axis. For the first condition slope (M/P) graph is D (given in the problem)

For the second condition slope

$\dfrac{2M}{P/2} = 4\left(\dfrac{M}{P}\right)$

i.e., slope becomes four times so graph A is correct in this condition

209 **(a)**

$P_1 = P, T_1 = T, \qquad P_2 = P + (0.4\% \text{ of } P)$

$\Rightarrow P_2 = P + \dfrac{0.4}{100}P = P + \dfrac{P}{250}$ and $T_2 = T + 1$

From Gay-Lussac's law

$\dfrac{P_1}{P_2} = \dfrac{T_1}{T_2}$

$\Rightarrow \dfrac{P}{P + \frac{P}{250}} = \dfrac{T}{T+1}$

(as V =constant for closed vessel)

By solving, we get $T = 250$ K

210 **(b)**

Thermal energy corresponds to internal energy

Mass=1 kg

Density $= 4 \text{ kg m}^{-3}$

Volume $= \frac{\text{Mass}}{\text{Density}} = \frac{1}{4} \text{ m}^3$

Pressure $= 8 \times 10^4 \text{ Nm}^{-2}$

$\therefore \qquad$ Internal energy $= \dfrac{5}{2}\, p \times V = 5 \times 10^4$ J

211 **(d)**

$$\frac{(v_{rms})_1}{(v_{rms})_2} = \sqrt{\frac{T_1}{T_2}} \Rightarrow \frac{500}{(v_{rms})_2} = \sqrt{\frac{0+273}{819+273}}$$

$$= \sqrt{\frac{273}{1092}}$$

$$(v_{rms})_2 = 500\sqrt{\frac{1092}{273}} = 500\sqrt{4} = 1000\frac{m}{s} = 1\frac{km}{s}$$

212 **(c)**

$\Delta U = nC_v\Delta T$

Also, $\frac{C_p}{C_v} = \gamma$

Hence $\frac{C_p - C_v}{C_v} = \gamma - 1$

$\Rightarrow C_v = R/(\gamma - 1)$

$$\Delta U = \frac{nR}{\gamma-1}\Delta T = \frac{p\Delta V}{\gamma-1} = \frac{p(2V-V)}{\gamma-1} = \frac{pV}{\gamma-1}$$

213 **(c)**

From ideal gas equation

$PV = RT$ (i)

$P\Delta V = R\Delta T$ (ii)

Dividing Eq. (ii) by Eq. (i), we get

$\frac{\Delta V}{V} = \frac{\Delta T}{T} \Rightarrow \frac{\Delta V}{V\Delta T} = \frac{1}{T} = \delta$ (given)

$\therefore \delta = \dfrac{1}{T}$

So the graph between δ and T will be a rectangular hyperbola

214 **(d)**

Thermal equilibrium implies that the temperature of gases is same. Hence Boyle's law is applicable $i.e$

$P_aV_a = P_bV_b$

215 **(c)**

At absolute temperature $T = 0 \Rightarrow v_{rms} = \sqrt{\frac{3RT}{M}} = 0$

Therefore, there is no motion of gas molecules at this temperature

216 **(c)**

$PV = \mu RT$ [Gas equation] $\Rightarrow PV \propto T$

218 **(a)**

The value of universal gas constant is approx.

$2\dfrac{cal}{mole - Kelvin}$

219 **(d)**

$P = \frac{2}{3} \times$ (Energy per unit volume) $= \frac{2}{3}\frac{E}{V} \Rightarrow PV = \frac{2}{3}E$

220 **(b)**

Here, $V_0 = 10^3$ cc

$\gamma_r = 180 \times 10^{-6}{}^\circ\text{C}^{-1}$

$\text{g} = 40 \times 10^{-6}{}^\circ\text{C}^{-1}$, $t = 100^\circ\text{C}$

$\gamma_a = \gamma_r - \text{g} = (180 - 40)10^{-6}$

$V_t = V_0(1 + 140 \times 10^{-6} \times 10^2)$

$= (10^3 + 14)$cc

$\therefore$ Volume of mercury that will overflow

$= V_t - V_0 = 14\ cc$

221 **(b)**

$$\gamma_{\text{mix}} = \frac{\frac{\mu_1\gamma_1}{\gamma_1-1} + \frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1} + \frac{\mu_2}{\gamma_2-1}} = \frac{\frac{3\times1.3}{(1.3-1)} + \frac{2\times1.4}{(1.4-1)}}{\frac{3}{(1.3-1)} + \frac{2}{(1.4-1)}} = 1.33$$

222 **(d)**

Kinetic energy per $g\ mole$ $E = \frac{f}{2}RT$

If nothing is said about gas then we should calculate the translational kinetic energy

$$i.e., E_{\text{Trans}} = \frac{3}{2}RT = \frac{3}{2} \times 8.31 \times (273 + 0)$$
$$= 3.4 \times 10^3 J$$

223 **(b)**

$$C_P - C_V = R \Rightarrow C_P = R + C_V = R + \frac{f}{2}R$$
$$= R + \frac{3}{2}R = \frac{5}{2}R$$

224 **(c)**

Since temperature is constant, so v_{rms} remains same

225 **(c)**

$$C_V = \frac{R}{0.67} = 1.5R = \frac{3}{2}R$$

This is the value for monoatomic gases

226 **(a)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow T \propto M \Rightarrow \frac{T_{He}}{T_H} = \frac{M_{He}}{M_H}$$
$$\Rightarrow \frac{(273 + 0)}{T_{He}} = \frac{2}{4} \Rightarrow T_{He} = 546K = 273°\text{C}$$

227 **(a)**

For one $g\ mole$; average kinetic energy $= \frac{3}{2}RT$

228 **(c)**

Kinetic energy ∝ Temperature. Hence if temperature is doubles, kinetic energy will also be doubled

229 **(a)**

$V \propto T$ [as constant pressure]

231 **(d)**

Process CD is isochoric as volume is constant, process DA is isothermal as temperature is constant and process AB is isobaric as pressure is constant

232 **(a)**

$$\frac{T_A}{M_A} = 4\frac{T_B}{M_B} \Rightarrow \sqrt{\frac{T_A}{M_A}} = 2\sqrt{\frac{T_B}{M_B}}$$
$$\Rightarrow \sqrt{\frac{3RT_A}{M_A}} = 2\sqrt{\frac{3RT}{M_B}} \Rightarrow C_A = 2C_B \Rightarrow \frac{C_A}{C_B} = 2$$

233 **(a)**

The temperature at which protons in a proton gas would have enough energy to overcome Coulomb barrier between them is given by

$\frac{3}{2}k_B T = K_{av}$ ...(i)

Where k_{av} is the average kinetic energy of the proton, T is the temperature of the proton gas and k_B is the Boltzmann constant

From (i), we get $T = \frac{2K_{av}}{3K_B}$

Substituting the values, we get

$$T = \frac{2 \times 4.14 \times 10^{-14} J}{3 \times 1.38 \times 10^{-23} JK^{-1}} = 2 \times 10^9 K$$

234 **(a)**

$$PV = \mu RT = \frac{m}{M}RT$$

$\Rightarrow \frac{PV}{T} \propto \frac{1}{M}$ [$\because M$ = molecule mass]

From graph $\left(\frac{PV}{T}\right)_A < \left(\frac{PV}{T}\right)_B < \left(\frac{PV}{T}\right)_C$

$\Rightarrow M_A > M_B > M_C$

235 **(d)**

Pressure is directly proportional to square of the diameter of the balloon,

$\frac{P_2}{P_1} = \frac{D_2^2}{D_1^2}$ (i)

When $V_2 = 2V_1 \Rightarrow D_2^3 = 2D_1^3 =$

$\Rightarrow \frac{D_2}{D_1} = \left(\frac{V_2}{V_1}\right)^{1/3}$ (ii)

From Eqs. (i) and (ii),

$$\frac{P_2}{P_1} = \left(\frac{V_2}{V_1}\right)^{2/3}$$

$\Rightarrow PV^{-2/3}$ = constant

236 **(a)**

Ideal gas equation, in terms of density,

$\frac{P_1}{\rho_1 T_1} = \frac{P_2}{\rho_2 T_2}$ =constant

$$\therefore \frac{\rho_1}{\rho_1} = \frac{P_1}{P_2} \times \frac{T_2}{T_1}$$
$$\frac{\rho_{\text{Top}}}{\rho_{\text{Bottom}}} = \frac{P_{\text{Top}}}{P_{\text{Bottom}}} \times \frac{T_{\text{Bottom}}}{T_{\text{Top}}} = \frac{70}{76} \times \frac{300}{280} = \frac{75}{76}$$

237 **(a)**

Let p_1 and p_2 are the initial and final pressures of the gas filled in A. Then

$$p_1 = \frac{n_A RT}{V} \text{ and } p_2 = \frac{n_A RT}{2V}$$
$$\Delta p = p_2 - p_1 = -\frac{n_A RT}{2V}$$
$$= -\left(\frac{m_A}{M}\right)\frac{RT}{2V}$$

...(i)

where M is the atomic weight of the gas.

Similarly, $1.5\Delta p = -\left(\frac{m_B}{M}\right)\frac{RT}{2V}$

...(ii)

Dividing Eq.(ii) by Eq. (i), we get

$$1.5 = \frac{m_B}{m_A} \quad \text{or} \quad \frac{3}{2} = \frac{m_B}{m_A}$$

or $3m_A = 2m_B$

238 **(c)**

Pressure of gas $A, P_A = \frac{125\times0.6}{1000} = 0.075\ atm$

Pressure of gas $B, P_B = \frac{150\times0.8}{100} = 0.120\ atm$

Hence, by using Dalton's law of pressure

$P_{mixture} = P_A + P_B = 0.075 + 0.120 = 0.195\ atm$

239 **(c)**

Below 100 K only translational degree of freedom is considered. Hence

$\gamma_{mixture} = \frac{\frac{\mu_1\gamma_1}{\gamma_1-1}+\frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1}+\frac{\mu_2}{\gamma_2-1}}$ according

to question, $\mu_1 = \mu_2$ and $\gamma_1 = \gamma_2 = 1 + \frac{2}{3} = \frac{5}{3}$

$\Rightarrow \gamma_{mix} = \gamma_1 = \frac{5}{3}$

240 **(a)**

$\frac{V_1}{V_2} = \frac{T_1}{T_2}$

$\frac{1}{2} = \frac{300}{T_2}$

$T_2 = 600\text{ K} = 600 - 273 = 327°\text{C}$

$\Delta t = 327 - 27 = 300°\text{C}$

241 **(a)**

$E = \frac{3}{2}RT \Rightarrow \frac{E'}{E} = \frac{T'}{T} = \frac{400}{300} = \frac{4}{3} = 1.33$

242 **(c)**

$\Delta Q = Q_1 + Q_2 + Q_3 + Q_4$

$= 5960 - 5585 - 2980 + 3645 = 1040\text{J}$

$\Delta W = W_1 + W_2 + W_3 + W_4$

$= 220 - 825 - 1100 + W_4 = 275 + W_4$

For a cyclic process, $U_f = U_f$

$\Delta U = U_f - U_i = 0$

From the first law of thermodynamics,

$\Delta Q = \Delta U + \Delta W$

$1040 = 0 = 275 + W_4$ or $W_4 = 765$ J

243 **(d)**

$$\frac{V_{rms_{He}}}{V_{rms_{Ar}}} = \frac{\sqrt{\frac{3RT}{m_{He}}}}{\sqrt{\frac{3RT}{m_{Ar}}}} = \sqrt{\frac{m_{Ar}}{m_{He}}} = \sqrt{\frac{40}{4}} = \sqrt{10} \approx 3.16$$

244 **(a)**

From ideal gas equation,

$PV = \mu RT$

$\therefore P = \frac{\mu R}{V}T$

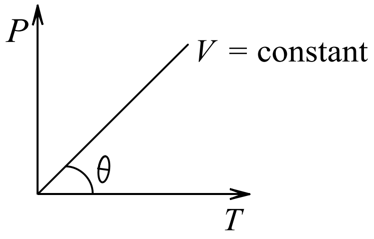
Comparing, this equation with $y = mx$

Slope of line, $\tan\theta = m = \mu R/V$

i.e., $V \propto \frac{1}{\tan\theta}$

It means line of smaller slope represents greater volume of gas

for the given problem figure



Points 1 and 2 are on the same line, so they will represent same volume, i.e., $V_1 = V_2$.

Similarly points 3 and 4 are on the same line, so they will represent same volume, i.e., $V_3 = V_4$

But $V_1 > V_3(= V_4)$ or $V_2 > V_3(= V_4)$ as slope of line $1 - 2$ is less than that of $3 - 4$

245 **(d)**

$C_V = \frac{5}{2}R$ and $C_p = \frac{7}{2}R$

$\therefore \qquad \gamma = \frac{C_p}{C_V} = \frac{7}{5}$

246 **(d)**

Quantity of gas in these bulbs is constant ,i.e., initial no. of moles in both the bulbs =final number of moles

$\mu_1 + \mu_2 = \mu_1' + \mu_2'$

$\frac{PV}{R(273)} + \frac{PV}{R(273} = \frac{1.5\ PV}{R(273)} + \frac{1.5PV}{R(T)}$

$\Rightarrow \frac{2}{273} = \frac{1.5}{273} + \frac{1.5}{T}$

$\Rightarrow T = 819\text{K} = 546°\text{C}$

247 **(a)**

Root mean square velocity

$v_{rms} \propto \frac{1}{\sqrt{M}}$

So $\quad \frac{(v_{rms})_{\text{O}_2}}{(v_{rms})_{\text{H}_2}} = \sqrt{\frac{M_{\text{H}_2}}{M_{\text{O}_2}}}$

$= \sqrt{\frac{2}{32}} = \frac{1}{4}$

248 **(a)**

From the first law of thermodynamics

$dQ = dU + dW$

Here $dW = 0$ (given)

$\therefore dQ = dU$

Now since $dQ < 0$ (given)

$\therefore dQ$ is negative $\Rightarrow dU = -$ve

$\Rightarrow dU$ decreases⇒Temperature decreases

∴ The correct option is (a)

249 **(c)**

At TK, pressure of gas (P) in the jar

= Total pressure – saturated vapour pressure

$\Rightarrow P = (830 - 30) = 800mm\ of\ Hg$

New temperature $T' = \left(T - \frac{T}{100}\right) = \frac{99T}{100}$

Using Charle's law $\frac{P}{T}=\frac{P'}{T'}\Rightarrow P'=\frac{PT'}{T}$

$=\dfrac{800\times 99T}{100T}=792 mm\ of\ Hg$

Saturated vapour pressure at $T'=25\ mm\ of\ Hg$

∴ Total pressure in the jar

= Actual pressure of gas + Saturated vapour pressure

$=792+25=817\ mm$ of Hg

250 **(a)**

In free expansion of Vander waal's gas, its temperature decreases

251 **(b)**

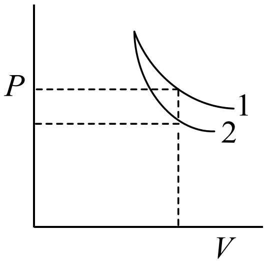
For adiabatic process, PV^{γ} =constant

For monatomic gas, $\gamma=\frac{C_p}{C_v}=1.67$

For diatomic gas, $\gamma=1.4$

Since $\gamma_{\text{diatomic}}<\gamma_{\text{monatomic}}$, so with increase in volume, decrease in pressure will be more for monatomic gas

⇒ Graph 1 is for diatomic and Graph 2 is for monatomic. Correct option is (b)



252 **(d)**

$PV=mrT\Rightarrow P\propto m$ [$\because V,r,T\rightarrow$ constant]

$\Rightarrow\dfrac{m_1}{m_2}=\dfrac{P_1}{P_2}\Rightarrow\dfrac{10}{m_2}=\dfrac{10^7}{2.5\times 10^6}\Rightarrow m_2=2.5\ kg.$

Hence mass of the gas taken out of the cylinder $=10-2.5=7.5kg$

253 **(c)**

$PV=\frac{m}{M}RT$(for ideal gas)

$\therefore MV=\dfrac{mRT}{P}$

In the position of equilibrium of stopper S,

$P_1=P_2,T_1=T_2,m_1=m_2$

$\therefore MV=$ constant

$M_1V_1=M_1V_2$

$\Rightarrow A\times 32(360-\alpha)=28\alpha\times A$

$\alpha=192°$

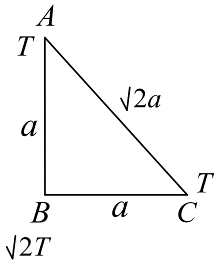
254 **(b)**

$\left(\dfrac{\Delta Q}{\Delta t}\right)_{BC}=\left(\dfrac{\Delta Q}{\Delta t}\right)_{CA}$

$\Rightarrow\dfrac{kA(\sqrt{2}T-T_C)}{a}=\dfrac{kA(T_C-T)}{\sqrt{2}a}$

Solve to get

$\dfrac{T_C}{T}=\dfrac{3}{\sqrt{2}+1}$



255 **(a)**

No work is done along path AB because the process is isochoric

∴ work done= $P_B(V_D-V_A)$

$=8\times 10^4(5\times 10^{-3}-2\times 10^{-3})=240$ J

$(\Delta Q)_{AC}=(\Delta Q)_{AB}+(Q)_{BC}=600+200=800$J

$\therefore(\Delta U)_{AC}=(\Delta Q)-(\Delta W)=800-240=560$J

256 **(a)**

Kinetic energy for 1 $mole\ gas\ E=\frac{f}{2}RT$

$\Rightarrow E_{\text{Translation}}=\dfrac{3}{2}RT$

[∵ For all gases translational degree of freedom $f=3$]

257 **(d)**

From the first law of thermodynamics

$Q=W+\Delta U$

For an isobaric process

$W=R\Delta T,Q=C_P\Delta T=\left(\dfrac{f+2}{2}\right)R\Delta T$

$\dfrac{W}{Q}=\dfrac{2}{f+2}$

Where f is the number of degree of freedom

For an isochoric process,

$W=0,\dfrac{W}{Q}=0$

The straight line 1 corresponds to an isochoric process. For monoatomic gas $f=3$ and for diatomic gas $f=5$

$\frac{W}{Q}=\frac{1}{2}$ (for monatomic gas)

$=\frac{2}{7}$ (for diatomic gas)

Straight line 2 corresponds to isobaric process for diatomic gas and straight line 3 corresponds to isobaric process for monatomic gas

For isotherm $W=Q,\tan\theta_4=1$ straigh line 4 corresponds to isothermal process because $W=Q$ only if $\Delta T=0$ i.e., $\Delta U=0$. For an adiabatic process $Q=0$, the straight line 5 corresponds to it

258 **(a)**

$\Delta p=mV-(-mV)=2mV$

259 **(c)**

The work done=area of $P-V$ diagram

$$a=\frac{V_2-V_1}{2}, b=\frac{P_2-P_1}{2}$$

$$W=-\pi\left(\frac{V_2-V_1}{2}\right)\left(\frac{P_2-P_1}{2}\right)$$

But the cyclic process is anticlockwise. Hence, the work done is negative

260 **(b)**

Heat required to convert 5 Kg of water into steam

$$\Delta Q=mL=5\times 2.3\times 10^6=11.5\times 10^6\text{J}$$

Work done in expanding volume,

$$\Delta W=P\Delta V$$

$$=5\times 10^5(1.671-10^{-3})=0.835\times 10^6\text{J}$$

Now by the first law of thermodynamics

$$\Delta U=\Delta Q-\Delta W$$

$$\Rightarrow \Delta U=11.5\times 10^6-0.835\times 10^6=10.66\times 10^6\text{J}$$

261 **(b)**

Process AB is an isothermal process, i.e., $P\propto 1/V$ and since $\rho\propto 1/V, \rho-V$ graph will be a rectangular hyperbola. Pressure is increasing; therefore, volume will increase. Process BC is an isochoric process. Therefore, $V=$constant and since $\rho=m/V$, density is also constant, i.e.,$\rho-V$ graph is a dot. Process CD is inverse of process AB and process DA is inverse is BC

262 **(c)**

If number of molecules in gas increases then number of collisions of molecules with walls of container would also increase and hence the pressure increses, $i.e., P\propto N$.

$$\Rightarrow\frac{P_2}{P_1}=\frac{N_2}{N_1}=\frac{2}{1}\Rightarrow P_2=2P_1$$

263 **(c)**

$$C_V=\frac{R}{(\gamma-1)}\Rightarrow\gamma=1+\frac{R}{C_V}=1+\frac{R}{\frac{3}{2}R}=\frac{5}{3}$$

265 **(c)**

$$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$$

$$\frac{(1.38\times 10^7\,\text{Pa})(16\text{L})}{300\text{K}}=\frac{(10^5\text{Pa})\left(2.4\frac{\text{L}}{\text{m}}t\right)}{300\text{K}}$$

$$t=\frac{1.38\times 10^7\times 16}{10^5\times 2.4}=920\text{ min}$$

$$=\frac{920}{60}\text{h}=15\text{ h (approx.)}$$

266 **(b)**

$$W=\int_{V_1}^{V_2}P\,dV=\int_{V_1}^{V_2}KV\,dV$$

$$\left(\because\frac{p}{V}=K=\text{constant}\right)$$

$$\therefore W=\frac{1}{2}k(V_2^2-V_1^2)$$

$$PV=RT$$

But $p=KV$

$$\therefore KV^2=RT$$

or $K(V_2^2-V_1^2)=R(T_2-T_1)$

$$\therefore W=\frac{R}{2}(T_2-T_1)$$

267 **(a)**

Change in temperature in process 1 will be greater and in process 3 will be least

268 **(a)**

We treat water like a solid. For each atom average energy is $3k_BT$. Water molecule has three atoms, two hydrogen and one oxygen. The total energy of one mole of water is

$$U=3\times 3k_BT\times N_A=9RT\quad\left[\because k_B=\frac{R}{N_A}\right]$$

$\therefore$ Heat capacity per mole of water is

$$C=\frac{\Delta Q}{\Delta T}=\frac{\Delta U}{\Delta T}=9R$$

269 **(d)**

$$C_P=\left(\frac{f}{2}+1\right)R=\left(\frac{5}{2}+1\right)R=\frac{7}{2}R$$

270 **(a)**

When electric spark is passed, hydrogen reads with oxygen to form water (H_2O). Each gram of hydrogen reacts with eight grams of oxygen. Thus 96 gm of oxygen will be totally consumed together with 12 gm of hydrogen. The gas left in the vessel will be 2 gm of hydrogen $i.e.$

Number of moles $\mu=\frac{2}{2}=1$

Using $PV=\mu RT\Rightarrow P\propto\mu\Rightarrow\frac{P_2}{P_1}=\frac{\mu_2}{\mu_1}$

($\mu_1=$ Initial number of moles $=7+3=10$ and $\mu_2=$ Final number of moles $=1$)

$$\Rightarrow\frac{P_2}{1}=\frac{1}{10}\Rightarrow P_2=0.1\,atm$$

271 **(c)**

Process is isothermal. Therefore, $T=$ constant. Volume is increasing: therefore, pressure will decrease $\left(P\propto\frac{1}{V}\right)$ in chamber A →

$$\Delta P=(P_A)_i-(P_A)_f=\frac{n_ART}{V}-\frac{n_ART}{2V}$$

$$=\frac{n_ART}{2V}\quad\text{(i)}$$

In chamber B →

$$1.5\Delta p=(P_B)_i-(P_B)_f=\frac{n_BRT}{V}-\frac{n_BRT}{2V}$$

$$=\frac{n_BRT}{2V}\quad\text{(ii)}$$

From Eqs. (i) and (ii),

$$\frac{n_A}{n_B}=\frac{1}{1.5}=\frac{2}{3}$$

$$\frac{m_A/M}{m_B/M}=\frac{2}{3}$$
$$\frac{m_A}{m_B}=\frac{2}{3}$$
$3m_A = 2m_B$

272 **(d)**

We have $v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$; at $T = T_0$(NTP)

$$v_{\text{rms}} = \sqrt{\frac{3RT_0}{M}}$$

But at temperature T,

$$v_{\text{rms}} = 2 \times \sqrt{\frac{3RT_0}{M}}$$

$\Rightarrow \quad \sqrt{\frac{3RT}{M}} = 2\sqrt{\frac{3RT_0}{M}}$

$\Rightarrow \quad \sqrt{T} = \sqrt{4T_0}$

or $\quad T = 4T_0$

$T = 4 \times 273\text{K}=1092\text{K}$

$\therefore \quad T = 819℃$

273 **(c)**

The number of moles of the system remains same,

$$\frac{P_1V_1}{RT_1}+\frac{P_2V_2}{RT_2}=\frac{P(V_1+V_2)}{RT} \Rightarrow T$$
$$=\frac{P(V_1+V_2)T_1T_2}{(P_1V_1T_2+P_2V_2T_1)}$$

According to Boyle's law,

$$P_1V_1+P_2V_2 = P(V_1+V_2) \ \therefore T$$
$$=\frac{(P_1V_1+P_2V_2)T_1T_2}{(P_1V_1T_2+P_2V_2T_1)}$$

274 **(c)**

$E \propto T$

276 **(c)**

As number of moles increases, pressure increases and at certain pressure vapour condenses hence pressure now decreases

277 **(b)**

RMS speed of gas molecules does not depends on the pressure of gas (if temperature remains constant) because $p \propto \rho$. If pressure is increased n times density will also increase by n times but v_{rms} remains constant.

278 **(c)**

Moist and hot air being lighter rises up and leaves the room throught the ventilator near the roof and fresh air rushes into the room throught the doors.

279 **(d)**

$P = 4.5 \times 10^5$ Pa; $dQ = 800$ kJ

$V_1 = 0.5\ \text{m}^3; V_2 = 2\ \text{m}^3$

$dW = P(V_2 - V_1) = 4.5 \times 10^5(2 \times 0.5)$

$= 6.75 \times 10^5\text{J}$

Change in internal energy

$dU = dQ - dW$

$= 800 \times 10^3 - 6.75 \times 10^5 = 1.25 \times 10^5$ J

280 **(a)**

Work done during the cycle = area enclosed in the curve = $(2P-P)(2V-V)=PV$

281 **(c)**

$$\eta = 1-\frac{T_2}{T_1}$$
$$\omega = \frac{T_2}{T_1-T_2}=\frac{T_2/T_1}{1-(T_2/T_1)}=\frac{(1-\eta)}{\eta}=\frac{1}{\eta}-1$$

283 **(b)**

Ideal gas equation can be written as

$$pV = nRT$$

...(i)

From Eq. (i), we have

$\frac{n}{V}=\frac{p}{RT}$ =constant

So, at constant pressure and temperature, all gases will contain equal number of molecules per unit volume.

284 **(c)**

From the given $V-T$ diagram, we can see that in process $AB, V \propto T$.therefore pressure is constant (as quantity of the gas remains same)

In process BC, V =constant and in process CA, T =constant

Therefore these processes are correctly represented on $P-V$ diagram by graph (c)

285 **(a)**

According to kinetic theory, molecules of a liquid are in a state of continuous random motion. They continuously collide against the walls of the container. During each collision, certain momentum is transferred to the walls of the container. So, kinetic energy of molecules increases, hence due to random motion, the temperature increase. So, random motion of molecules and not ordered motion cause rise of temperature.

286 **(d)**

It is because of their low densities

287 **(b)**

Root mean square speed

$$v_{\text{rms}} \propto \frac{1}{\sqrt{\rho}}$$

$$\therefore \quad \frac{v_{\text{rms}_1}}{v_{\text{rms}_2}} = \sqrt{\frac{\rho_2}{\rho_1}}$$

Given, $\quad \frac{\rho_1}{\rho_2} = \frac{9}{8}$

$$\Rightarrow \quad \frac{v_{\text{rms}_1}}{v_{\text{rms}_2}} = \sqrt{\frac{8}{9}} = \frac{2\sqrt{2}}{3}$$

288 **(d)**

Root means square velocity of molecule in left part

$$v_{rms} = \sqrt{\frac{3KT}{m_L}}$$

Mean or average speed of molecule in right part

$$v_{av} = \sqrt{\frac{8}{\pi}\frac{KT}{m_R}}$$

According to problem $\sqrt{\frac{3KT}{m_L}} = \sqrt{\frac{8}{\pi}\frac{KT}{m_R}}$

$$\Rightarrow \frac{3}{m_L} = \frac{8}{\pi\, m_R} \Rightarrow \frac{m_L}{m_R} = \frac{3\pi}{8}$$

289 **(a)**

Root mean square velocity (v_{rms}), given by

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

where R is gas constant, T the temperature and M molecular weight.

Given, $\quad T_1 = 27°\text{C} = 273 + 27 = 300$ K,

$\quad T_2 = 327°\text{C} = 327 + 273 = 600$ K

$$\therefore \quad \frac{(v_{\text{rms}})_1}{(v_{\text{rms}})_2} = \sqrt{\frac{300}{600}} = \sqrt{\frac{1}{2}}$$

$$\Rightarrow \quad (v_{\text{rms}})_2 = \sqrt{2}\,(v_{\text{rms}})_1$$

Hence, rms speed increases $\sqrt{2}$ times.

290 **(b)**

Neglecting bond length, the volume of an oxygen molecule has been taken as 2 times that of one oxygen atom.

In 22.4 litres $i.e.$, $22.4 \times 10^{-3} m^3$, there are $N_A = 6.23 \times 10^{23}$ molecules

Total volume of oxygen molecules $= 2 \times \frac{4}{3}\pi r^3 \times N_A$

$22.4 \times 10^{-3} m^3$ is occupied by N_A molecules

$\therefore$ Fraction of volume occupied

$$= \frac{2 \times \frac{4}{3} \times \pi \times (1.5 \times 10^{-10})^3 \times 6.2 \times 10^{23}}{(22.4 \times 10^{-3})}$$

$$= 8 \times 10^{-4}$$

292 **(d)**

$$C_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

Or $M = \frac{3RT}{C_{\text{rms}}^2} = \frac{3 \times 8.31 \times 300}{(1920)^2}$

$= 2 \times 10^{-3}$ kg $=$ 2g

Since, $M = 2$ for the hydrogen molecule. Hence, the gas is hydrogen.

293 **(c)**

Since the volume of cylinder is fixed, the heat required is determined by C_V

He is a monoatomic gas.

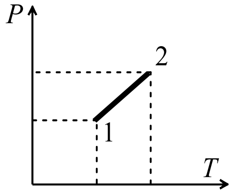
Therefore, its molar specific heat at constant volume is

$$C_V = \frac{3}{2}R$$

$\therefore$ Heat required = no. of moles × molar specific × rise in temperature

$$= 2 \times \frac{3}{2}R \times 20 = 60R = 60 \times 8.31 = 498.6J$$

294 **(c)**



$PV = \mu RT$

$\Rightarrow V \propto \frac{T}{P}$ ($\because$ μ and R are fixed)

Since, T increases rapidly and P increases slowly thus volume of the gas increases

295 **(c)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow T \propto M \quad [\because v_{rms}, R \to \text{constant}]$$

$$\Rightarrow \frac{T_{O_2}}{T_{N_2}} = \frac{M_{O_2}}{M_{N_2}} \Rightarrow \frac{T_{O_2}}{(273+0)} = \frac{32}{28} \Rightarrow T_{O_2} = 312K$$

$$= 39°\text{C}$$

296 **(c)**

Work done by the balloon

$$W = \int_{15\text{ m}^3}^{20\text{ m}^3} P_0 dV + \int_{20\text{ m}^3}^{25\text{ m}^3} P dV$$

$$= \int_{15\text{ m}^3}^{20\text{ m}^3} P_0 dV + \int_{20\text{ m}^3}^{25\text{ m}^3} [P_0 + 2(V - V_0)^2] dV$$

$$= \left[100 \times 5 + 100 \times 5 + 2 \times \frac{(25-20)^3}{3}\right] \text{kJ}$$

$$= 1083 \text{ kJ}$$

297 **(b)**

$(\Delta Q)_P = \mu C_P \Delta T$ and $(\Delta Q)_V = \mu C_V \Delta T$

$$\Rightarrow \frac{(\Delta Q)_V}{(\Delta Q)_P} = \frac{C_V}{C_P} = \frac{\frac{3}{2}R}{\frac{5}{2}R} = 3/5$$

$$\left[\because (C_V)_{mono} = \frac{3}{2}R, (C_P)_{mono} = \frac{5}{2}R\right]$$

$$\Rightarrow (\Delta Q)_V = \frac{3}{5} \times (\Delta Q)_P = \frac{3}{5} \times 210 = 126\,J$$

298 **(b)**

RMS velocity is given by

$$v = \sqrt{\frac{3kT}{m}} \qquad \text{or} \qquad v^2 = \frac{3kT}{m}$$

For a gas, k and m are constants.

$$\therefore \qquad \frac{v^2}{T} = \text{constant}$$

299 **(d)**

BC is isochoric. $V_B > V_A, V_B = V_c, V_D > V_c$

300 **(b)**

We know fraction of given energy that goes to increase the internal energy $= 1/\gamma$.

So we can say the fraction of given energy that is supplied for external work $= 1 - (1/\gamma)$

301 **(c)**

$C_{\text{isothermal}} = \infty$ and $C_{\text{adiabatic}} = 0$

302 **(b)**

Kinetic energy for $1g \Rightarrow E_{\text{Trans}} = \frac{3}{2}rT = \frac{3}{2}\frac{RT}{M}$

303 **(c)**

$\gamma = 1 + \frac{2}{f} \Rightarrow 1.4 = 1 + \frac{2}{f} \Rightarrow$ Degree of freedom $f = 5$

$\Rightarrow$ Degree of freedom of diatomic gas is 5 and it's $C_P = \frac{7}{2}R$ and $C_V = \frac{5}{2}R$

304 **(d)**

$$PV = \mu RT \Rightarrow P\left(\frac{m}{\rho}\right) = \mu RT \Rightarrow \rho \propto \frac{P}{T}$$

Since T becomes four times and P becomes twice so ρ becomes $\frac{1}{2}$ times

305 **(d)**

Average kinetic energy $E = \frac{f}{2}kT$

Sinec f and T are same for both the gases so they will have equal energies also

306 **(a)**

As $\theta_2 > \theta_1 \Rightarrow \tan\theta_2 > \tan\theta_1 \Rightarrow \left(\frac{T}{P}\right)_2 > \left(\frac{T}{P}\right)_1$

Also from $PV = \mu RT; \frac{T}{P} \propto V \Rightarrow V_2 > V_1$

308 **(a)**

$6T_1 = 3T_2 = 2T_4 = T_3 = 1800\text{K}$

$T_1 = 300\text{ K};\ \ T_2 = 600\text{ K}$

$T_4 = 900\text{ K}; T_3 = 1800\text{ K}$

$4 \to 1$ and $2 \to 3$ are isochoric processes in which Work done $= 0$

$W_{12} = P(V_2 - V_1) = nR(T_2 - T_1)$

$= 2 \times R(600 - 300) = 600R$

$W_{34} = P(V_4 - V_3) = nR(T_4 - T_3)$

$= 2 \times R(900 - 1800) = -1800R$

$W_{\text{Total}} = 600R - 1800R = -1200R = -10000\text{ J}$

309 **(a)**

No. of moles $n = \frac{m}{\text{molecular weight}} = \frac{5}{32}$

So, from ideal gas equation

$$pV = nRT$$

$$\Rightarrow \qquad pV = \frac{5}{32}RT$$

310 **(c)**

$n_1C_{v1}\Delta T_1 = n_2C_{v2}\Delta T_2$

$$\Rightarrow n_1 \times \frac{3}{2}R \times 10 = n_2 \times \frac{5}{2}R \times 6 \Rightarrow \frac{n_1}{n_2} = 1$$

311 **(b)**

$$P = \frac{P_0}{1 + (V/V_0)^3} = \frac{P_0}{2}$$

$$T = \frac{P_0V_0}{2R}$$

Therefore translational kinetic energy is equal to

$$\frac{3}{2}RT = \frac{3R}{2}\frac{P_0V_0}{2R} = \frac{3P_0V_0}{4}$$

312 **(d)**

$$v_{rms} \propto \frac{1}{\sqrt{M}}; \text{so } \frac{(v_{rms})_{O_2}}{(v_{rms})_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{2}{32}} = 1:4$$

313 **(d)**

$$\frac{\Delta Q}{\Delta t} = KA\left(\frac{\Delta T}{\Delta x}\right) = K\pi r^2\left(\frac{\Delta T}{l}\right) \propto \frac{r^2}{l}$$

As $\frac{r^2}{l}$ is maximum for (d), it is the correct choice.

314 **(c)**

$v_{rms} = \sqrt{\frac{3RT}{M}}$. According to problem T will become $2T$ and M will becomes $M/2$ so the value of v_{rms} will increase by $\sqrt{4} = 2$times, $i.e.$, new root mean square velocity will be $2v$

315 **(b)**

$P_f = 2p + \bar{p}$

Saturated vapour pressure will not change if temperature remains constant.

317 **(b)**

Number of translational degrees of freedom (3) are same for all types of gases

318 **(d)**

Kinetic energy $E = 1.5 \times 10^5$ J, volume, $V = 20L = 20 \times 10^{-3}\text{m}^3$

Pressure

$$= \frac{2}{3}\frac{E}{V} = \frac{2}{3}\left(\frac{1.5 \times 10^5}{20 \times 10^{-3}}\right) = 5 \times 10^6\text{N/m}^2$$

319 **(d)**

For adiabatic process:

Bulk modules: $B = \gamma P$

For point p: $P = \frac{nRT}{V} = \frac{nR3T_0}{3V_0} = \frac{nRT_0}{V_0}$

$\Rightarrow B = \dfrac{\gamma nRT_0}{V_0}$ (i)

Now $TV^{\gamma-1}$ =constant

$\Rightarrow (\gamma-1)TdV + VdT = 0$

$\Rightarrow \dfrac{dV}{dT} = \dfrac{-V}{(\gamma-1)T}$

For point $P \rightarrow$

$\dfrac{-3V_0}{3T_0} = \dfrac{-(3V_0)}{(\gamma-1)(3T_0)}$

$\Rightarrow \gamma = 2$

So form Eq.(i), $B = \frac{2nRT_0}{V_0}$

320 **(b)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow v_{rms}^2 \propto T$$

321 **(b)**

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{3}\sqrt{\frac{RT}{M}} = 1.73\sqrt{\frac{RT}{M}}$$

322 **(a)**

$$v_{\text{rms}} \propto \sqrt{\frac{3RT}{M}}$$

$$\Rightarrow \quad T \propto v_{\text{rms}}^2$$

$$\Rightarrow \quad \frac{T_2}{T_1} = \left[\frac{v_2}{v_1}\right]^2 = \frac{1}{4} \Rightarrow T_2 = \frac{T_1}{4}$$

$$= \frac{273+327}{4}$$

$$= 150\text{ K} = -123\text{°C}$$

323 **(d)**

Root mean square velocity,

$$c = \sqrt{\frac{3pV}{M}} = \sqrt{\frac{3RT}{M}}$$

$$c_1 = \sqrt{\frac{3R(T/2)}{2M}} = \frac{1}{2}\sqrt{\frac{3RT}{M}}$$

$$= \frac{c}{2} = \frac{300}{2} = 150\text{ ms}^{-1}$$

324 **(c)**

At constant pressure $V \propto T \Rightarrow \frac{\Delta V}{V} = \frac{\Delta T}{T}$

Hence ratio of increase in volume per degree rise in kelvin temperature to it's original volume

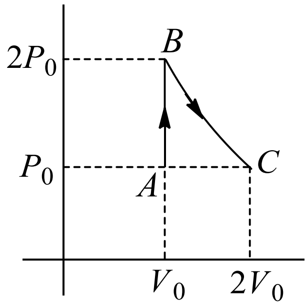
$= \frac{(\Delta V/\Delta T)}{V} = \frac{1}{T}$

325 **(c)**

$Q_{AB} = \Delta U_{AB} + W_{AB}$

$W_{AB} = 0$

$\Delta U_{AB} = \dfrac{f}{2}nR\Delta T$



$\dfrac{f}{2}(\Delta PV)\Delta U_{AB} = \dfrac{5}{2}(\Delta PV)$

$Q_{AB} = 2.5\,P_0V_0$

Process $BC, Q_{BC} = \Delta U_{BC} + W_{BC}$

$Q_{BC} = 0 + 2\,P_0V_0\log 2 = 1.4\,P_0V_0$

$Q_{\text{net}} = Q_{AB} + Q_{BC} = 3.9\,P_0V_0$

326 **(c)**

In the given graph, line has a positive slope with the x-axis and negative intercept on the y –axis. So we can write the equation of line as

$y = mx - c$ (i)

According to Charles's law

$V_t = \dfrac{V_0}{273}t + V_0$

By rewriting this equation, we get

$t = \left(\frac{273}{V_0}\right)V_t - 273$ (ii)

By comparing Eqs. (i) and (ii), we can say that time is represented on the y-axis and volume on the x-axis

327 **(c)**

Process AB is isochoric; therefore

$W_{AB} = P\Delta V = 0$

Process BC is isothermal; therefore

$W_{BC} = RT_2\text{In}\left(\dfrac{V_2}{V_1}\right)$

Process CA is isobaric; therefore

$W_{CA} = P\Delta V = R\Delta T = R(T_2 - T_1)$

328 **(b)**

$$v_{av} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{v_{He}}{v_H} = \sqrt{\frac{M_H}{M_{He}}} = \sqrt{\frac{1}{4}} = \frac{1}{2} \Rightarrow v_{He} = \frac{v_H}{2}$$

329 **(b)**

$$C_P - C_V = \frac{R}{J} \Rightarrow C_P = \frac{R}{J} + C_V = \frac{R}{J} + \frac{R}{J(\gamma-1)}$$

$$\Rightarrow C_P = \frac{R}{J}\left(\frac{\gamma}{\gamma-1}\right) = \frac{R}{J}\left(\frac{1.5}{1.5-1}\right) = \frac{3R}{J}$$

331 **(b)**

Energy of 1 mol of gas

$= \dfrac{f}{2}RT = \dfrac{f}{2}PV$

Where f = degree of freedom

Monatomic or diatomic gases possess equal degree of freedom for translation motion and that is equal to 3, i.e., $f = 3$

$\therefore\ E = \frac{3}{2}PV$

332 **(d)**

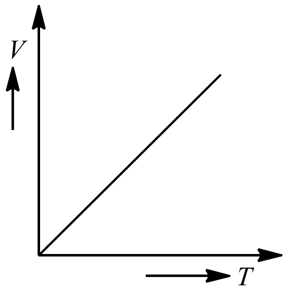
C_v for hydrogen $= 5R/2$, C_V for helium$= 3R/2$, C_v for water vapour $= 6R/2$

$$\therefore (C_v)_{\text{mix}} = \frac{4 \times \frac{5R}{2} + 2\frac{3R}{2} + 1 \times 3R}{4 + 2 + 1} = \frac{16R}{7}$$

$$\therefore C_P + C_V + R = \frac{16R}{7} + R = \frac{23R}{7}$$

333 **(c)**

At constant pressure, the volume of a given mass of a gas is directly proportional to its absolute temperature (T).



ie., $\frac{V}{T}$=constant

This is another form of Charles' law. Hence, variation of volume with temperature is as shown.

Hence, correct graph will be (C).

334 **(b)**

When temperature of gas increases, it expands. As the cross-sectional area of area of right piston is more, greater force will work on it (because $F = PA$). Piston will move towards right

335 **(c)**

Specific heat at constant pressure (C_p) is the amount of heat (Q) required to raise n moles of substance by $\Delta\theta$ when pressure is kept constant. Then

$$C_p = \frac{Q}{n\Delta\theta}$$

Given, Q=70 cal, $n = 2$,

$\Delta\theta = (35 - 35)°\text{C} = 5°\text{C}$

$$\therefore \qquad C_p = \frac{70}{2\times5}\text{=7 cal mol}^{-1} - \text{K}^{-1}$$

From Mayer's formula $C_p - C_V = R$

where R is gas constant ($= 2$ cal mol^{-1})

$\therefore \quad 7 - C_V = 2$

$\Rightarrow \quad C_V = 5\ \text{cal mol}^{-1} - \text{K}^{-1}$

Hence, amount of heat required at constant volume (C_V) is

$$Q' = nC_V\Delta\theta$$
$$Q' = 2 \times 5 \times 5 = 50\ \text{cal}$$

336 **(c)**

We have $v_{\text{rms}} = \sqrt{\frac{v_1^2+v_2^2+...+v_n^2}{n}}$

$$= \sqrt{\frac{4+25+9+36+9+25}{6}}$$

$= \sqrt{\frac{108}{6}} = \sqrt{18} = 3\sqrt{2} = 3 \times 1.414 = 4.242$ unit.

337 **(c)**

Here, $\Delta l = 80.3 - 80.0 = 0.3$ cm

$l = 80$ cm, $\alpha = 12\ \times 10^{-6}°\text{C}^{-1}$

Rise in temperature $\Delta T = \frac{\Delta l}{l\alpha}$

$$\Delta T = \frac{0.3}{80 \times 12 \times 10^{-6}} = 312.5°\text{C}$$

338 **(c)**

The root mean square velocity

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

where R is gas constant, T the temperature and M the molecular weight.

Given, $v_{\text{He}} = v_{\text{H}}$, $T_{\text{H}} = 273$ K, $M_{\text{H}} = 2$, $M_{\text{He}} = 4$

$$\therefore \qquad \frac{v_{\text{H}}}{v_{\text{He}}} = \sqrt{\frac{T_{\text{H}}}{T_{\text{He}}} \times \frac{M_{\text{He}}}{M_{\text{H}}}}$$

$$\therefore \qquad 1 = \sqrt{\frac{273}{T_{\text{He}}} \times \frac{4}{2}}$$

$\Rightarrow \qquad T_{\text{He}} = 546$ K

In °C, $T_{\text{He}} = (546 - 273)°\text{C} = 273°\text{C}$

339 **(d)**

$(\Delta Q)_P = \mu C_P \Delta T \Rightarrow 207 = 1 \times C_P \times 10$

$\Rightarrow C_P = 20.7\frac{Joule}{mol - K}$. Also $C_P - C_V = R$

$\Rightarrow C_V = C_P - R = 20.7 - 8.3 = 12.4\frac{Joule}{mole - K}$

So, $(\Delta Q)_V = \mu C_V \Delta T = 1 \times 12.4 \times 10 = 124\,J$

340 **(d)**

$C_P - C_V = R$ and R is constant for all gases

341 **(c)**

At constant volume

$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \left(\frac{P_2}{P_1}\right)T_1$

$\Rightarrow T_2 = \left(\frac{3P}{P}\right) \times (273 + 35) = 3 \times 308 = 924K$

$= 651°\text{C}$

342 **(b)**

Speed of sound in gases in given by

$$v_{\text{sound}} = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}} = \sqrt{\frac{d_2}{d_1}}$$

343 **(c)**

From $\frac{\Delta Q}{\Delta t} = KA\left(\frac{\Delta T}{\Delta x}\right)$

$$\Delta t = \frac{\Delta Q \Delta x}{KA(\Delta T)}$$

In arrangement (b), A is doubled and Δx is halved.

$\therefore\ \Delta t\ \rightarrow \frac{1/2}{2} \rightarrow \frac{1}{4}$ time

ie , $\frac{1}{4} \times 4$ min= 1 min

344 **(c)**

$\because C_P - C_v = R$

Fractional part of heat energy $= \frac{C_P - R}{C_P}$

$$= \frac{\frac{7}{2}R - R}{\frac{7}{2}R} = \frac{5}{7}$$

345 **(a)**

If the volume remains constant, then

$$\frac{p_1}{p_2} = \frac{T_1}{T_2}$$

$$\Rightarrow \qquad \frac{p}{p + \frac{0.4}{100}p} = \frac{T}{T+1}$$

or $\qquad T = 250$ K

346 **(d)**

Mean kinetic energy for μ mole gas $= \mu . \frac{f}{2} RT$

$$\therefore E = \mu \frac{7}{2} RT = \left(\frac{m}{M}\right)\frac{7}{2} NkT = \frac{1}{44}\left(\frac{7}{2}\right) NkT$$

$= \frac{7}{88} NkT$ [As $f = 7$ and $M = 44$ for CO_2]

347 **(b)**

$$P = \frac{\mu RT}{V} = \frac{mRT}{MV} \quad \left(\mu = \frac{m}{M}\right)$$

So, at constant volume pressure-versus temperature graph is a straight line passing through origin with slope $\frac{mR}{MV}$. As the mass is doubled and volume is halved slope becomes four times. Therefore, pressure versus temperature graph will be shown by the line B

348 **(d)**

Since the gas is slowly heated, it remains in equilibrium (more or less) with the atmosphere, i.e., the process takes place at a constant pressure

Now, from $PV = nRT, PdV = nRdT$ (i)

or, $P\Delta V$ is the work done by the gas

So, $\Delta W = nR\Delta T = (2 \text{ mol})(R)(4T_0 - T_0) = 6RT_0$

[From Eq. (i) $\Delta V \propto \Delta T, \text{i.e.}, \text{if } \Delta V = 3V_0, \Delta T = 3T_0$]

349 **(c)**

As $\Delta U = 0$ in a cyclic process,

$\Delta Q = \Delta W =$ area of circle$= \pi r^2$

or $\Delta W = 10^2 \pi$ J

350 **(a)**

$C = C_v + \beta V$

$$\frac{dQ}{dT} = \frac{dU}{dT} + P\frac{dV}{dT} \Rightarrow C = C_V + \frac{PdV}{dT}$$

Comparing, $P\frac{dV}{dT} = \beta V$

$$\frac{RT}{V}\frac{dV}{dT} = \beta V \Rightarrow \frac{dV}{V^2} = \frac{\beta}{R}\frac{dT}{T}$$

On integration

$$\frac{-1}{V} = \frac{\beta}{R}\text{In}\, T \Rightarrow -\text{In}\, T = \frac{R}{\beta V}$$

$\Rightarrow T^{\beta v/R}$ =constant

351 **(a)**

For an adiabatic process, $PV^\gamma = K$

Here, $\gamma = 3/2$ and K =constant

$\therefore PV^{3/2} = K$

$$\log P + \frac{3}{2}\log V = \log K$$

$$\frac{\Delta P}{P} + \frac{3}{2}\frac{\Delta V}{V} = 0$$

$$\therefore \frac{\Delta V}{V} = -\frac{2}{3}\frac{\Delta P}{P}$$

$$\frac{\Delta V}{V} \times 100 = -\left(\frac{2}{3}\right)\left(\frac{\Delta P}{P} \times 100\right) = -\frac{2}{3} \times \frac{2}{3} = -\frac{4}{9}$$

Therefore volume decreases by about (4/9)%

352 **(d)**

A is free to move; therefore, heat will be supplied at constant pressure

$dQ = nC_p dT_A \quad (i)$

B is held fixed, therefore, heat will be supplied at constant

Volume

$dQ_B = nC_V dT_B \quad (ii)$

But $dQ_A = dQ_B$

$nC_p dT_A = nC_v dT_B$

$$dT_B = \left(\frac{C_p}{C_v}\right) dT_A$$

$= \gamma(dT_A) \quad (\gamma = 1.4 \text{ (diatomic)}(dT_A = 30K)$

$= (1.4)(30K)$

$dT_B = 42K$

353 **(a)**

Let t be the temperature of mixture,

Heat gained by CO_2 = Heat lost by O_2

$\Rightarrow \mu_1 C_{v_1} \Delta T_1 = \mu_2 C_{v_2} \Delta T_2$

$$\Rightarrow \frac{22}{44}(3R)(t - 27) = \frac{16}{32}\left(\frac{5}{2}R\right)(37 - t)$$

$$\Rightarrow 3(t - 27) = \frac{5}{2}(37 - t)$$

By solving we get $t = 31.5$°C

354 **(d)**

Kinetic energy ∝ Temperature

$\Rightarrow \frac{E_1}{E_2} = \frac{T_1}{T_2} \Rightarrow \frac{E_1}{E_2} = \frac{(273+27)}{(273+927)} = \frac{300}{1200} = \frac{1}{4}$

$\Rightarrow E_2 = 4E_1$

355 **(b)**

$VP^3 = \text{constant} = k \Rightarrow P = \frac{k}{V^{1/3}}$

Also $PV = \mu RT \Rightarrow \frac{k}{V^{1/3}}.V = \mu RT \Rightarrow V^{2/3} = \frac{\mu RT}{k}$

Hence $\left(\frac{V_1}{V_2}\right)^{2/3} = \frac{T_1}{T_2} \Rightarrow \left(\frac{V}{27V}\right)^{2/3} = \frac{T}{T_2} \Rightarrow T_2 = 9T$

356 **(c)**

In the absence of intermolecular forces, there will be no stickness of molecules. Hence, pressure will increase.

357 **(a)**

$$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{(v_{rms})_{H_2}}{(v_{rms})_{He}} = \sqrt{\frac{M_{He}}{M_{H_2}}} = \sqrt{\frac{4}{2}} = \frac{\sqrt{2}}{1}$$

358 **(d)**

$$v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 + v_4^2 + v_5^2}{5}} = 4.24$$

359 **(b)**

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}} \qquad \text{or} \qquad v_{\text{rms}} \propto \sqrt{T}$$

v_{rms} is to reduce two times, *ie*, the temperature of the gas will have to reduce force times or

$$\frac{T'}{T} = \frac{1}{4}$$

During adiabatic process,

$$TV^{\gamma-1} = T'V'^{\gamma-1}$$

or $\frac{V'}{V} = \left(\frac{T}{T'}\right)^{\frac{1}{\gamma-1}}$

$= (4)^{\frac{1}{1.5-1}} = 4^2 = 16$

∴ $V' = 16\,V$

360 **(a)**

Work done is equal to area under the curve on PV diagram (a) is the correct option

361 **(c)**

When saturated vapour is compressed some of the vapour condenses but pressure does not change

362 **(d)**

Root mean square velocity

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

where R is gas constant, T the temperature and M molecular weight.

Given, $M_{\text{N}_2} = 28$, $M_{\text{O}_2} = 32$, $T_{\text{O}_2} = 127°\text{C} = 127 + 273 = 400\ \text{K}$

∴ $\frac{v_{\text{O}_2}}{v_{\text{N}_2}} = \sqrt{\frac{T_{\text{O}_2}}{M_{\text{O}_2}} \times \frac{M_{\text{N}_2}}{T_{\text{N}_2}}} = \sqrt{\frac{400}{32} \times \frac{28}{T_{\text{N}_2}}}$

$= 1$

⇒ $T_{\text{N}_2} = 350\ \text{K} = 77°\text{C}.$

364 **(b)**

$\frac{C_v}{C_P} \times Q = nC_v dT$

$dT = \frac{Q}{nC_P} = \frac{20}{2 \times \frac{5}{2} \times R} = 5\ \text{K}$

365 **(c)**

$$\gamma_{\text{max}} = \frac{\frac{\mu_1\gamma_1}{\gamma_1 - 1} + \frac{\mu_2\gamma_2}{\gamma_2 - 1}}{\frac{\mu_1}{\gamma_1 - 1} + \frac{\mu_2}{\gamma_2 - 1}}$$

$$= \frac{\frac{1\times\frac{5}{3}}{\left[\frac{5}{3}-1\right]} + \frac{1\times\frac{7}{5}}{\left[\frac{7}{5}-1\right]}}{\left[\frac{1}{\frac{5}{3}-1}\right] + \left[\frac{1}{\frac{7}{5}-1}\right]} = \frac{3}{2} = 1.5$$

366 **(c)**

Mean kinetic energy of molecule depends upon temperature only. For O_2 it is same as that of H_2 at the same temperature of −73°C

367 **(b)**

The mean kinetic energy for gas molecules

$$E = \frac{3}{2}kT \Rightarrow E \propto T$$

So, $\frac{E_1}{E_2} = \frac{T_1}{T_2}$ ... (i)

According to question both gases are at the same temperature T.

So, $\frac{E_1}{E_2} = \frac{T}{T} = \frac{1}{1}$

⇒ $E_1 : E_2 = 1 : 1$

368 **(d)**

From $C_V = \frac{1}{2}fR = \frac{1}{2} \times 6R = 3R$

369 **(d)**

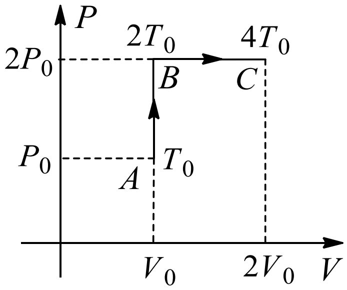
$r.m.s.$ velocity does not depend upon pressure

370 **(c)**

Molecules of ideal gas behaves like perfectly elastic rigid sphere

371 **(b)**

Let initial pressure, volume and temperature be P_o, V_0andT_0, respectively, indicated by state A in $P-V$ diagram. The gas is then isochorically taken to state $B(2P_0, V_0, 2T_0)$ and then taken from state B to state$C(2P_0, 2V_0, 4T_0)$ isobarically



Total heat absorbed by 1 mol of gas

$\Delta Q = C_v(2T_0 - T_0) + C_P(4T_0 - 2T_0)$

$= \frac{5}{2}RT_0 + \frac{7}{2}R \times 2T_0 = \frac{19}{2}RT_0$

Total change in temperature from serious A to C is $\Delta T = 3T_0$

Therefore,

Molar heat capacity $= \frac{\Delta Q}{\Delta T} = \frac{\frac{19}{2}RT_0}{3T_0} = \frac{19}{6}R$

372 **(d)**

Using $\gamma_r = \gamma_a +$ g, we get

$\gamma_r = \gamma_1 + 3\alpha = \gamma_2 + 3\beta$

$\therefore \beta = \frac{\gamma_1 - \gamma_2}{3} + \alpha$

373 **(b)**

The molecules of a gas are in a state of random motion. They continuously collide against the walls of the container. Even at ordinary temperature and pressure, the number of molecular collisions with walls is very large. During each collision, certain momentum is transferred to the walls of the container. The pressure exerted by the gas is due to continuous bombardment of gas molecules against the walls of the container. Due to this continuous bombardment, the walls of the container experience a continuous force which is equal to the total momentum imparted to the walls per second. The average force experienced per unit area of the walls container determines the pressure exerted by the gas. This should be clear from the fact that although the molecular collisions are random the pressure remains constant.

374 **(c)**

$p = \frac{n_1RT + n_2RT + n_3RT}{V}$

$= (n_1 + n_2 + n_3)\frac{RT}{V}$

$= \left(\frac{8}{16} + \frac{14}{28} + \frac{22}{44}\right) \times \frac{0.082 \times 300}{10} = 3.69$ atm

375 **(b)**

For an adiabatic process $TV^{\gamma-1}$ =constant.

Therefore,

$\frac{T_1}{T_2} = \left[\frac{V_2}{V_1}\right]^{\gamma-1}$

$\Rightarrow T_2 = T_1\left[\frac{V_1}{V_2}\right]^{\gamma-1}$

$= 300\left[\frac{27}{8}\right]^{5/3-1} = 300\left[\frac{27}{8}\right]^{2/3} = 675$ K

$\Rightarrow \Delta T = 675 - 300 = 375$ K

376 **(b)**

Heat added to helium during expansion

$H = nC_V\Delta T =$

$8 \times \frac{3}{2}R \times 30$ $\left(C_V \text{ for monoatomic gas} = \frac{3}{2}R\right)$

$=360\ R$

$= 360 \times 8.31$ J (R=8.31 J mol^{-1} – K^{-1})

≈ 3000 J

377 **(b)**

For first vessel, number of moles

$n_1 = \frac{m_1}{M_1} = \frac{32}{32} = 1$

Volume=V, Temperature=T

$\therefore$ $p_1V = RT$

..(i)

For second vessel number of moles

$=n_2 = \frac{m_2}{M_2} = \frac{4}{2} = 2$

Volume=V, Temperature=$2T$

$\therefore$ $p_2V = 2R(2T)$

...(ii)

From Eqs. (i) and (ii),

$p_2 = 4p_1 = 4\,p$

379 **(c)**

Boyle's and Charle's law follow kinetic theory of gases

380 **(c)**

For carbon dioxide, number of moles

$(n_1) = \frac{22}{44} = \frac{1}{2}$;

molar specific heat of CO_2 at constant volume

$C_{V_1} = 3\ R$

For oxygen, number of moles $(n_2) = \frac{16}{32} = \frac{1}{2}$;

molar specific heat of O_2 at constant volume

$C_{V_2} = \frac{5R}{2}$.

Let TK be the temperature of mixture.

Heat lost by O_2 = Heat gained by CO_2.

$n_2 C_{V_2} \Delta T_2 = n_1 C_{V_1} \Delta T_1$

$\frac{1}{2}\left(\frac{5}{2}R\right)(310 - T) = \frac{1}{2} \times (3R)(T - 300)$

Or $1550 - 5T = 6T - 1800$

Or $T = 304.54\text{K} = 31.5℃$

381 **(d)**

$PV = kT \Rightarrow P\left(\frac{m}{\rho}\right) = kT \Rightarrow \rho = \frac{Pm}{kT}$

382 **(c)**

$Q = nC_v\,\Delta T = n(C_p - R)\Delta T$

$= 5\left(7.03 - \frac{8.31}{4.2}\right) \times (20 - 10) = 250\text{ cal}$

383 **(a)**

By the graph, $W_{AB} = 0$ and $W_{BC} = 8 \times 10^4[5 - 2] \times 10^{-3} = 240\text{ J}$

$\therefore\ W_{AC} = W_{AB} + W_{BC} = 0 + 240 = 240\text{ J}$

Now,

$\Delta Q_{AC} = \Delta Q_{AB} + \Delta Q_{BC} = 600 + 200 = 800\text{ J}$

From the first law of thermodynamics,

$\Delta Q_{AC} = \Delta U_{AC} + \Delta W_{AC}$

$\Rightarrow 800 = \Delta U_{AC} + 240 \Rightarrow \Delta U_{AC} = 560\text{ J}$

384 **(c)**

According to Boyle's law $(P_1V_1)_{\text{bottom}} = (P_2V_2)_{\text{top}}$

$(10 + h) \times \frac{4}{3}\pi r_1^3 = 10 \times \frac{4}{3}\pi r_2^3$ but $r_2 = 2r_1$

$\therefore (10 + h)r_1^3 = 10 \times 8r_1^3 \Rightarrow 10 + h = 80\ \therefore h = 70m$

385 **(a)**

At sonstant pressure

$V \propto T \Rightarrow \frac{V_2}{V_1} = \frac{T_2}{T_1} \Rightarrow T_2 = \left(\frac{V_2}{V_1}\right)T_1$

$\Rightarrow T_2 = \left(\frac{3V}{V}\right) \times 273 = 819K = 546℃$

386 **(d)**

Consider n moles of a gas which undergo isochoric process, *ie*, V=constant. From first law of thermodynamics,

$$\Delta Q = \Delta W + \Delta U$$

...(i)

Here, $\Delta W = 0$ as $V =$ constant

$$\Delta Q = nC_V\Delta T$$

Substituting in Eq. (i), we get

$$\Delta U = nC_V\Delta T$$

...(ii)

Mayer's relation can be written as

$$C_p - C_V = R$$

$$\Rightarrow \qquad C_V = C_p - R$$

...(iii)

From Eqs. (ii) and (iii), we have

$$\Delta U = n(C_p - R)\Delta T$$

Given, $n = 6,\ C_p = 8\text{ cal mol}^{-1} - \text{K}^{-1}$,

$R = 8.31\text{ J mol}^{-1} - \text{K}^{-1}$

$\approx 2\text{ cal mol}^{-1} - \text{K}^{-1}$

Hence, $\Delta U = 6(8 - 2)(35 - 20)$

$= 6 \times 6 \times 15 = 540\text{ cal}$

387 **(c)**

We know that $C_P - C_V = \frac{R}{J}$

$\Rightarrow J = \frac{R}{C_P - C_V}$

$C_P - C_V = 1.98\frac{cal}{g - mol - K}$

$R = 8.32\frac{J}{g - mol - K}$

$\therefore J = \frac{8.32}{1.98} = 4.20J/cal$

388 **(b)**

For an adiabatic process,

$0 = dU + PdV$

or $d(a + bPV) + PdV = 0$

or $bP\,dV + bV\,dP + PdV = 0$

or $(b + 1)PdV + bV\,dP = 0$

or $(b + 1)\frac{dV}{V} + b\frac{dP}{P} = 0$

or $(b + 1)\log V + b\log P =$constant

$V^{b+1}P^b =$ constant

or $PV^{\frac{b+1}{b}} =$ constant

$\therefore \gamma = \frac{b + 1}{b}$

389 **(b)**

$\frac{E_1}{E_2} = \frac{T_1}{T_2} = \frac{300}{450} = \frac{2}{3}$

390 **(b)**

As $f = 6$ (given), therefore

$\gamma = 1 + \frac{2}{f} = 1 + \frac{2}{6} = \frac{4}{3}$

Fraction of energy given for external work

$\frac{\Delta W}{\Delta Q} = \left(1 - \frac{1}{\gamma}\right)$

$\Rightarrow \frac{25}{\Delta Q} = \left(1 - \frac{1}{4/3}\right) = 1 - \frac{3}{4} = \frac{1}{4}$

$\Rightarrow Q = 25 \times 4 = 100\text{ J}$

391 **(a)**

Change the internal energy

$\Delta U = \mu C_v\Delta T \Rightarrow U_2 - U_1 = \mu C_v(T_2 - T_1)$

Let initially $T_1 = 0$ so $U_1 = 0$ and finally $T_2 = T$ and$U_2 = U$

$U = \mu C_v T = \mu T \times C_v = \frac{PV}{R} \times \frac{R}{\gamma - 1} = \frac{PV}{\gamma - 1}$

(As $PV = \mu RT, \therefore \mu T = PV/R$ and $C_v = R/(\gamma - 1)$)

392 **(a)**

Average speed (v_{av}) of gas molecules is

$$v_{\text{av}} = \sqrt{\frac{8RT}{\pi M}}$$

where R is gas constant and M the molecular weight.

Given, $v_1 = v, \quad M_1 = 64, \quad v_2 = 4v$

$$\therefore \qquad \frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{v}{4v} = \sqrt{\frac{M_2}{64}}$$

$$\Rightarrow \qquad M_2 = \frac{64}{16} = 4$$

Hence, the gas is helium (molecular mass 4).

393 **(b)**

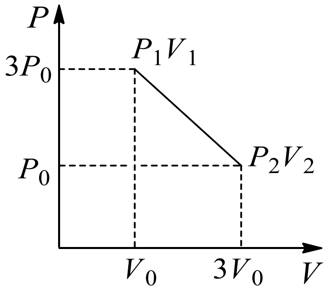
Neon gas is monoatomic and for monoatomic gases

$$C_V = \frac{3}{2}R$$

394 **(c)**

$$\frac{P - P_1}{P_1 - P_2} = \frac{V - V_1}{V_1 - V_2}$$

$$(P - P_1)(V_1 - V_2) = (V - V_1)(P_1 - P_2)$$



$$(P - 3P_0)(V_0 - 3V_0) = (V - V_0)(3P_0 - P_0)$$

$$(P - 3P_0)(-2V_0) = (V - V_0)(2P_0)$$

$$-2V_0P + 6P_0V_0 = 2VP_0 - 2P_0V_0$$

$$2VP_0 + 2V_0P - 8P_0V_0 = 0$$

$$VP_0 + \frac{V_0nRT}{V} - 4P_0V_0 = 0$$

$$V^2P_0 - 4P_0V_0 + V_0nRT = 0$$

$$T = \frac{P_0(-V^2 + 4VV_0)}{V_0nR}$$

For maximum or minimum value of T,

$$\frac{dT}{dV} = -2V + 4V_0 = 0 \Rightarrow V = 2V_0$$

$$\frac{d^2T}{dV^2} = -2$$

It is negative so

T is maximum at $V = 2V_0$

$$T_{\max} = \frac{P_0(-4V_0^2 + 8V_0^2)}{V_0nR} = \frac{4P_0V_0}{nR}$$

395 **(c)**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$T_2 = \frac{P_2V_2}{P_1V_1}T_1 = \frac{2}{1} \times \frac{3}{1} \times 300 = 1800K = 1527°\text{C}$$

396 **(c)**

Mean kinetic energy per molecule $E = \frac{f}{2}kT = \frac{n}{2}kT$

398 **(d)**

For an ideal gas keeping the temperature same throughout,

$$pV = \text{constant}$$

Hence, for a given mass, the graph between pV and V will be a straight line parallel to V-axis whatever may be the volume.

399 **(a)**

$$PV = \mu RT = \frac{m}{M}RT \Rightarrow P = \frac{d}{M}RT \left[\text{Density } d = \frac{m}{V}\right]$$

$$\Rightarrow \frac{P}{dT} = \text{constant or} \frac{P_1}{d_1T_1} = \frac{P_2}{d_2T_2}$$

400 **(a)**

At constant temperature

$PV =$ constant

$$\Rightarrow \frac{P_1}{P_2} = \frac{V_2}{V_1} \Rightarrow \frac{70}{120} = \frac{V_2}{1200} \Rightarrow V_2 = 700\, ml$$

401 **(c)**

$$\frac{E_1}{E_2} = \frac{T_1}{T_2} \Rightarrow \frac{E}{2E} = \frac{(273 + 27)}{T_2} \Rightarrow T_2 = 600K$$

$$= 327°\text{C}$$

402 **(a)**

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

Room temperature, $T \approx 300$ K

$$1930 = \sqrt{\frac{3 \times 8.31 \times 10^3 \times 300}{M}}$$

$M = 2$ g

or the gas is H_2

403 **(c)**

At constant volume the total energy will be utilized in increasing the temperature of gas i.e., $(\Delta Q)_v = \mu C_v \Delta T = \mu C_v(120 - 100) = 80$

$$\Rightarrow \mu C_v = \frac{80}{20} = 4\ \text{J/K}$$

This is the heat capacity of 5 mol gas

404 **(d)**

The square root of $\bar{v}^2$ is called the root mean square velocity (rms) speed of the molecules.

$$v_{\text{rms}} = \sqrt{\bar{v}^2} = \sqrt{\frac{v_1^2+v_2^2+v_3^3+v_4^4}{4}}$$

$$= \sqrt{\frac{(1)^2+(2)^2+(3)^2+(4)^2}{4}}$$
$$= \sqrt{\frac{1+4+9+16}{4}} =$$
$$\sqrt{\frac{30}{4}} = \sqrt{\frac{15}{2}} \text{ kms}^{-1}$$

405 **(d)**

$p = p_1 + p_2 + p_3$

$= \left(\frac{nRT}{V}\right)_{O_2} + \left(\frac{nRT}{V}\right)_{N_2} + \left(\frac{nRT}{V}\right)_{CO_2}$

$= \left(n_{O_2} + n_{N_2} + n_{CO_2}\right)\frac{RT}{V}$

$= \frac{(0.25+0.5+0.5)(8.31)\times 300}{4\times 10^{-3}}$

$= 7.79 \times 10^5 \text{ Nm}^{-2}$

406 **(b)**

Here , $m = 0.1$ kg, $h_1 = 10$m, $h_2 = 5.4$ m

$c = 460$ J-kg^{-1}°C^{-1}, g $= 10$ms^{-2}, $\theta = ?$

Energy dissipated, $Q = mg(h_1 - h_2)$

$= 0.1 \times 10(10 - 5.4) = 4.6j$ J

From $Q = c\, m\, \theta$

$$\theta = \frac{Q}{cm} = \frac{4.6}{460 \times 0.1} = 0.1°\text{C}$$

407 **(c)**

$PV = nRT$ or $P = \frac{nRT}{V}$ or $P \propto T$

If V and n are same. Therefore, if T is doubled, pressure also become two times, i.e., $2P$

408 **(b)**

According to Wein's displacement law,

$\lambda_m T =$constant where λ_m is the wavelength for which intensity of radiation emitted is maximum

$(\lambda_m)_s T_s = (\lambda_m)_{NS} \times T_{NS}$

$S =$ sun

$NS =$north star

$$\Rightarrow \frac{T_s}{T_{NS}} = \frac{(\lambda_m)_{NS}}{(\lambda_m)_S} = \frac{350}{510} = 0.69$$

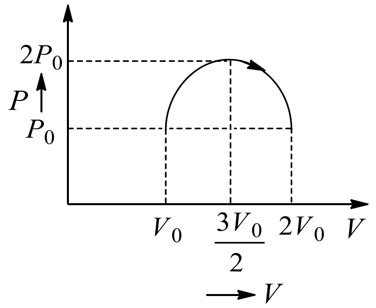
409 **(c)**

The $P - V$ equation is given as

$$P = \frac{12P_0}{V_0}V - \frac{4P_0}{V_0^2}V^2 - 7P_0$$

Putting $P = P_0$, we get

$V^2 - 3V_0 V + 2V_0^2 = 0$



$$V = \frac{+3V_0 \pm \sqrt{9V_0^2 - 8V_0^2}}{2} = 2V_0 \text{or} V_0$$

At $P = 2P_0, V = \frac{3V_0}{2}$

$\frac{dP}{dV} = 0$ at $V = \frac{3V_0}{2}$

$\frac{d^2P}{dV^2} =$negative

P attains the maximum value at $V = 3V_0/2$

410 **(d)**

Kinetic energy of a gas molecule

$$E = \frac{3}{2}kT$$

where k is Boltzmann's constant.

$\therefore \quad E \propto T$

or $\quad \frac{E_1}{E_2} = \frac{T_1}{T_2} \quad$ or $\quad \frac{E}{(E/2)} = \frac{300}{T_2}$

or $\quad T_2 = 150$ K

$T_2 = 150 - 273 = -123°$C

411 **(c)**

Let for mixture of gases, specific heat at constant volume be C_V

$$C_V = \frac{n_1(C_V)_1 + n_2(C_V)_2}{n_1 + n_2}$$

where for oxygen; $C_{V_1} = \frac{5R}{2}, n_1 = 2$ mol

For helium; $C_{V_2} = \frac{3R}{2}, n_2 = 8$ mol

Therefore, $C_V = \frac{\frac{2\times 5R}{2} + 8\times\frac{3R}{2}}{2+8} = \frac{17R}{10} = 1.7\, R$

412 **(b)**

The gas pressure

$= \frac{\text{weight of piston}}{\text{area of cross} - \text{section}} + \text{atm. pressure}$

$= \frac{8 \times 9.8}{60 \times 10^{-4}} + 1.00 \times 10^5 \text{ Nm}^2$

$= 1.13 \times 10^5 \text{ N/m}^2$

During the heating pressure, the internal energy is changed by ΔU_1 and work $\Delta W_1$is done

Therefore, $\Delta Q_1 = \Delta U_1 + \Delta W_1 = \Delta U_1 + PdV$

$= \Delta U_1 + (1.13 \times 10^5)(0.20 \times 60 \times 10^{-4})$

$= \Delta U_1 + 136$ J

During the cooling process, no work is done as volume is constant, $\Delta W = 0$

Hence, $\Delta Q_2 = \Delta U_2$. But ΔU_2 is negative as the temperature decreases, and since the gas returns to its original temperature, $\Delta U_2 = -\Delta U_1$

Hence

$[\Delta Q_1 - |\Delta Q_2|] = (\Delta U_1 + 136 - \Delta U_1) = +136$ J

413 **(b)**

Density of mixture, $\rho_{\text{mix}} = \frac{PM_{\text{mix}}}{RT}$

Mass of nitrogen gas, $m_N = 7g = 7 \times 10^{-3}$kg

Mass of carbon dioxide, $m_{CO_2} = 11$ g $= 11 \times$

10^{-3}kg

Molecular weight of nitrogen gas, $M_{\mathrm{N}} = 28 \times 10^{-3}$kg

Molecular weight of carbon dioxide, $M_{\mathrm{CO_2}} = 44 \times 10^{-3}$kg

$$M_{\mathrm{mix}} = \frac{n_N M_N}{n_N + n_{\mathrm{CO_2}}} = \frac{\frac{m_N}{M_N} M_N + \frac{m_{\mathrm{CO_2}}}{M_{\mathrm{CO_2}}} M_{\mathrm{CO_2}}}{\frac{m_N}{M_N} + \frac{m_{\mathrm{CO_2}}}{M_{\mathrm{CO_2}}}}$$

$$= \frac{m_{\mathrm{N}} + m_{\mathrm{CO_2}}}{\frac{m_{\mathrm{N}}}{M_{\mathrm{N}}} + \frac{m_{\mathrm{CO_2}}}{M_{\mathrm{CO_2}}}} = \frac{(7 + 11) \times 10^{-3}}{\left(\frac{7}{28} + \frac{11}{44}\right)}$$

$$= \frac{18 \times 10^{-3}}{\frac{1}{4} + \frac{1}{4}} = 36 \times 10^{-3}\mathrm{kg}$$

$$\rho = \frac{(1 \times 10^5)(36 \times 10^{-3})}{\frac{25}{3} \times 300} = 1.44\ \mathrm{kg/m^3}$$

414 **(d)**

Pressure due to an ideal gas is given by

$$p = \frac{M}{3V} v^2$$

Putting $\frac{M}{V} = \rho$, the density of gas

$$p = \frac{1}{3} \rho v^2$$

$$\Rightarrow \qquad v = \sqrt{\left(\frac{3p}{\rho}\right)}$$

$$\therefore \qquad v \propto \frac{1}{\sqrt{\rho}}$$

415 **(d)**

Escape velocity from the earth's surface is 11.2 km/sec

So, $v_{rms} = v_{\mathrm{escape}} = \sqrt{\frac{3RT}{M}} \Rightarrow T = \frac{(v_{\mathrm{escape}})^2 \times M}{3R}$

$$= \frac{(11.2 \times 10^3)^2 \times (2 \times 10^{-3})}{3 \times 8.31} = 10063K$$

416 **(c)**

Average velocity of gas molecule is

$$v_{av} = \sqrt{\frac{8RT}{\pi M}} \Rightarrow v_{av} \times \frac{1}{\sqrt{M}}$$

$$\Rightarrow \frac{< C_H >}{< C_{He} >} = \sqrt{\frac{M_{He}}{M_H}} = \sqrt{\frac{4}{1}} = 2 \Rightarrow < C_H > = 2 < C_{He} >$$

417 **(d)**

PV ∝Mass of gas × Temperature

In this problem pressure and volume remain constant, so $M_1 T_1 = M_2 T_2$=constant

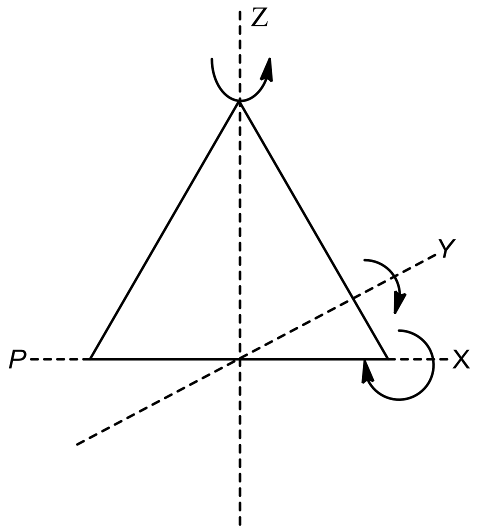
$$\therefore \frac{M_2}{M_1} = \frac{T_1}{T_2} = \frac{(27 + 273)}{(52 + 273)} = \frac{300}{325} = \frac{12}{13}$$

$$\Rightarrow M_2 = M_1 \times \frac{12}{13} = 13 \times \frac{12}{13}\mathrm{g} = 12\ \mathrm{g}$$

i.e., the mass of gas released from the flask $= 13\mathrm{g} - 12\ \mathrm{g} = 1\ \mathrm{g}$

418 **(c)**

As temperature requirement is not given so, the molecule of a triatomic gas has a tendency of rotating about any of three coordinate axes. So, it has 6 degrees of freedom; 3 translational and 3 rotational.



Thus,

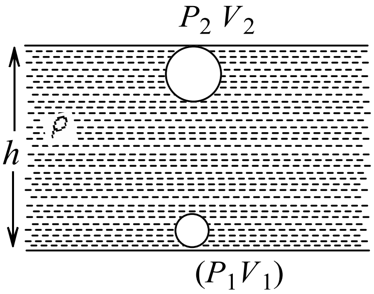
(3 translational+3 rotational) at room temperature.

419 **(c)**

In second part there is a vacuum, i.e., $P = 0$. So work done in expansion $= P\Delta V = 0$. Also, $\Delta Q = 0$. From the first law of thermodynamics, $\Delta U = 0$ i.e., temperature of an ideal gas remains same due to free expansion

420 **(d)**

According to Boyle's law, multiplication of pressure and volume will remain constant at the bottom and top.



If P is the atmosphere at the top of the lake and the volume of bubble just before touching surface is V. then from $P_1 V_1 = P_2 V_2$

$$(P + h\rho\mathrm{g}) V_0 = PV \Rightarrow V = \left(\frac{P + h\rho\mathrm{g}}{P}\right) V_0$$

$$\therefore\ V = V_0 \left[1 + \frac{\rho\mathrm{g}h}{P}\right]$$

421 **(a)**

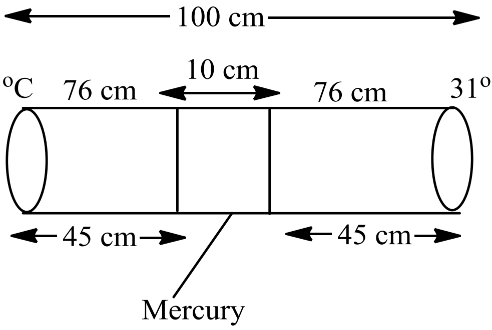
$(\Delta Q)_V = \mu C_V \Delta T \Rightarrow (\Delta Q)_V = 1 \times C_V \times 1 = C_V$

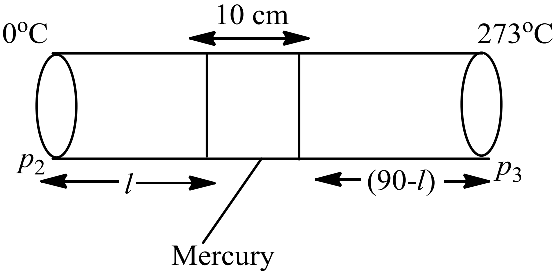
For monoatomic gas $C_V = \frac{3}{2}R$

$\therefore (\Delta Q)_V = \frac{3}{2}R$

422 **(c)**

On keeping the temperature of the ends of tube at 0°C and 273°C.





Applying ideal gas equation

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2} = \frac{p_3V_3}{T_3}$$

$$\frac{76\times45}{(273+31)} = \frac{p_2\times l}{(273+0)} = \frac{p_3(90-l)}{273+273}$$

$$\underset{\text{I}}{\frac{76\times45}{304}} = \underset{\text{II}}{\frac{p_2\times l}{273}} = \underset{\text{III}}{\frac{p_3(90-l)}{546}}$$

From II and III

$$\frac{p_2\times l}{273} = \frac{p_3(90-l)}{546}$$

(Mercury column is at rest, so pressure difference $p_2 - p_3 = 0 \Rightarrow p_2 = p_3$)

$$\therefore \quad \frac{p_2\times l}{273} = \frac{p_2(90-l)}{546}$$

$$\Rightarrow \quad 2l = 90 - l \Rightarrow l = 30 \text{ cm}$$

From I and II

$$\frac{76\times45}{304} = \frac{p_2\times30}{273}$$

$$\Rightarrow \quad p_2 = \frac{76\times45\times273}{30\times304}$$

$$p_2 = 102.4$$

423 **(b)**

The average speed of molecules of an ideal gas is given by

$$< v >= \sqrt{\frac{8RT}{\pi M}}$$

i.e., $< v > \propto \sqrt{T}$ for same gas

Since temperature of A and C are same, average speed of O_2 molecules will be equal in A and C, i.e., v_1

424 **(c)**

Here temperature remain constant

So $P_1V_1 = P_2V_2 \Rightarrow 76\times5 = P_2\times35$

$\Rightarrow P_2 = \frac{76\times5}{35} = 10.85 cm$ of Hg

425 **(b)**

$C_P - C_V = R =$ Universal gas constant

426 **(b)**

Molar specific heat of the mixture at constant volume is

$$C_V = \frac{n_1C_{V_1} + n_2C_{V_2}}{(n_1+n_2)}$$

$$= \frac{2\left(\frac{3}{2}R\right)+3\left(\frac{5}{2}R\right)}{2+3} = 2.1\ R$$

427 **(b)**

Number of moles $n = 5$ mol, $T_1 = 100°\text{C}$, $T_2 = 120°\text{C}$, $\Delta U = 80$ J

Rise in temperature $\Delta t = 120 - 100 = 20°\text{C}$

$$\Delta U = ms\Delta t$$

$$\frac{80}{5} = 1 \times s \times 20$$

$$s = 0.8 \text{ J}$$

$\therefore$ For 5 mol, $s = 0.8 \times 5\ \text{JK}^{-1} = 4\ \text{JK}^{-1}$

428 **(b)**

$C_P - C_V = R$

At constant pressure, Heat $= nC_P\theta$

$\Rightarrow 310 = 2 \times C_P \times (35 - 25) = 20C_P$

$\Rightarrow C_P = \frac{310}{20} = 15.5$

At constant volume, Heat required $= nC_V\theta$

$\Rightarrow Q = 2 \times (C_P - R) \times (32 - 25)$

$= 2 \times (15.5 - 8.3) \times 10 = 2 \times 7.2 \times 10 = 144J$

429 **(c)**

$\mu_1 = \frac{PV}{RT}, \mu_2 = \frac{PV}{RT}$

$P' = \frac{(\mu_1 + \mu_2)RT}{V} = \frac{2PV}{RT} \times \frac{RT}{V} = 2P$

430 **(d)**

The main kinetic energy of one mole of gas n degree of freedom.

$$E = \frac{n}{2}RT$$

The mean kinetic energy of one mole of gas per degree of freedom.

$$E' = \frac{E}{n} = \frac{\frac{n}{2}RT}{n}$$

$$E' = \frac{1}{2}RT$$

431 **(b)**

In isothermal changes, temperature remains constant

432 **(b)**

The pressure exerted by the gas,

$$p=\frac{1}{3}\rho c^2$$
$$=\frac{1}{3}\frac{m}{V}\bar{c}^2$$
$$=\frac{2}{3}\left(\frac{1}{2}m\bar{c}^2\right)$$

$(\because \frac{1}{2}m\bar{c}^2=\frac{E}{V}=$ energy per unit volume, $V=1)$

$$p=\frac{2}{3}E$$

433 **(c)**

1. The dotted line in the diagram shows that there is no derivation in the value of $\frac{pV}{nT}$ for different temperature T_1 and T_2 for increasing pressure so, this gas behaves ideally. Hence, dotted line corresponds to 'ideal' gas behavior.

2. At high temperature, the derivation of the gas is less and at low temperature the derivation of gas is more. In the graph, derivation for T_2 is greater than for T_1. Thus,

$$T_1>T_2$$

3. Since, the two curves intersect at dotted line so, the value of $\frac{pV}{nT}$ at that point on the y-axis is same for all gases.

434 **(a)**

From ideal gas equation, we have

$$pV=nRT$$
$$\therefore \quad n=\frac{pV}{RT}$$

Given, $p=22.4$ atm pressure

$=22.4\times1.01\times10^5\ \text{Nm}^{-2}$,

$V=2\text{L}=2\times10^{-3}\ \text{m}^3$,

$R=8.31\ \text{J mol}^{-1}-\text{K}^{-1}$,

$T=273$ K

$$\therefore \quad n=\frac{22.4\times1.01\times10^5\times2\times10^{-3}}{8.31\times273}$$
$$n=1.99\approx2$$

Since, $n=\frac{\text{Mass}}{\text{Atomic weight}}$

We have,

mass $=n\times$ atomic weight $=2\times14=28$ g

435 **(a)**

When C_P and C_V are given with *calorie* and R with *Joule* then $C_P-C_V=R/J$

436 **(a)**

Apparent weight (w_a)= Actual weight (w) – upthrust (F), where upthrust = weight of water displaced $=V\,p\omega$ g

Now, $F_0=V_0\,\rho_0$ g and $F_{50}=V_{50}\,\rho_{50}$g

$$\therefore \frac{F_{50}}{F_0}=\frac{V_{50}\,\rho_{50}\text{ g}}{V_0\,\rho_0\text{ g}}=\frac{1+\gamma_m\times50}{1+\gamma_w\times50}$$

As $\gamma_m<\gamma_w$, therefore, $F_{50}<F_0$

Hence , $(w_a)_{50}\ (w_a)_0$ or $w_2>w_1$ or $w_1<w_2$

437 **(c)**

For mono atomic gas, C_V is constant $\left(\frac{3}{2}R\right)$. It doesn't vary with temperature

438 **(b)**

Universal gas constant

$$R=C_p-C_V$$

439 **(a)**

$$v_{rms}\propto\sqrt{T},\frac{v_2}{v_1}=\sqrt{\frac{T_2}{T_1}}\Rightarrow v_2=\sqrt{\frac{(273+927)}{(273+27)}}v_1$$
$$\Rightarrow v_2=2v_1$$

440 **(a)**

Here, $h_1=50$ cm, $t_1=50$°C

$h_2=60$ cm, $t_2=100$°C

Now, $\frac{h_1}{h_2}=\frac{d_2}{d_1}=\frac{d_0}{1+\gamma t_2}\times\frac{1+\gamma t_1}{d_0}$

$$\frac{50}{60}=\frac{1+\gamma\times50}{1+\gamma\times100}$$
$$\therefore\ \gamma=\frac{1}{200}=0.005°\text{C}^{-1}$$

441 **(a)**

$$v_{rms}=\sqrt{\frac{3p}{\rho}}\Rightarrow\frac{v_1}{v_2}=\sqrt{\frac{\rho_2}{\rho_1}}=\sqrt{\frac{16}{1}}=\frac{4}{1}$$

442 **(a)**

$$\frac{C_P}{C_V}=\gamma=1+\frac{2}{f}$$

443 **(a)**

$$PV=\mu\,RT=\frac{m}{M}RT\Rightarrow V=\frac{mRT}{MP}$$

$$=\frac{2\times10^{-3}\times8.3\times300}{32\times10^{-3}\times10^{5}}=1.53\times10^{-3}m^{3}$$

$$=1.53\ litre$$

444 **(c)**

Due to increase in temperature root-mean-square velocity of gas molecules increases. So they strike the wall more often with higher velocity. Hence the pressure exerted by a gas on the walls of the container increases

445 **(c)**

Work done =area of the ΔABC

$$=\frac{1}{2}\times AC\times AB=\frac{1}{2}\times(3V_1-V_1)\times(4P_1-P_1)$$

$$=\frac{1}{2}\times2V_1\times3P_1=3P_1V_1$$

446 **(b)**

Using the relation $p=\frac{1}{3}\frac{mnv^2}{V}$

...(i)

and also $p'=\frac{1}{3}\frac{\frac{m}{2}n(2v)^2}{V}$

...(ii)

Dividing Eq.(ii) by Eq. (i), we get

$$\frac{p'}{p}=2$$

So, $p:p'=1:2$

The ratio of initial and final pressures is 1: 2.

447 **(b)**

Given, $p_1=100$ mm, $V_1=200$ mL and $p_2=400$ mm

From Boyle' Law

$$p_1V_1=p_2V_2$$

$$V_2=\frac{p_1V_1}{p_2}$$

$$=\frac{100\times200}{400}$$

$$V_2=50\text{ mL}$$

Volume of 2 mol gas$=2\times50=100$ mL

448 **(b)**

$$v_{rms}=\sqrt{\frac{3P}{\rho}}=\sqrt{\frac{3PV}{m}}\Rightarrow v_{rms}\propto\sqrt{\frac{P}{m}}$$

$$\Rightarrow\frac{v_1}{v_2}=\sqrt{\frac{P_1}{P_2}\times\frac{m_2}{m_1}}\Rightarrow\frac{v}{2v}=\sqrt{\frac{P_0}{P2}\times\frac{m/2}{m}}\Rightarrow P_2$$

$$=2P_0$$

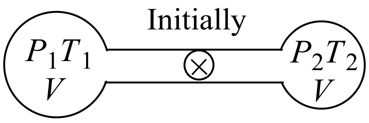
449 **(d)**

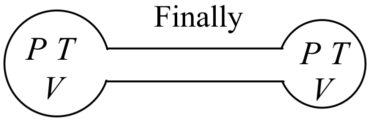
Number of moles in the first vessel

$$\mu_1=\frac{P_1V}{RT_1}$$

Number of moles in the second vessel

$$\mu_2=\frac{P_2V}{RT_2}$$





If both vessel are joined together, then quantity of gas remains same i.e., $\mu=\mu_1+\mu_2$

$$\frac{P(2V)}{RT}=\frac{P_1V}{RT_1}+\frac{P_2V}{RT_2}$$

$$\frac{P}{T}=\frac{P_1}{2T_1}+\frac{P_2}{2T_2}$$

450 **(b)**

From Andrews curve

451 **(b)**

Work done by the system=area of shaded portion on $P-V$diagram

$=(300-100)10^{-6}\times(200-100)\times10^{3}=20$ J

And direction of process is anticlockwise so work done will be negative, i.e., $\Delta W=-20$ J

452 **(a)**

Average kinetic energy per molecule per degree of freedom $=1/2kT$. Since both the gases are diatomic and are at same temperature (300 K), both will have the same number of rotational degree of freedom, i.e., two. Therefore, both the gases will have the same average rotational kinetic energy per molecule

$$=2\times\frac{1}{2}kT=kT$$

Thus, the ratio will be 1:1

453 **(b)**

$$v_{\text{rms}}=\sqrt{\frac{3RT}{M}}$$

$$v_{\text{rms}}\propto\sqrt{T}$$

When temperature is increased from 120 K to 480 K (i.e., four times), the root mean square speed will become $\sqrt{4}$ or 2 times i.e., $2v$

454 **(b)**

In case of given graph, V and T are related as $V=aT-b$, where a and b are constants.

From ideal gas equation, $PV=\mu RT$

We find $P=\frac{\mu RT}{aT-b}=\frac{\mu R}{a-b/T}$

Sinec $T_2>T_1$, therefore $P_2<P_1$

455 **(c)**

As $\eta=1=\frac{T_2}{T_1}$

$$\therefore \frac{50}{100} = 1 = \frac{500}{T_1} \text{ or } T_1 = 1000\text{K}$$

Again, $\frac{60}{100} = 1 - \frac{T_2}{1000}$

Or $T_2 = 400$ K

456 **(a)**

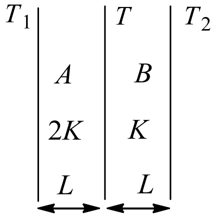
It is free expansion, temperature will remain constant

457 **(c)**

$v_{r.m.s.}$ is independent of pressure but depends upon temperature as $v_{rms} \propto \sqrt{T}$

458 **(b)**

$$H = \frac{2kA(T_1 - T)}{L} = \frac{kA(T - T_2)}{L}$$



$\Rightarrow 2T_1 - 3T = -T_2$

Adding T_1 on both sides:

$3T_1 - 3T = T_1 - T_2$

$$\Rightarrow T_1 - T = \frac{T_1 - T_2}{3}$$

$$= \frac{36}{3} = 12°\text{C}$$

459 **(b)**

At lower pressure we can assume that given gas behaves as ideal gas so $\frac{PV}{RT}$ = constant but when pressure increases, the decrease in volume will not take place in same proportion so $\frac{PV}{RT}$ will increase

460 **(d)**

$$v_{rms} = \sqrt{\frac{3P}{\rho}} \Rightarrow P = \frac{v_{rms}^2 \rho}{3}$$

$$= \frac{(3180)^2 \times 8.99 \times 10^{-2}}{3}$$

$= 3.03 \times 10^5 N/m^2 = 3\ atm$

461 **(d)**

Heat given, ΔQ

$= 20$ cal $= 20 \times 4.2 = 84$ J

Work done, $\Delta W = -50$ J

(as the process is anticlockwise)

By the first law of thermodynamics,

$\Delta U = \Delta Q - \Delta W = 84 - (-50) = 134$ J

462 **(a)**

$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow (v_{rms})_1 < (v_{rms})_2 < (v_{rms})_3$ also in mixture temperature of each gas will be same, hence kinetic energy also remains same

463 **(d)**

$$P \propto T \Rightarrow \frac{P_2}{P_1} = \frac{T_2}{T_1} = \frac{(273 + 100)}{(273 + 0)} = \frac{373}{273}$$

$$\Rightarrow P_2 = \frac{760 \times 373}{273} = 1038 mm$$

464 **(c)**

$$v_{rms} \propto \sqrt{T} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{200}{800}} = \frac{1}{2} \Rightarrow v_2 = 2v_1$$

465 **(b)**

$v_{rms} \propto \sqrt{T}$; To double the rms velocity temperature should be made four times, $i.e.$,

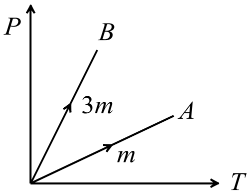
$T_2 = 4T_1 = 4(273 + 0) = 1092K = 819°\text{C}$

466 **(c)**

$$V \propto T \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2} \Rightarrow \frac{V}{2V} = \frac{(273 + 27)}{T_2} = \frac{300}{T_2}$$

$\Rightarrow T_2 = 600K = 327°\text{C}$

467 **(a)**



For a gas, $PV = \mu RT = \frac{m}{M} RT$

For graph A, $PV = \frac{m}{M} RT$

Slope of graph A,

$\left(\frac{P}{T}\right) = \frac{m}{M}\frac{R}{V}$ ...(i)

For graph B, $PV = \frac{3m}{M} RT$

Slope of graph B,

$\left(\frac{P}{T}\right) = \frac{3m}{M}\frac{R}{V}$ ...(ii)

$$\frac{\text{Slope of curve } B}{\text{Slope of curve } A} = \frac{\frac{3m}{M}\frac{R}{V}}{\frac{m}{M}\frac{R}{V}} = \frac{3}{1}$$

468 **(c)**

$$V \propto T \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$\Rightarrow \frac{V}{V_2} = \frac{(273 + 27)}{(273 + 327)} = \frac{300}{600} = \frac{1}{2} \Rightarrow V_2 = 2V$$

469 **(b)**

As the quantity of gas remains constant,

$\mu_A + \mu_B = \mu$

$$\frac{P_A V_A}{RT} + \frac{P_B V_B}{RT} = \frac{P(V_A + V_B)}{RT}$$

$$P = \frac{P_A V_A + P_B V_B}{V_A + V_B} = \frac{1.4 \times 0.1 + 0.70 \times 0.15}{0.1 + 0.15}$$

$\Rightarrow P = 0.98$ MPa

470 **(c)**

Gas equation for N molecules $PV = NkT$

$\Rightarrow N = \dfrac{PV}{kT}$

$= \dfrac{1.2 \times 10^{-10} \times 13.6 \times 10^3 \times 10 \times 10^{-4}}{1.38 \times 10^{-23} \times 300}$

$= 3.86 \times 10^{11}$

471 **(c)**

Internal energy of n moles of an ideal gas at temperature T is given by

$U = \frac{f}{2} nRT \quad (f = \text{degree of freedom})$

$U_1 = U_2$

$f_1 n_1 T_1 = f_2 n_2 T_2$

$\therefore \dfrac{n_1}{n_2} = \dfrac{f_2 T_2}{f_1 T_1} = \dfrac{3 \times 2}{5 \times 1} = \dfrac{6}{5}$

Here f_2 = degrees of freedom of He = 3

and f_1 =degree of freedom of $H_2 = 5$

472 **(c)**

Differentiating

$\gamma T^{\gamma-1} dT\, P^{1-\gamma} + T^{\gamma}(1-\gamma)P^{-\gamma} dP = 0$

or, $dT = \frac{(\gamma-1)T}{\gamma P} dP$

or, $dT = \left(\frac{1.5-1}{1.5}\right)\left(\frac{273}{76 \times 13.6 \times 981} \times 0.001\right)$

$= 8.97 \times 10^{-8}\text{K}$

473 **(a)**

Area enclosed by curve 1< Area enclosed by curve 2 < Area enclosed by curve 3

$\therefore Q_1 < Q_2 < Q_3$(As ΔU is for all the curves)

474 **(a)**

Average kinetic energy $E = \frac{f}{2} kT = \frac{3}{2} kT$

$\Rightarrow E = \dfrac{3}{2} \times (1.38 \times 10^{-23})(273 + 30)$

$= 6.27 \times 10^{-21} J$

$= 0.039 eV < 1\, eV$

475 **(b)**

CO is diatomic gas, for diatomic gas

$C_P = \frac{7}{2} R$ and $C_V = \frac{5}{2} R \Rightarrow \gamma_{di} = \frac{C_P}{C_V} = \frac{7R/2}{5R/2} = 1.4$

476 **(a)**

$dU = 0$

Therefore by the first law of thermodynamics

$dQ_{\text{Cyclic}} = dW_{\text{Cyclic}}$

Since $B \rightarrow C$ is an isochoric process

$\Rightarrow dW_{a \to c} = 0$

$\Rightarrow 5 = dW_{A \to B} + dW_{a \to C} + dW_{C \to A}$

$\Rightarrow 5 = 10(2-1) + 0 + dW_{c \to A}$

$\Rightarrow dW_{C \to A} = -5$ J

477 **(c)**

According to law of equipartion of energy, kinetic energy per degree of freedom of a gas molecule is $\frac{1}{2} kT$

478 **(c)**

As we know that slope of isothermal and adiabatic curves are always negative and slope of adiabatic curve is always greater than that of isothermal curve, in the given graph curves A and curve B represent adiabatic and isothermal change, respectively

479 **(d)**

Here $TV^{\gamma-1}$ =constant

As $\gamma = 5/3$, hence $TV^{2/3}$ = constant

Now $T_1 L_1^{2/3} = T_2 L_2^{2/3} \quad (\because V \propto L)$

Hence $\frac{T_1}{T_2} = \left(\frac{L_2}{L_1}\right)^{2/3}$

480 **(d)**

Given $c_p - c_v = 4150$ (i)

and $C_p/C_v = 1.4 \Rightarrow c_P = 1.4\, c_v$ (ii)

By substituting the value of c_P in Eq (i), we get

$1.4\, c_v - c_v = 4150$

$\Rightarrow 0.4\, c_v = 4150$

$\therefore c_V = \dfrac{4150}{0.4} = 10375$ J/kg − K

481 **(c)**

Molar specific heat at constant pressure $C_P = \frac{7}{2} R$

Since, $C_P - C_V = R \Rightarrow C_V = C_P - R = \frac{7}{2} R - R = \frac{5}{2} R$

$\therefore \dfrac{C_P}{C_V} = \dfrac{(7/2)R}{(5/2)R} = \dfrac{7}{5}$

482 **(a)**

$C_P - C_V = R = 2.\dfrac{cal}{g - mol - K}$

Which is correct for option (a) and (b). Further the ratio $\frac{C_P}{C_V}(= \gamma)$ should be equal to some standard value corresponding to that of either, mono, di, or triatomic gases. From this point of view option (a) is correct because $\left(\frac{C_P}{C_V}\right)_{mono} = \frac{5}{3}$

483 **(a)**

When the piston is in equilibrium, the pressure is same on both the sides of the piston. It is given that temperature and weight of gas on the two sides of piston not change. From ideal gas equation, $pV = n\,RT$, we have $V \propto$ mass of the gas.

So, $\frac{V_1}{V_2} = \frac{m_1}{m_2}$ or $\frac{V_1}{V_2} + 1 = \frac{m_1}{m_2} + 1$

Or $\frac{V_1 + V_2}{V_2} = \frac{m_1 + m_2}{m_2}$

Or $\frac{V_2}{V_1 + V_2} = \frac{m_2}{m_1 + m_2} = \frac{2m}{m + 2m} = \frac{2}{3}$

484 **(b)**

Molecular mass of He; $M = 4g$

$\Rightarrow$ Molar value of $C_V = Mc_V = 4 \times 3 =$

$12\frac{J}{mole-kelvin}$

At constant volume $P \propto T$, therefore on doubling the pressure temperature also doubles

$i.e., T_2 = 2T_1 \Rightarrow \Delta T = T_2 - T_1 = 273K$

Also $(\Delta Q)_V = \mu C_V \Delta T = \frac{1}{2} \times 12 \times 273 = 1638J$

485 **(b)**

$$PV = \mu\, RT = \frac{m}{M}RT \Rightarrow \frac{m}{VP} \Rightarrow \frac{\text{density}}{P} = \frac{M}{RT}$$

$\left(\frac{\text{density}}{P}\right)_{At\ 0°C} = \frac{M}{R(273)} = x$ ...(i)

$\left(\frac{\text{density}}{P}\right)_{At\ 100°C} = \frac{M}{R(373)}$ ...(ii)

$$\Rightarrow \left(\frac{\text{density}}{P}\right)_{At\ 100°C} = \frac{273x}{373}$$

486 **(b)**

Work done during process 1 is positive while during process 2 it is negative, because 1 is clockwise, while process 2 is anticlockwise. But area enclosed by $P - V$ graph (i.e., work done) is process 1 is smaller, so net work done will be negative

487 **(c)**

For isothermal process

$P_1V = p_2'\frac{V}{2} \Rightarrow P_2' = 2P_1$ (i)

For adiabatic process

$$P_1V^\gamma = P_2\left(\frac{V}{2}\right)^\gamma$$

$\Rightarrow P_2 = 2^\gamma P_1$ (ii)

Since $\gamma > 1, P_2 > P_2{}'$

488 **(a)**

A monoatomic gas molecule has only three translational degrees of freedom

489 **(d)**

Since $v_{rms} \propto \sqrt{T}$. Also mean square velocity $\overline{v^2} = v_{rms}^2$

490 **(b)**

Since volume is constant,

Hence $\frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{1}{3} = \frac{(273+30)}{T_2}$

$\Rightarrow T_2 = 909K = 636°C$

491 **(c)**

As temperature decreases to half and volume made twice, hence pressure becomes $\frac{1}{4}$ times

492 **(c)**

For a closed system, the total number of moles remains constant. So

$p_1V = n_1RT_1$ and $p_2V = n_2RT_2$

$\therefore\ p(2V) = (n_1 + n_2)RT$

$$\therefore\ \frac{p}{T} = \frac{(n_1+n_2)}{2}R = \frac{1}{2}\left[\frac{P_1}{T_1} + \frac{P_2}{T_2}\right]$$

$$= \frac{1}{2}\left[\frac{p_1T_2 + p_2T_1}{T_1T_2}\right]$$

493 **(d)**

Average kinetic energy ∝ Temperature

$$\Rightarrow \frac{E_1}{E_2} = \frac{T_1}{T_2} \Rightarrow \frac{100}{E_2} = \frac{300}{450} \Rightarrow E_2 = 150J$$

494 **(a)**

Here, $\frac{K_1}{K_2} = \frac{1}{2}, \frac{r_1}{r_2} = \frac{1}{2}$

$$\therefore\ \frac{A_1}{A_2} = \frac{1}{4}$$

$$\frac{dx_1}{dx_2} = \frac{1}{2}, \frac{dQ_2}{dt} = 4\ \text{cals}^{-1}, \qquad \frac{dQ_1}{dt} = ?$$

$$\frac{dQ_2/dt}{dQ_1/dt} = \frac{K_2A_2dT/dx_2}{K_1A_1dT/dx_1} = \frac{K_2}{K_1}\frac{A_2}{A_1}\frac{dx_1}{dx_2}$$

$= 2 \times 4 \times \frac{1}{2} = 4$

$$\frac{dQ_1}{dt} = \frac{dQ_2/dt}{4} = \frac{4}{4} = 1\ \text{cals}^{-1}$$

495 **(a)**

$$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} \Rightarrow \frac{v_S}{400} = \sqrt{\frac{(273+227)}{(273+27)}} = \sqrt{\frac{5}{3}}$$

$\Rightarrow v_s = 400\sqrt{5/3} = 516m/s$

496 **(b)**

Temperature remain constant so

$$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{v_{O_2}}{v_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$$

497 **(a)**

$$v_{\text{rms}} \propto \sqrt{T}$$

$$\Rightarrow \quad \frac{v_1^2}{v_2^2} = \frac{T_1}{T_2}$$

$$\Rightarrow \quad \frac{v^2}{2v^2} = \frac{273}{T_2}$$

$$\Rightarrow \quad T_2 = 1092\ \text{K}$$

$=819°C$

498 **(c)**

For the gas in container A

$$\Delta P = (P_A)_{\text{final}} - (P_A)_{\text{initial}} = \frac{n_ART}{2V} - \frac{n_ART}{V}$$

$$\Delta P = -\frac{n_ART}{2V}$$

For gas in container B

$$1.5\Delta P = (P_B)_{\text{final}} - (P_B)_{\text{initial}} = \frac{n_BRT}{2V} - \frac{n_BRT}{V}$$

$1.5\Delta P = -\frac{n_BRT}{2V}$ (ii)

From Eqs. (i) and (ii), we get

$n_B = 1.5\ n_A$

$\Rightarrow 2n_B = 3n_A$

$\Rightarrow 2m_B = 3m_A$

499 **(d)**

The desired fraction is

$$f = \frac{\Delta U}{\Delta Q} = \frac{nC_V\Delta T}{nC_P\Delta T} = \frac{C_V}{C_P} = \frac{1}{\gamma}$$

$$f = \frac{5}{7} \quad \left(\text{as } \gamma = \frac{7}{5}\right)$$

500 **(d)**

$$l = l_0\left(1 + \frac{1}{100}\right)$$

$$\therefore\ 2l^2 = 2l_0^2\left(1 + \frac{1}{100}\right)^2$$

Or $2l^2 - 2l_0^2 = 2l_0^2 \times \frac{2}{100}$

Or $\Delta S = S\ \times \frac{2}{100}$ or $\frac{\Delta S}{S} = \frac{2}{100} = 2\%$

501 **(d)**

$(\Delta Q)_{ab} = +7000 = \mu C_v(1000 - 300)$ (i)

For the process ca:

$T_a = 300\text{K}, T_c = T_b = 1000\text{ K}$

$(\Delta Q)_{ca} = \mu C_p(300 - 1000) = -\mu C_p \times 700$

$= -\mu(C_v + R)700$ (ii)

For carbon monoxide:

$T_a = 300\text{K}, T_c = T_h = 1000\text{ K}$

$(\Delta Q)_{ca} = \mu C_p(300 - 1000) = -\mu C_p \times 700$

$= -\mu(C_v + R)700$

For carbon monoxide:

$$\gamma = \frac{7}{5}$$

$$C_v = \frac{R}{\gamma - 1} = \frac{R}{\frac{7}{5} - 1} = \frac{5R}{2} \quad \text{(iii)}$$

Hence, from Eq. (i)

$$7000 = \mu\frac{5R}{2} \times 700 \text{ or } \mu R = \frac{20}{5} = 4$$

$(\Delta Q)_{ca} = -(7000 + 4 \times 700) = -9800\text{ J}$

Negative sign shows that heat is ejected

502 **(c)**

For same isotherm; $T \rightarrow$ constant

$$\therefore P \propto \frac{1}{V} \Rightarrow P_1V_1 = P_2V_2$$

503 **(c)**

$P = 1\text{ atm } = 10^5\text{N/m}^2$

$T = 0°\text{C} = 273\text{ K}$

$$V = \frac{nRT}{P} = \frac{1 \times 8.3 \times 273}{10^5} = 0.0227\text{m}^2 = 22.7\text{ L}$$

$$C_v = \frac{5}{2}R; C_p = \frac{7}{2}R$$

Heat transferred

$$\Delta Q = nC_p\Delta T = n\frac{7R}{2}\Delta T = 13200\text{ J}$$

Work done

$$nR\Delta T = \frac{13200 \times 2}{7}$$

$= P(V_f - V_i) = 3771$

$V_f - V_i = 3771 \times 10^{-5} = 0.0377\text{ m}^3$

$V_f = V_i + 37.7\text{ L}$

$= 22.7\text{L} + 37.7\text{ L}$

$= 60.4\text{L} \approx 60\text{L}$

504 **(a)**

$$C_V = \frac{f}{2}R$$

For diatomic gas $f = 5$

$$\therefore C_V = \frac{5}{2}R$$

505 **(a)**

AB is isobaric process, BC is isothermal process, CD is isohoric process and DA is isothermal process

These process are correctly represented by graph (a)

506 **(d)**

Degree of freedom $f = 3$ (Translatory)+2(rotatory)+1(vibratory) = 6

$$\Rightarrow \frac{C_P}{C_V} = \gamma = 1 + \frac{2}{f} = 1 + \frac{2}{6} = \frac{4}{3} = 1.33$$

507 **(d)**

According to Stefan's law

$\Delta Q = e\sigma AT^4\Delta t$

Also $\Delta Q = mc\Delta T \Rightarrow \Delta Q = mc\Delta T = e\sigma AT^4\Delta t$

$$\Rightarrow \frac{\Delta T}{\Delta t} = \frac{e\sigma\ AT^4}{mc} = \frac{e\sigma T^4}{mc}\left[\pi\left(\frac{3m}{4\pi\rho}\right)^{2/3}\right]$$

$$= k\left(\frac{1}{m}\right)^{1/3}$$

$$\therefore\ \frac{\Delta T_1/\Delta t_1}{\Delta T_2/\Delta t_2} = \left(\frac{m_2}{m_1}\right)^{1/3} = \left(\frac{1}{3}\right)^{1/3}$$

508 **(c)**

$\log P = m\log V + C_1$, where C_1 is positive, m is slope

$$m = \frac{2.38 - 2.10}{1.1 - 1.3} = -1.4$$

$\log P = -1.4\log V + C_1$

$\log PV^{1.4} = C_1$

$PV^{1.4} = k$

Thus, it represents an ideal diatomic gas undergoing adiabatic change

509 **(c)**

$\mu = \mu_1 + \mu_2$

$$\frac{P(2V)}{RT_1} = \frac{P'V}{RT_1} + \frac{P'V}{RT_2} \Rightarrow \frac{2P}{RT_1} = \frac{P'}{R}\left[\frac{T_2 + T_1}{T_1T_2}\right]$$

$$P' = \frac{2PT_2}{(T_1 + T_2)} = \frac{2 \times 1 \times 600}{(300 + 600)} = \frac{4}{3}atm$$

510 **(b)**

For a real gas the two van der Waal's constants and Boyle's temperature (T_B) are related as

$$T_B = \frac{a}{bR}$$

511 **(d)**

The internal energy of n moles of a gas is

$u = \frac{1}{2} nFRT$

Where F =number of degrees of freedom

The internal energy of 2 moles of oxygen at temperature T is

$\mu_1 = \frac{1}{2} \times 2 \times 5RT = 5RT$ ($F = 5$ for oxygen molecule)

Total internal energy of 4 moles of organ at temperature T is

$= u_2 = \dfrac{1}{2} \times 4 \times 3RT = 6RT$

Total internal energy $= u_1 + u_2 = 11RT$

512 **(a)**

Since $c_{rms} << V_e$, hence molecules do not escape out

513 **(c)**

For intermolecular attraction is considered in real gas and for real gases pressure is given by

$P = \frac{nRT}{V-nb} - \frac{n^2 a}{V^2}$. Here $\left(\frac{n}{V}\right)^2$ represents the reduction in pressure due to intermolecular attraction

514 **(c)**

S.I. unit of R is $J/mol - K$

515 **(b)**

$Q_1 = nC_P \Delta T$

$Q_2 = nC_V \Delta T$

$\dfrac{Q_2}{Q_1} = \dfrac{C_V}{C_P} = \dfrac{1}{\gamma}$

$Q_2 = \dfrac{Q_1}{\gamma} = \dfrac{70}{1.4} = 50 \text{ cal}$

516 **(b)**

Vander Waal's gas equation for μ mole of real gas

$\left(P + \dfrac{\mu^2 a}{V^2}\right)(V - \mu b) = \mu RT$

$P = \left(\dfrac{\mu RT}{V - \mu b} - \dfrac{\mu^2 a}{V^2}\right)$

Given equation,

$P = \left(\dfrac{RT}{2V - b} = \dfrac{a}{4b^2}\right)$

On comparing the given equation with this standard equation, we get

$\mu = \dfrac{1}{2}$

Hence , $\mu = \frac{m}{M}$

$\Rightarrow$ mass of gas, $m = \mu M = \dfrac{1}{2} \times 44 = 22g$

517 **(a)**

As $dQ = dU + dW$

$\therefore \; dU = dQ - dW = 2240 - 168$

$= 2072$ J

518 **(c)**

For state $A, C_p - C_v = R$, i.e., the gas behaves as an ideal gas

For state $B, C_p - C_v = 1.06R (\neq R)$, i.e., the gas does not behave like an ideal gas

We know that at high temperature and at low pressure, nature of gas may be ideal

So we can say that $P_A < P_B$ and $T_A > T_B$

520 **(d)**

Let T_0 be the initial temperature of the black body

$\therefore \; \lambda_0 T_0 = b$ (Wien's law)

Power radiated, $P_0 = CT_0^4$, where, C is constant.

If T is new temperature of black body, then

$\dfrac{3\lambda_0}{4} T = b = \lambda_0 T_0$ or $T = \dfrac{4}{3} T_0$

Power radiated, $P = CT^4 = CT_0^4 \left(\frac{4}{3}\right)^4$

$P = P_0 \times \dfrac{256}{81}$ or $\dfrac{P}{P_0} = \dfrac{256}{81}$

521 **(c)**

According to kinetic theory of gases the temperature of a gas is a measure of the kinetic energies of the molecules of the gas.

522 **(b)**

For diatomic gases $\frac{C_P}{C_V} = \gamma = 1.4$

523 **(d)**

Heat absorbed by gas in three processes is given by

$Q_{ACB} = \Delta U + W_{ACB}$

$Q_{ADB} = \Delta U$

$Q_{AEB} = \Delta U + W_{AEB}$

The change in internal energy in all the three cases is same and W_{ACB} is positive , W_{AEB} is negative

Hence $Q_{ACB} > Q_{ADB} > Q_{AEB}$

524 **(a)**

Using $\frac{C}{5} = \frac{F-32}{9}$

$-\dfrac{183}{5} = \dfrac{F - 32}{9}$

$F - 32 = -\dfrac{183 \times 9}{5} = -329.4$

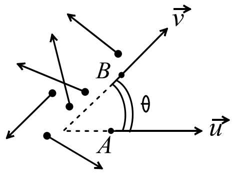
$F = -329.4 + 32 = -297.4°$

525 **(d)**

$E = \dfrac{3}{2} RT = \dfrac{3}{2} \times 8.31 \times 273 = 3.4 \times 10^3 J$

526 **(d)**

Figure shows the particles each moving with same speed v but in different directions. Consider any two particles having angle θ between directions of their velocities



Then, $\overrightarrow{v_{\text{rel}}} = \overrightarrow{v_B} - \overrightarrow{v_A}$

$i.e., v_{\text{rel}} = \sqrt{v^2 + v^2 - 2vv\cos\theta}$

$\Rightarrow v_{\text{rel}} = \sqrt{2v^2(1-\cos\theta)} = 2v\sin(\theta/2)$

So averaging v_{rel} over all pairs

$$\bar{v}_{\text{rel}} = \frac{\int_0^{2\pi} v_{\text{rel}} d\theta}{\int_0^{2\pi} d\theta} = \frac{\int_0^{2\pi} 2v\sin(\theta/2)}{\int_0^{2\pi} d\theta}$$

$$= \frac{2v \times 2[-\cos(\theta/2)]_0^{2\pi}}{2\pi}$$

$\Rightarrow \bar{v}_{\text{rel}} = (4v/\pi) > v \quad [\text{as } 4/\pi > 1]$

527 **(b)**

Using Newton's law of cooling,

$\log\frac{\theta_2-\theta_0}{\theta_1-\theta_0} = -Kt$

$\text{Log}\frac{40-\theta_0}{50-\theta_0} = -K \times 5 \quad .....(i)$

$\text{Log}\frac{33.33-\theta_0}{40-\theta_0} = -K \times 5 \quad .....(ii)$

From Eqs.(i) and (ii),

$$\frac{40-\theta_0}{50-\theta_0} = \frac{33.33-\theta_0}{40-\theta_0}$$

On solving, we get

$\theta_0 = 19.95°\text{C} \approx 20°\text{C}$

528 **(b)**

$$\frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4$$

$$= \left(\frac{273+84}{273+27}\right)^4 = \left(\frac{357}{300}\right)^4 = 2.0$$

529 **(a)**

According to Boyle's law $PV =$ constant

530 **(a)**

Internal energy of the gas remains constant, hence

$$T_2 = T$$

Using $\quad p_1V_1 = p_2V_2$

$$p.\frac{V}{2} = p_2V_2$$

$$p_2 = \frac{p}{2}$$

531 **(c)**

Fraction of energy supplied for increment in internal energy $= 1/\gamma = 3/5$ (as $\gamma = 5/3$ for monatomic gas) Therefore, percentage energy =30/5=60%

Fraction of energy supplied for external work done

$$= 1 - \frac{1}{\gamma} = \frac{\gamma-1}{\gamma} = \frac{\frac{5}{3}-1}{\frac{5}{3}} = \frac{2}{5}$$

∴ Percentage energy

$$= \frac{2}{5} \times 100\% = 40\%$$

532 **(c)**

The temperature rises by the same amount in the two cases and the internal energy of an ideal gas depends only on it's temperature

Hence $\frac{U_1}{U_2} = \frac{1}{1}$

533 **(a)**

For NH_3, degree of freedom $f = 6$

$$\Rightarrow \frac{C_P}{C_V} = \gamma = 1 + \frac{2}{f} = 1 + \frac{2}{6} = \frac{4}{3} = 1.33$$

534 **(d)**

For any gas $C_P - C_V = 1.99 = 2\frac{cal}{mol-K}$

536 **(d)**

According to the equilibrium theorem, the molar heat capacities should be independent of temperature. However, variations in C_V and C_P are observed as the temperature changes. At very high temperatures, vibrations are also important and that affects the values of C_V and C_P for diatomic and polyatomic gases. Here in this question according to given information (d) may be correct answer

537 **(d)**

According to Newton's law

$$\frac{\theta_1-\theta_2}{t} = K\left[\frac{\theta_1+\theta_2}{2} - \theta_0\right]$$

$\therefore \frac{60-50}{10} = K\left[\frac{60+50}{2} - 25\right] \quad ....(i)$

Let θ be the temperature after another 10 min

$\therefore \frac{50-\theta}{10} = K\left[\frac{\theta+50}{2} - 25\right] \quad ....(ii)$

Dividing Eq.(i) by Eq. (ii), we get

$$\frac{10}{50-\theta} = \frac{30 \times 2}{\theta} \quad \therefore \theta = 42.85°\text{C}$$

538 **(a)**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(P+h\rho g)1.0}{273+12} = \frac{P.V_2}{273+35}$$

$V_2 = 5.4cm^3$

539 **(c)**

According to the Dalton's law of partial pressure, the total pressure will be $P_1 + P_2 + P_3$

540 **(b)**

$$F = \frac{3}{2}kT \Rightarrow E \propto T$$

541 **(b)**

$E = \frac{f}{2}RT; f = 5$ for diatomis gas $\Rightarrow E = \frac{5}{2}RT$

542 **(a)**

$\Delta W = P\Delta V$: given: $PV = \mu RT + \alpha V$

$\therefore P\Delta V = \mu R\Delta T + \alpha\Delta V$

or, $\Delta V = [(\mu R\Delta T)/(P_0 - \alpha)]$

i.e., $\Delta W = \frac{P_0RT_0}{P_0-\alpha}(\mu = 1)$

543 **(a)**

$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow T \propto M$ [$\because v_{rms}, R \to$ constant]

$\frac{T_{H_2}}{T_{O_2}} = \frac{M_{H_2}}{M_{O_2}} = \frac{T_{H_2}}{(273+47)} = \frac{2}{32} \Rightarrow T_{H_2} = 20K$

544 **(b)**

Temperature becomes $\frac{1}{4}th$ of initial value

[$1200K = 927$°C $\rightarrow 300K = 27$°C]

So, using $v_{rms} \propto \sqrt{T}. r.m.s.$ velocity will be half of the initial value

545 **(d)**

$P \propto \frac{1}{V} \Rightarrow \frac{V_2}{V_1} = \frac{P_1}{P_2} = \frac{100}{105} \Rightarrow V_2 = \frac{100}{105}V_1$

$= 0.953\ V_1$

% change in volume $= \frac{V_1-V_2}{V_1} \times 100$

$= \frac{V_1 - 0.953V_1}{V_1} \times 100 = 4.76\%$

546 **(a)**

Mean free path, $\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$

Where, $n =$ Number of molecules per unit volume

$d =$ Diameter of the molecules

547 **(a)**

Let V be the volume of solid ; d be its density and m be its mass ; if g coefficient of volume expansion of liquid, then

Density at temperature t_1 is, $d_1 = \frac{d_0}{1+\gamma t_1}$

Density at temperature t_2 is, $d_2 = \frac{d_0}{1+\gamma t_2}$

According to Archimede's principle,

$f_1V\,d_1 = m = f_2\,Vd_2$

Or $\frac{d_1}{d_2} = \frac{f_2}{f_1} = \frac{d_0}{(1+\gamma t_1)}\frac{(1+\gamma t_2)}{d_0}$

Or $f_1 + f_1\gamma t_2 = f_2 + f_2\,\gamma t_1$

$f_1 - f_2 = \gamma(f_2t_1 - f_1t_2)$

$\gamma = \frac{(f_1 - f_2)}{f_2t_1 - f_1t_2}$

548 **(b)**

If m is the total mass of the gas, then its kinetic energy $= 2/1mv^2$

When the vessel is suddenly stopped, total kinetic energy will increases the temperature of the gas (because process will be adiabatic), i.e.,

$\frac{1}{2}mv^2 = \mu C_v\Delta T$

$= \frac{m}{M}C_v\Delta T$

$\Rightarrow \frac{m}{M}\frac{R}{\gamma-1}\Delta T = \frac{1}{2}mv^2\left(\text{As}C_v = \frac{R}{\gamma-1}\right)$

$\Rightarrow \Delta T = \frac{Mv^2(\gamma-1)}{2R}$

549 **(d)**

Specific heat for a monoatomic gas

$C_V = \frac{3}{2}R$

$\therefore$ Heat $dQ = \mu C_V\Delta T$

$dQ = \mu \times \frac{3}{2} \times R(473 - 273)$

$= 4 \times \frac{3}{2} \times R \times 200 \quad (\because \mu = 4)$

$\therefore \quad dQ = 4 \times 300R$

$= 1200R$

550 **(a)**

According to Avogadro's hypothesis

551 **(c,d)**

$v_{\text{rms}} = \sqrt{\frac{36RT}{M}}, \bar{v} = \sqrt{\frac{8}{\pi}.\frac{RT}{M}} \approx \sqrt{\frac{2.5RT}{M}}$

and $v_p = \sqrt{\frac{2RT}{M}}$

From these expressions we can see that

$v_p < \bar{v} < v_{\text{rms}}$

Second, $v_{\text{rms}} = \sqrt{\frac{3}{2}}v_p$

and average kinetic energy of a gas molecule

$= \frac{1}{2}mv_{\text{rms}}^2$

$= \frac{1}{25}m\left(\sqrt{\frac{3}{2}}v_p\right)^2 = \frac{3}{4}mv_p^2$

552 **(b,d)**

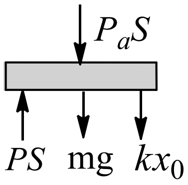
The expression of radius of curvature R is

$R = \frac{d}{(\alpha_1 - \alpha_2)\Delta t}$

Thus, $R \propto \frac{1}{\Delta t}$ and $R \propto \frac{1}{|\alpha_B - \alpha_C|}$

553 **(a,c)**

Equilibrium of piston gives



$PS = P_0S + mg + Kx_0$

$P = P_a + \frac{mg}{S} + \frac{Kx_0}{S}$

($P =$ final pressure of gas)

Work done by the gas

=work done against atmospheric pressure + elastic potential energy stored in the spring + increase in gravitational potential energy of the piston

$= P_a\Delta V + \frac{1}{2}Kx_0^2 + mgx_0 = P_aSx_0 + \frac{1}{2}Kx_0^2 + mgx_0$

There occurs decrease in internal energy of the gas, because the gas is thermally insulated and hence, work is done at the expense of internals energy of the gas

555 **(a,b)**

Energy emitted per second by body $A = \varepsilon_A\sigma T_A^4A$ where A is the surface area

Energy emitted per second by body $B = \varepsilon_B\sigma T_B^4A$

Given that power radiated is equal

$\varepsilon_A\sigma T_A^4A = \varepsilon_B\sigma T_B^4A,\ \ \varepsilon_AT_A^4 = \varepsilon_BT_B^4$

$\Rightarrow T_B = \left(\frac{\varepsilon_A}{\varepsilon_B}\right)^{1/4} T_A = 1934\text{ K}$

According to Wien's displacement law $(\lambda_m) \propto \frac{1}{T}$

Since temperature of A is more, therefore $(\lambda_m)_A$ is less

$\therefore (\lambda_m)_B - (\lambda_m)_A = 1 \times 10^{-6}\text{m}$ (given) (i)

Also according to Wien's displacement law

$(\lambda_m)_AT_A = (\lambda_m)_BT_B$

$\Rightarrow \frac{(\lambda_m)_A}{(\lambda_m)_B} = \frac{T_B}{T_A} = \frac{1934}{5802} = \frac{1}{3}$ (ii)

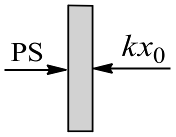
On solving Eqs. (i) and (ii),

We get $\lambda_B = 1.5 \times 10^{-6}\text{m}$

556 **(a,b,c,d)**

Equilibrium of piston gives $PS = Kx_0$

$P = \frac{Kx_0}{S}$



Since the chamber is thermally insulated,$\Delta Q = 0$

$\therefore$ Elastic PE of spring = Work done by gas

or, work done by gas $= \frac{1}{2}Kx_0^2$

This work is done at the expense of internal energy of the gas. Therefore, internal energy of the gas is decreased by $(1/2)Kx_0^2$

557 **(a,b,d)**

Graph is a straight line passing through origin therefore, $V =$ constant

$\therefore$ work done on the gas =0

Further, $\rho = \frac{m}{V} \propto \frac{1}{V}$

Volume of the gas is constant. Therefore, density of gas is also constant

$PV = nRT$

or $P = \left(\frac{nR}{V}\right)T$

i.e., slope of $P - T$ line $\propto n$

558 **(c,d)**

During expansion, an isotherm lies above an adiabat

Also $\begin{pmatrix}\text{Slope of}\\ \text{an adiabat}\end{pmatrix} = \gamma\begin{pmatrix}\text{Slope}\\ \text{of an}\\ \text{isotherm}\end{pmatrix}$

$\Rightarrow m_2 = \frac{C_p}{C_V}(m_1)$

$\Rightarrow m_2C_v = m_1C_p$

Since $\gamma - 1$,

$\Rightarrow m_2 > m_1$

559 **(b,d)**

According to Stefan's law $E = \alpha\, T^4$

Power radiated $P\ = (4\,\pi\, r^2)\sigma\, T^4 = ms\,\left(-\frac{dT}{dt}\right)$

$=\frac{3}{4}\,\pi r^3\,\rho s\frac{dT}{dt}$

Where, $\frac{dT}{dt}\ = R =$ rate of cooling

$\therefore\ P \propto r^2$

Also, from $4\rho r^2\rho T^4 = \frac{4}{3}\,\pi r^3\rho s(R)$

$R\ = \frac{3\sigma T^4}{r\rho s}$

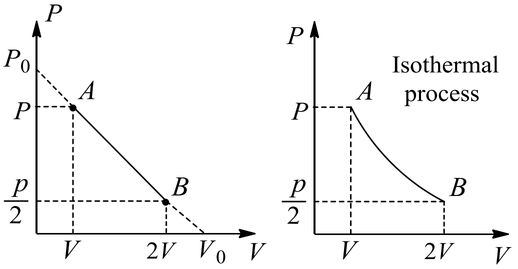
$R \propto \frac{1}{r}$

560 **(b,c)**

There is a decrease in volume during melting of an ice slab at 273 K. Therefore, negative work is done by ice water system on the atmosphere or positive work is done on the ice-water system by the atmosphere. Hence option (b) is correct. Second, heat is absorbed during melting (i.e., dQ is positive) and as we have seen, work done by ice water system is negative (dW is negative). Therefore, from the first law of thermodynamics, $dU = dQ - dW$, with change in internal energy of ice-water system, dU will be positive or internal energy will increase

561 **(a,b,d)**

Work done by the gas in the process A and B exceeds the work that would be done by it if the system were taken from A and B along the isotherm. This is because the work done is the area under the $P - V$ indicator diagram. As shown, the area under the graph in the first diagram will be more than that in the second diagram. When we extrapolate the graph shown in figure (a), let P_0 be the intercept on the P-axis and V_0 be the intercept on the V-axis. The equation of the line AB can be written as



(a) (b)

$$P=-\frac{P_0}{V_0}V+P_0 \ \ [\because y=mx+c] \ \ \text{(i)}$$

To find a relationship between P and T, we use

$$PV=RT \Rightarrow V=\frac{RT}{P} \quad \text{(ii)}$$

From Eqs. (i) and (ii),

$$P=-\frac{P_0}{V_0}\times\frac{RT}{P}+P_0$$

$$\Rightarrow P^2V_0-PP_0V_0=-P_0RT \quad \text{(iii)}$$

Relation between P and T is the equation of a parabola

Also $PV=RT$

$$\therefore \ P=\frac{RT}{V} \ \ \text{(iii)}$$

From Eqs. (i) and (ii),

$$\frac{RT}{V}=-\frac{P_0}{V_0}V+P_0$$

$$\Rightarrow RT=-\frac{P_0}{V_0}V^2+P_0V \ \ \text{(iv)}$$

The above equation is of a parabola (between T and V)

$$T=-\frac{P_0}{V_0R}V^2+\frac{P_0}{R}V$$

Differentiating the above equation w.r.t. V we get

$$\frac{dT}{dV}=-\frac{P_0}{V_0R}\times 2V+\frac{P_0}{R}$$

When $\frac{dT}{dV}=0$,

Then $\frac{P_0}{V_0R}\times 2V=\frac{P_0}{R}\Rightarrow V=\frac{V_0}{2}$

Also $\frac{d^2T}{d^2V}=\frac{-2P_0}{V_0R}=-\text{ve}$

$\Rightarrow V=V_0/2$ is the value of maxima of temperature

Also $P_AV_A=P_BV_B\Rightarrow T_A=T_B$ (From Boyle's law)

$\Rightarrow$ In going frm A to B, the temperature of the gas first increases to a maximum (at $V=V_0/2$) and the decreases and reaches back to the same value

562 **(a,b,c)**

The critical step is that work in path $1-3$ is mean of that for $1-2-3$ and $1-4-3$ (considering areas)

For (a) $100-40=x-10$

Or, $x=70$ cal

(b) It is also correct as half of $(40+10)$ is 25 cal

(c) dU is -60, work is -25

So $-60=dQ-(-25)$

or $dQ=-85\text{cal}$

(d) $dU=100-40=60\text{cal}$

Hence, option (d) is not correct

563 **(b,d)**

For an isothermal process, $PV=\text{constant}$

$$P=\frac{\text{constant}}{V} \text{ or } P\propto\frac{1}{V}$$

It means, for an isothermal process the graph between P and $1/V$ will be a straight line passing through origin. Hence, the straight line AB will pass through orogin Hence, option (a) is wrong. During process AB, the pressure P remains constant but $1/V$ increases. It means, volume V decraeses. Hence, AB is isobaric compression. Since volume of the gas decreases at constant pressure, therefore its temperature decreases. But temperature at C is equal to that of A. Hence during the process BC, the temperatsure of the gas increases. In fact, process BC is an isochoric heating. Therefore, option (b) is correct. Since during the process BC, volume remains constant, no work is done by the gas against external pressure. Therefore option (c) is wrong.

During process CA, $1/V$ decreases, it means volume V increases. Since the volume increases, work is done by the gas against external pressure. Since process CA is an isothermal process, no change in internal energy of the gas takes place, according to the first law of thermodynamics, $Q=W+\Delta U$; heat supplied during this process is equal to work done by the gas against external pressure. Hence option (d) is correct

564 **(b,c,d)**

Statement (a) is incorrect. It is true only if the two bodies have the same thermal capacity

Statement (b) is correct. The coolant is used to prevent the engine or the nuclear plant from becoming too hot. The heat absorbed by a substance per unit mass is directly proportional to its specific heat. Therefore if a coolant has a high specific heat, it will remove a large amount of heat from the engine or the nuclear plant.

Statement (c) is correct. If the volume of vapour is decreased, at a constant temperature a apart of the vapour will condense into liquid such that the vapour pressure remains unchanged. In other words, the pressure does not increase but the volume of vapour decreases

Statement (d) is also correct. Since the vessels are of the same capacity, the volume occupied by the gas is doubled, hence the pressure reduces to half

565 **(a,c)**

For an adiabatic process, $PV^{\gamma}=$ constant

Differentiating w.r.t.V, we get

$$\frac{dP}{dV}V^{\gamma}+p\gamma V^{\gamma-1}=0$$

or $\frac{dP}{dV}=-\frac{\gamma P}{V}$

For isothermal process, $PV=$ constant

Hence,

$$\frac{dP}{dV}=-\frac{P}{V}$$

Now, dP/dV is the slope of the $(P-V)$graph. Thus, the slope of the $(P-V)$ graph for an adiabatic process is γ times that for an isothermal process. Hence, curves BC and DA both represent adiabatic process and curves AB and CD both represent isothermal process. Thus, the correct choices are (a) and (c)

566 **(a,b,d)**

A real gas can behave as an ideal gas under low pressure and high temperature, then all the gas laws are obeyed.

567 **(a,c,d)**

$T=$constant

$PV=$constant (Boyle's law)

or $P\propto\frac{1}{V}$

Pressure of the gas is increasing. Therefore, volume should decrease. Work done by the gas is negative or work done on the gas is constant. Therefore, internal energy will remain constant

568 **(a,c)**

For 1 mole of an ideal gas

$pV=RT$ (i)

At constant pressure:

$PdV=RdT$

From Eqs. (i) and (ii), we get

$$\frac{dV}{V}=\frac{dT}{T}$$

The coefficient of volume expansion at constant pressure is given by

$$\frac{dV}{VdT}=\frac{1}{T}$$

Same for all gases at same temperature.

The average translational kinetic energy per molecule is $(3/2)kT$ and not $3kT$. With decrease in pressure, volume of the gas increases so its mean free path increases. [Option (c)]

The average translational kinetic energy of the molecules is depended of their nature, so each component of the gaseous mixture will have the same value of average translational kinetic energy

569 **(a,b,c)**

For an ideal gas $pV=$ a constant when temperature is constant. Thus, the variation between pV and V is a straight line parallel to V-axis. Hence, graphs (a), (b) and (c) are wrong.

570 **(a,b,c,d)**

In the equilibrium position, the net force on the partition will be zero

Hence pressure on both sides is same

Hence, (a) is correct

$$n_1=\frac{P_1V_1}{RT_1}=\frac{PV}{RT}$$

$$n_2=\frac{(2P)(2V)}{RT}=4\frac{PV}{RT}\Rightarrow n_2=4n_1$$

Moles remain conserved

Finally pressure becomes equal in both the parts

Using , $P_1V_1=n_1RT_1$

$P_2V_2=n_2RT_2$

$P_1=P_2$ and $T_1=T_2$

$$\frac{V_1}{V_2}=\frac{n_1}{n_2}=\frac{1}{4}$$

$V_2=4V_1$

Also, $V_1+V_2=3V\Rightarrow V_1+4V_1=3V$

$V_1=\frac{3}{5}V$ and $V_2=\frac{12}{5}V$

Hence option (b) and (c) are correct.

In Compartment I:

$P_1'V_1=n_1RT_1$

$$P_1'\left(\frac{3V}{5}\right)=\left(\frac{PV}{RT}\right)R(T)$$

$$P_1'=\frac{5PV}{3V}=\frac{5}{2}P$$

Hence option (d) also correct

571 **(a,b,d)**

(i) Work done = area under the curve,

$$W_1=\left(P+\frac{P}{2}\right)(2V-V)=\frac{3}{2}PV$$

Work done under isothermal process

$$W_2=RT\times 2.3026\log\left(\frac{2V}{V}\right)$$

$=0.693\,RT=0.693PV$

$\therefore W_1>W_2$, i.e., option (a) is correct

(ii) Let P_0 and V_0 be the intercepts on the P and$V$ axes. Now the eqution of straight line would be

$P = -\frac{P_0}{V_0} \times V + P_0$

$(\because y = mx + c)$

Further $PV = RT$ or $P = \frac{RT}{V}$

(This represents parabola, so option (b) is also correct)

572 **(a,c)**

Process AB in the given figure is an isobaric process. During this process

$V \propto T$

But $PV = nRT$

or $PV \propto T$

Therefore during this process, pressure P remains constant. Process BC is an isochoric cooling. During this process, volume of the gas remain constant but the temperature decreases

Process CA is an isothermal process. During this process volume decreases and temperature remains constant. Hence, pressure increases during this process. Hence, on $P-V$ diagram, process AB will be a straight line parallel to the V –axis, process BC will be a straight line parallel to the P-axis and CA will be a rectangular hyperbola. Hence, option (c) is correct, while (d) is wrong

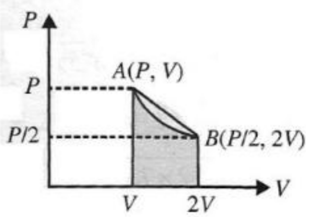
On $T-V$ diagram, process AB will be a straight line parallel to the T-axis, during which temperature increases. Process BC will be a straight line passing origin, during which temperatsure and apressures both decreases and process CA will be a straight line parallel to the P-axis during which pressure increases. Hence, option (a) is correct while (b) is wrong

573 **(a,b,c)**

Internal energy (U)depends only on the initial and final states. Hence ΔU will be same in all three paths. In all the three paths, work done by the gas is positives and the products PV or temperature T is increasing. Therefore, internal energy is also increasing. So, from the first law of thermodynamics, heat will be absorbed by the gas. Further, area under $P-V$ graph is maximum in path 1 while ΔU is same for all the three paths. Therefore, heat absorbed by the absorbed by the gas is maximum in path 1. For temperature of the gas we can see that product PV first increases in path 1 but whether it is decreasing later on we cannot says anything about it unless the exact value are known to us

574 **(a,b,d)**

Figure shows the straight line path along with the corresponding isothermal path. Since the work done by the gas is equal to area under the curve (such as shown in the figure by the shaded portion for the isothermal path), it is obvious that the gas does more work along the straight line path as compared with that for the isothermal path.



As the volume is increased from $V$to$2V$, the difference of pressure between the straight line path and isothermal path initially increases and then decreases after attaining a maximum value. The same trend is observed in the case of temperature $(P \propto T, \therefore V$is constant)

Now, the slope of straight line path is

$$m = \frac{P - P/2}{V - 2V} = -\frac{P}{2V}$$

or $P = -2Vm$

Putting this in the ideal gas equation,

$PV = nRT$

or $[-2Vm]V = nRT$

$$V^2 = -\frac{nR}{2m}T$$

$V^2 = kT$

Which is the equation of a parabola

Similarly, eliminating V from ideal gas equation, we get

$$P\left[-\frac{P}{2m}\right] = nRT$$

or $P^2 = (\text{constant})T$

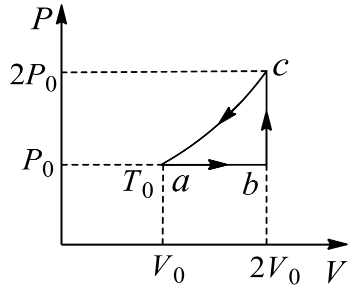
Which is again an equation of a parabola

575 **(a,d)**

Vibrational kinetic energy of a monatomic gas =0 at all temperatures. So, $C_v = 3R/2$ for a monoatomic gas at high temperatures also. In case of a diatomic gas $C_v = 5R/2$ at low temperatures while, $C_v > 5R/2$ at high temperatures due to vibrationl KE

576 **(a,b,c,d)**

One mole of an ideal monatomic gas (initial temperature T_0) is made to go through the cycle $abcd$ shown in figure U denotes the internal energy



For the process $ab, \frac{P_0V_0}{T_0} = \frac{2P_0V_0}{T_0}$

$T_b = 2T_0$

$T_b > T_a \Rightarrow U_b > U_a$

$U_b - U_a = C_v\Delta T = \dfrac{3R}{2}(2T_0 - T_0) = \dfrac{3RT_0}{2}$

For the process bc,

$\dfrac{P_0(2V_0)}{2T_0} = \dfrac{2P_0(2V_0)}{T_C} \Rightarrow T_C = 4T_0$

$T_c > T_0$

$U_c - U_b = \dfrac{3R}{2}(4T_0 - 2T_0) = 3RT_0$

For the process ca,

$U_c - U_a = \dfrac{3R}{2}(4T_0 - T_0) = \dfrac{9RT_0}{2}$

577 **(a,b,d)**

During process $A$and$B$, pressure and volume both are decreasing. Therefore, temperature and hence internal energy of the gas will decrease ($T \propto PV$) or $\Delta V_A \rightarrow_B$= negatives. Further, $\Delta W_A \rightarrow_B$ is negative.

In process B to C, process of the gas is constant while volume is increasing. Hence, temperature should increaseor $\Delta U_B \rightarrow_c$=positive. During C to A volume is constant while pressure is increasing. Therefore, temperature and hence internal energy of the gas should increase or $\Delta U_C \rightarrow_A$=positives. During processCAB, volume of the gas is decreasing. Hence, work done by the gas is negative

578 **(a,d)**

$V_{\text{rms}} = \sqrt{\dfrac{3kT}{m}}$

Since $PV = nRT$, therefore P and V both can change simultaneously keeping the temperature constant

579 **(b,d)**

For monoatomic gas $C_v = \frac{3}{2}R, C_p = \frac{5}{2}R$

And for diatomic gas $C_v = \frac{5}{2}R, C_p = \frac{7}{2}R$

$C_p - C_v = R$ (for all gases). So option (a) is no correct.

$C_p + C_v = 4R$ (for monoatomic gases) $= 6R$ (for diatomic gases). So option (b) is correct.

$\frac{C_p}{C_v} = \frac{5}{3} = 1.67$ (for monoatomic gases) $= \frac{7}{5} = 1.4$ (for diatomic gases). So option (c) is incorrect.

$C_p \times C_v = \frac{15}{4}R^2$ (for monoatomic gases) $= \frac{35}{4}R^2$ (for diatomic gases). So option (d) is correct

580 **(a,b,c,d)**

a. $\Delta U = Q - W = nC_p\Delta T - P\Delta V$

$= nC_P\Delta T - nR\Delta T = n(C_P - R)\Delta T$

$= nC_v\Delta T = nC_v(T_2 - T_1)$

b. $\Delta Q = \Delta U + \Delta W$

But $\Delta Q = 0$ for adiabatic process; hence

$\Delta U = -\Delta W$

or, $|\Delta U| - |\Delta W|$

c. $\Delta U = nC_v\Delta T = 0$ $(\because \Delta T = 0)$

d. $\Delta Q = 0$ (in adiabatic change)

581 **(b,c)**

According to the problem, mass of glass is equal so number of moles will not be equal, i.e., $\mu_A \neq \mu_B$

From ideal gas equation, $PV = \mu RT$

$\therefore \frac{P_AV_A}{\mu_A} = \frac{P_BV_B}{\mu_B}$ (as temperatures of the containers are sequal) From this relation it is clear that if $P_A = P_B$: then

$\dfrac{V_A}{V_B} = \dfrac{\mu_A}{\mu_B} \neq 1$

i.e., $V_A \neq V_B$

Similarly, if $V_A = V_B$ then

$\dfrac{P_A}{P_B} = \dfrac{\mu_A}{\mu_B} \neq 1$

i.e., $P_A \neq P_B$

582 **(b,c)**

For adiabatic process 'bc'

$T_1V_b^{g-1} = T_2V_c^{g-1}$ (i)

For adiabatic process 'da'

$T_2V_d^{\gamma-1} = T_1V_a^{\gamma-1}$ (ii)

Multiplying Eqs. (i) and (ii)

$\Rightarrow T_1T_2(V_bV_d)^{\gamma-1} = T_1T_2(V_aV_c)^{\gamma-1}$

$\Rightarrow V_bV_d = V_aV_c$

Since adiabatic expansion leads to cooling so $T_1 > T_2$

583 **(a,c,d)**

According to Kirchhoff's law, good absorbers are bad reflectors, but they are good emitters.

584 **(b,d)**

$\dfrac{P^2}{\rho} = k \implies \dfrac{P^2RT}{PM} = k$

$PT = \left(\dfrac{kM}{R}\right) \implies P \propto \dfrac{1}{T}$ (i)

$\dfrac{P^2}{\rho} = \dfrac{P'^2}{\rho/2} \implies P' = \dfrac{P}{\sqrt{2}}$

Hence from Eq. (i) $T' = T\sqrt{2}$

$PT =$ constant, hence $P - T$ curve is a parabola

585 **(a,b,c)**

The molar heat capacity has the general definition

$$C = \frac{1}{n}\frac{\Delta Q}{\Delta T}$$

Where n =number of moles

ΔQ = heat absorbed by the gas

ΔT= rise in temperature of gas

It is possible to obtain almost any set of value for ΔQ and ΔT by proper selection of a process

586 **(a,c)**

Let the process start from initial pressure P_A, volume V_A and temperature T_A

$$\begin{tikzcd} A(P_A, V_A, T_A) \arrow[r, "\text{I}"] & B\left(\frac{P_A}{2}, 2V_A, T_A\right) \arrow[d, "\text{II}"] \\ & C\left(\frac{P_A}{2}, V_A, \frac{T_A}{2}\right) \arrow[ul, "\text{III}"] \end{tikzcd}$$

I: Isothermal expansion ($PV =$ constant) at temperature $T_A$to twice the initial volume V_A

II: Compression at constant pressure $P_A/2$ to original volume V_A(i.e., $V \propto T$)

III: Isochoric process (at volume V_A) to initial conditions (i.e., $P \propto T$)

587 **(a,c)**

For a cyclic process, $\Delta U = 0$

i.e., $\Delta U = \Delta U_1 + \Delta U_2 = 0$

From relation $\Delta Q = \Delta U + \Delta W$

As $\Delta U = 0$

Hence, $\Delta Q = \Delta W$

or $\Delta Q - \Delta W = 0$

588 **(a,b)**

$$p = \frac{1}{3}\frac{mm}{V}c^2 \text{ and } c^2 \propto T \text{ or } c^2 = kT$$

$$\therefore\ p = \frac{1}{3}\frac{mm}{V}\ kT$$

Thus, $p \propto mT$

589 **(a,c)**

Initial state is same for all the three processes (say initial internal energy = E_0)

In the final state, $V_A = V_B = V_C$

And $P_A > P_B > P_C$

$P_AV_A > P_BV_B > P_CV_C$

$E_A > E_B > E_C$

If $T_1 < T_2$, then $E_0 > E_f$ for all the three processes and hence $(E_0 - E_A) < (E_0 - E_B) < (E_0 - E_C)$

$|\Delta E_A| < |\Delta E_B| < |\Delta E_C|$

If $T_1 < T_2$, then $E_0 < E_f$ for all the three processes and hence $(E_A - E_0) > (E_B - E_0) > (E_C - E_0)$

$|\Delta E_A| > |\Delta E_B| > |\Delta E_C|$

590 **(b,c)**

As $\beta = 2\,\alpha$ and $\gamma = 3\,\alpha$

$$\therefore\ \frac{\beta}{\gamma} = \frac{2\alpha}{3\alpha} = \frac{2}{3} \text{ and } \frac{\gamma}{\alpha} = \frac{3\alpha}{\alpha} = \frac{3}{1}$$

Both these choices are correct.

591 **(a,c)**

The mean translational kinetic energy is $\frac{3}{2}kT$ is independent of the nature of the gas. It dependents only on it's temperature. In jar both the gases are at same temperature so they have the same average translational kinetic energy. Also, as hydrogen is diatomic with $f = 5$ and for helium $f = 3$, so average energy of H_2 molecule $(\frac{5}{2}kT)$ is greater than that of helium $\left(\frac{3}{2}kT\right)$. It is a common misconception that all gases at same temperature have same mean kinetic energy

592 **(a,b,c,d)**

Since both the gases are contained in the same vessel, temperature of both the gases is same

Average KE per molecule of a diatomic gas is $5/2KT$. Hence, average KE per molecule of both the gases is same. Therefore, option (a) is correct

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

Hence,

$$\frac{(v_{\text{ens}})_2}{(v_{\text{rns}})_1} = \sqrt{\frac{M_1}{M_2}} = \sqrt{16} = 4$$

Hence, option (b) is correct

Let molar mass of B be M, then that of A will be equal to $16M$

Let mass of gas B in the vessel be m; then that of A will be $2m$. The number of moles of a gas, in the vessel will be n=m/M. Hence, number of moles of gases A and B will be

$$n_1 = \frac{2m}{16M} \text{ and } n_2 = \frac{m}{M}$$

Hence,

$$\frac{n_1}{n_2} = \frac{1}{8}$$

Hence, option (d) is correct

Partial pressure exerted by a gas is

$$P = \frac{nRT}{V}$$

Hence,

$$\frac{P_2}{P_1} = \frac{n_2}{n_1} = 8$$

Therefore, option (c) is also correct

593 **(b,c,d)**

The average KE of molecule of a gas $=\frac{3}{2}\,kT$, which depends on T. The average KE per mole of a gas, $E=\frac{3}{2}\,RT$ and average KE per gram of a gas $=\frac{3}{2}\frac{RT}{M}$. Where, M is the molecular weight of the gas. As M is different gases, hence average KE per gram of every gas is not same

594 **(b,d)**

Initial mass of air, $m=\frac{P_1V}{RT_1}$

Final mass of air

$$=\frac{m}{2}=\frac{P_2V}{RT_2}$$

$$\frac{P_1V}{2RT_1}=\frac{P_2V}{RT_2}$$

$$\left(\frac{T_2}{T_1}\right)=2\left(\frac{P_2}{P_1}\right)$$

As the tank is insulated, the process is adiabatic with $\gamma=\frac{5}{3}$

$$T_2=T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\Rightarrow\left(\frac{T_2}{T_1}\right)^{\frac{5}{2}}=\left(\frac{P_2}{P_1}\right)$$

$$\frac{T_2}{T_1}=2\left(\frac{T_2}{T_1}\right)^{\frac{5}{2}}\Rightarrow T_2=\frac{T_1}{2^{\frac{2}{3}}}$$

$$=\frac{T_2}{T_1}=2\left(\frac{T_2}{T_1}\right)^{\frac{5}{2}}\Rightarrow T_2=\frac{T_1}{2^{\frac{2}{3}}}$$

$$=\frac{320}{2^{\frac{2}{3}}}=200\text{K}=-73°\text{C}\quad[\text{Given}\sqrt[3]{4}=1.6]$$

595 **(a,b,c,d)**

$\Delta U=nC_v\Delta T\rightarrow$ for any process

In adiabatic process: $\Delta Q=0$, so $\Delta U=-\Delta w\Rightarrow|\Delta U|=|\Delta w|$

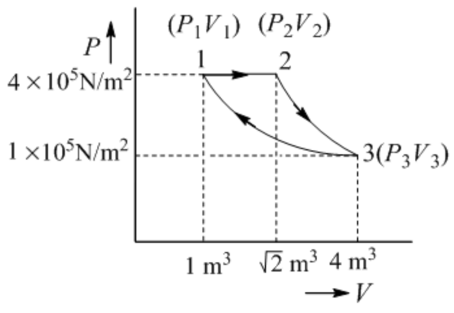
In isothermal process, $\Delta T=0$, so $\Delta U=0$

596 **(a,b,c)**

For the process 3 → 1

$$P_1V_1=P_3V_3\Rightarrow V_3=\frac{P_1V_1}{P_3}=\frac{4\times10^5\times1}{1\times10^5}=4\text{ m}^3$$

For the process 2 → 3



$$P_2V_2^\gamma=P_3V_3^\gamma\Rightarrow\left(\frac{P_3}{P_2}\right)^{\frac{1}{\gamma}}V_3=4\left(\frac{1}{4}\right)^{\frac{3}{4}}$$

$$=4^{\frac{1}{4}}\text{m}^3=\sqrt{2}\text{m}^3$$

For the process 1 → 2,

$$W_{12}=P_1(V_2-V_1)$$

$$=(\sqrt{2}-1)4\times10^5\text{ J}$$

For the process 2 → 3,

$$W_{23}=\frac{(P_2V_2-P_3V_3)}{(\gamma-1)}$$

$$=\frac{(4\sqrt{2}-1\times4)\times10^5}{\left(\frac{4}{3}-1\right)}=12(\sqrt{2}-1)\times10^5\text{ J}$$

For the process 3 → 1,

$$W_{31}=-P_1V_1\text{In}\frac{V_3}{V_1}$$

$$=-4\times10^5\times1\times\text{In}\left(\frac{4}{1}\right)$$

$$\Delta U=0$$

$$\overset{\Delta Q}{1\rightarrow2\rightarrow3\rightarrow1}=\Delta U+\Delta W=4\times10^5(\sqrt{2}-1)$$

$$+12\times10^5(\sqrt{2}-1)-4\times10^5\times1.386$$

$$\approx1.08\times10^5\text{J}$$

$$\Delta Q=\Delta W\approx1.08\times15^5\text{J}$$