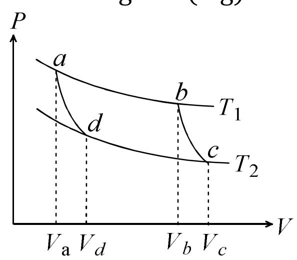
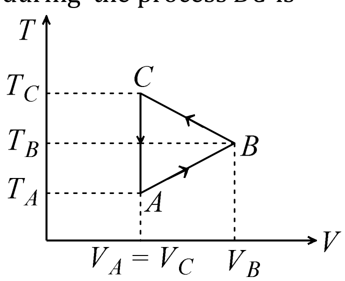
Single Correct Answer Type

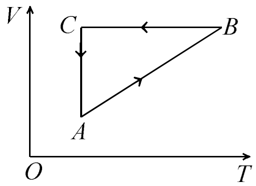
1. A gas does 4.5 J of external work during adiabatic expansion. If its temperature falls by 2K , its internal energy will
   a) Increase by 4.5 J b) decrease by 4.5 J c) decrease by 2.25 J d) Increase by 9.0 J
2. Two different adiabatic paths for the same gas intersect two isothermals at T_1 and T_2 as shown in the $P-V$ diagram (Fig). Then

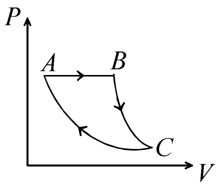


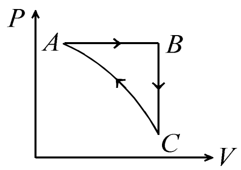
   a) $\frac{V_a}{V_c}=\frac{V_b}{V_d}$ b) $\frac{V_a}{V_b}=\frac{T_2}{T_1}$ c) $\frac{V_a}{V_b}=\frac{V_d}{V_c}$ d) $\frac{V_a}{V_d}=\frac{T_1}{T_2}$
3. For a gas, the difference between the two specific heats is 4150 J $kg^{-1}K^{-1}$ and the ratio of the two specific heats is 1.4. What is the specific heat of the gas at constant volume in units of J $kg^{-1}K^{-1}$?
   a) 8475 b) 5186 c) 1660 d) 10375
4. Three moles of an ideal gas are taken through a cyclic process $ABCA$ as shown on $T-V$ diagram in Fig. The gas loses 2510 J of heat in the complete cycle. If $T_A=100$ K and $T_B=200$ K, The work done by the gas during the process BC is

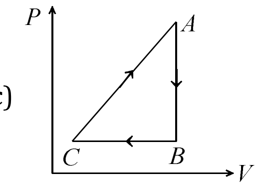


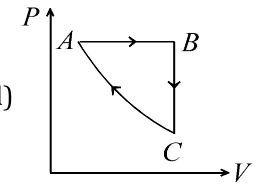
   a) 5000 J b) −5000 J c) 4000 J d) −2500 J
5. A thermally insulated rigid container contains an ideal gas at 27°C. It is fitted with a heating coil of resistance 50 Ω . A current is passed through the coil for 10 minutes by connecting it to a d. c. source of 10 V. The change in the internal energy is
   a) Zero b) 300 J c) 600 J d) 1200 J
6. A Carnot's engine whose sink is at a temperature of 300 K has an efficiency of 40%. By how much should the temperature of the source be increased so as to increase the efficiency to 60%?
   a) 250 K b) 275 K c) 300 K d) 325 K
7. Two monoatomic ideal gases 1 and 2 of molecular masses, M_1 and M_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to that in gas 2 is
   a) $\sqrt{\frac{M_1}{M_2}}$ b) $\sqrt{\frac{M_2}{M_1}}$ c) $\frac{M_1}{M_2}$ d) $\frac{M_2}{M_1}$
8. Figure shows a cyclic process $ABCA$ in the $V-T$ diagram. Which of the diagrams shown in Fig. shows the same process on a $P-V$ diagram



a) 

b) 

c) 

d) 

9. For a thermodynamic process, the $P - V$ graph for a monoatomic gas is a straight line passing through the origin and having a positive slope. The molar heat capacity of the gas in this process is

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

10. An ideal gas ($\gamma = 1.4$) expands from $5 \times 10^{-3} \mathrm{m}^3$ to $25 \times 10^{-3} \mathrm{m}^3$ at a constant pressure of 1×10^5Pa. The heat energy supplied to the gas in this process is

a) 7 J b) 70 J c) 700 J d) 7000 J

11. The pressure and density of a diatomic gas ($\gamma = 7/5$) change adiabatically form $(p_1, d_1)$to (p_2, d_2). If $\frac{d_2}{d_1} = 32$, then $\frac{p_2}{p_1}$ is

a) $\frac{1}{128}$ b) 32 c) 128 d) 256

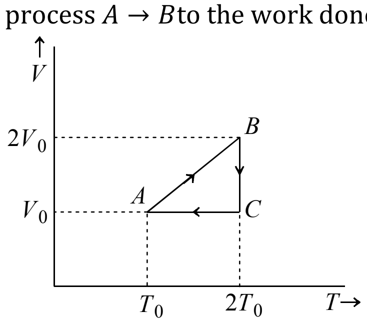
12. One mole of a monoatomic gas ($\gamma = 5/3$) is mixed with one mole of a diatomic gas ($\gamma = 7/5$). What will be value of γ for the mixture?

a) 1.5 b) 1.54 c) 1.4 d) 1.45

13. A gas mixture consists of 2 moles of oxygen and 4 moles argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is

a) $4\,RT$ b) $15\,RT$ c) $9\,RT$ d) $11\,RT$

14. Figure shows a cyclic process $ABCA$ for an ideal diatomic gas. The ratio of the heat energy absorbed in the process $A \rightarrow B$to the work done on the gas in the in the process $B \rightarrow C$ is



a) $\frac{7}{4 \ln (2)}$ b) $\frac{7}{2 \ln (2)}$ c) $\frac{5 \ln (2)}{4}$ d) $\frac{5 \ln (2)}{2}$

15. A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. In the initial temperature of the gas is T_f (in kelvin) and the final temperature is T_f, the value of a is

a) 4 b) 6 c) 5 d) 9

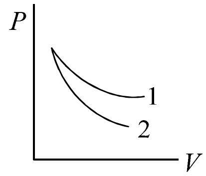
16. 5 moles of Hydrogen $\left(\gamma = \frac{7}{5}\right)$ initially at S.T.P. are compressed adiabatically so that its temperature becomes 400°C. The increase in the internal energy of the gas in kilo-joules is:
$(R = 8.30\ \mathrm{J\ mol^{-1} K^{-1}})$

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

17. 5.6 L of helium gas at STP is adiabatically compressed to 0.7 L. Taking the initial temperature to be T_1, the work done in the process is

a) $\frac{9}{8}RT_1$ b) $\frac{3}{2}RT_1$ c) $\frac{15}{8}RT_1$ d) $\frac{9}{2}RT_1$

18. $P - V$ plots for two gases during adiabatic processes are shown in Fig. Plots 1 and 2 should correspond respectively to



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

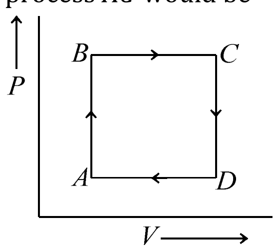
19. A balloon is filled with a mixture of ideal gases. The pressure P in the balloon is related to the volume V as $PV^{2/3} = k$, where k is a constant. If T is the temperature of the mixture, volume V is proportional to

a) T b) T^2 c) T^3 d) T^4

20. A certain amount of heat energy is supplied to a monoatomic ideal gas which expands at constant pressure. What fraction of the heat energy is converted into work?

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

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



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

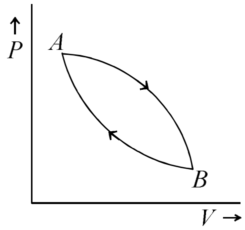
22. A vessel contains 1 mole of O_2 gas (molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing one mole of He gas (molar mass 4) at a temperature2 T has a pressure of

a) $\frac{P}{8}$ b) P c) $2P$ d) $8P$

23. The internal energy of 3 moles of hydrogen at temperature T is equal to the internal energy of n moles of helium at temperature $T/2$. The value of n is (assume hydrogen and helium to behave like ideal gases)

a) 5 b) 10 c) $\frac{3}{2}$ d) 6

24. Figure shows a cyclic process. When a given mass of a gas is expanded from state A to state B, it absorbs 30J of heat energy. When the gas is adiabatically compressed from state B to state A, the work done on the gas is 50 J. The change in internal energy of the e gas in the process $A \rightarrow B$ is



a) 80 J b) 20 J c) -20 J d) -50 J

25. During an adiabatic process, the pressure of a gas is proportional to the cube of its absolute temperature. The value of C_p/C_v for that gas is:

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

26. A monoatomic 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 pison suddenly. If

L_1 and L_2 are the lengths 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) $\left(\frac{L_2}{L_1}\right)^{2/3}$

27. 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

28. Two cylinders A and B fitted with pistons contain equal amounts 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 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

29. Two identical containers A and B fitted with frictionless pistons contain the same idal 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 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) $3\ m_A = 2\ m_B$ d) $9\ m_A = 4\ m_B$

30. The equation of state corresponding to 8 g of O_2 is (assume O_2 to be an ideal gas)

a) $PV = 8\ RT$ b) $PV = \frac{RT}{4}$ c) $PV = RT$ d) $PV = \frac{RT}{2}$

31. 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) $W_1 > W_3 > W_2$

32. Two moles of ideal helium gas are in a rubber balloon at 30°C. The balloon is fully expandable and can be assumed to require no energy in its expansion. The temperature of the gas in the balloon is slowly changed to 35°C. The amount of heat required in raising the temperature is nearly (take $R = 8.31\ J/mol.K$)

a) $62J$ b) $104J$ c) $124J$ d) $208J$

33. A closed hollow insulated cylinder is filled with gas at 0°C and also contains an insulated piston of negligible weight and negligible thickness at the middle point. The gas on one side is heated to 100°C. If the piston moves through 5 c m, the length of the follow cylinder is

a) 13.65 cm b) 27.3 cm c) 38.6 cm d) 64.6 cm

34. The isothermal Bulk modulus of an ideal gas at pressure P is

a) P b) γP c) $P/2$ d) P/γ

35. If the ratio $C_p/C_v = \gamma$, the change in internal energy of the mass of a gas, when the volume changes from $V\ to\ 2\ V$ at constant pressure$P$ is

a) $\frac{R}{(\gamma - 1)}$ b) PV c) $\frac{PV}{(\gamma - 1)}$ d) $\frac{\gamma\ PV}{(\gamma - 1)}$

36. The equation of state of a gas is

$$\left(P + \frac{aT^2}{V}\right) \times V^c = (RT + b)$$

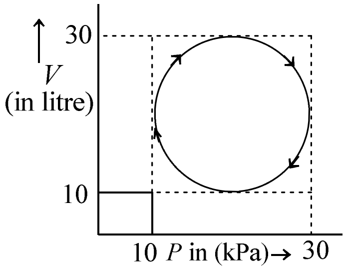
Where a, b, c and $R$are constants. The isotherms can be represented by

$P = AV^m - BV^n$

Where A and B depend only on temperature and

a) $m = -c, n = -1$ b) $m = c, n = 1$ c) $m = -c, n = 1$ d) $m = c, n = -1$

37. Heat energy absorbed by a system in going through a cyclic process shown in Fig. is

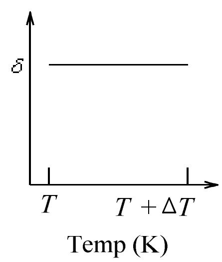


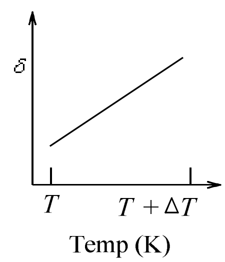
a) $10^7\ \pi$ joule b) $10^4\ \pi$ joule c) $10^2\ \pi$ joule d) $10^{-3}\ \pi$ joule

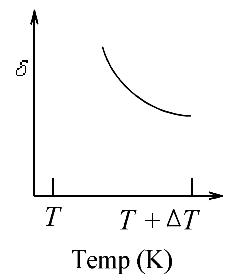
38. If 2 moles of an ideal monoatomic gas at temperature T are mixed with 3 moles of another monoatomic gas at temperature $2T$, the temperature of the mixture will be

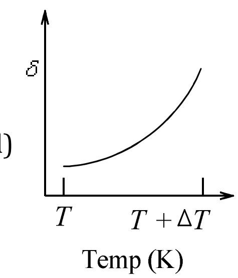
a) $\frac{8T}{5}$ b) $\frac{6T}{5}$ c) $\frac{4T}{3}$ d) $\frac{3T}{2}$

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

a) 

b) 

c) 

d) 

40. In a certain process, pressure P, volume V and temperature T of a gas are related as $PV = kT^n$ where k and n are constants. The work done by the gas when the pressure is kept constant, is proportional to

a) $(T)^{1/n}$ b) $(T)^n$ c) $T^{(n+1)}$ d) $T^{(n-1)}$

41. One mole of an ideal gas requires 207 J heat to raise its 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 will be (R, the gas constant = 8.3 $\mathrm{JK^{-1}mol^{-1}}$)

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

42. $C_v and\ C_p$ 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) $\frac{C_p}{C_v}$ 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

43. If the pressure of an ideal gas in a closed container is increased by 2%, the temperature of the gas increases by 5°C. The initial temperature of the gas is

a) 100 K b) 150 K c) 200 K d) 250 K

44. A sample of an ideal gas has volume V, pressure P and temperature T. The mass of each molecule of the gas is m. The density of the gas is (k is the Boltzmann's constant)

a) mkT b) $\frac{P}{kT}$ c) $\frac{P}{kVT}$ d) $\frac{mP}{kT}$

45. In rising from the bottom of a lake to the top, the temperature of an air bubble remains unchanged, but its diameter is doubled. If h is the barometric height (expressed in meters of mercury of relative density ρ) at the surface of the lake, the depth of the lake is (in meters)

a) 8 ρh b) 4 ρh c) 7 ρh d) 2 ρh

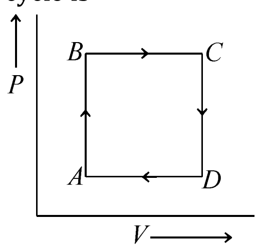
46. One mole of an ideal gas ($\gamma = 1.4$) is adiabatically compressed so that its temperature rises from 27°Cto 35°C. The change in the internal energy of the gas is (given $R = 8.3$ J/mole/K)

a) − 166 J b) 166 J c) − 168 J d) 168 J

47. Entropy of a thermodynamic system does not change when the system is used for
a) Conduction of heat from a hot reservoir to a cold reservoir
b) Conversion of heat into work adiabatically
c) Conversion of heat into internal energy isochorically
d) Conversion of work into heat isothermally

48. When an ideal monoatomic gas is heated at constant pressure, the fraction of 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) $\frac{3}{4}$

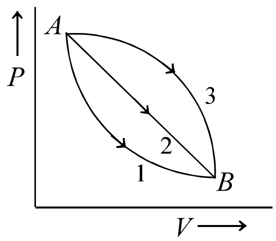
49. An ideal monoatomic gas is taken round the cycle $ABCA$ as shown in the Fig. The work done during the cycle is



a) Zero b) 3 PV c) 6 PV d) 9 PV

50. The temperature of n moles of an ideal gas is increased from T to $3T$ in a process in which the temperature changes with volume as $T = kV^2$ where k is a constant. The work done by the gas in this process is
a) $n\,R\,T$ b) $2\,n\,R\,T$ c) $\frac{3}{2}\,n\,R\,T$ d) $3\,n\,R\,T$

51. A given mass of a gas expands from state A to B by three different paths 1, 2 and 3 as shown in Fig. If W_1, W_2 and W_3 respectively be the work done by the gas along the three paths, then



a) $W_1 > W_2 > W_3$ b) $W_1 < W_2 < W_3$ c) $W_1 = W_2 = W_3$ d) $W_1 < W_2; W_1 < W_3$

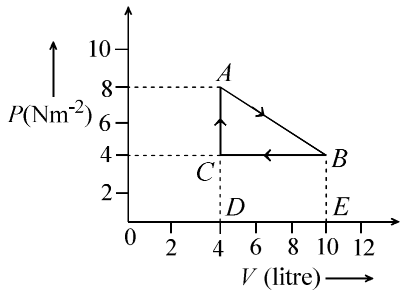
52. $dU+dW=0$ is valid for
a) Adiabatic process b) Isothermal process c) Isobaric process d) Isochoric process

53. If heat energy ΔQ is supplied to an ideal diatomic gas, the increase in internal energy is ΔU and the work done by the gas is ΔW. The ratio $\Delta Q : \Delta U : \Delta W$ is
a) 5 : 3 : 2 b) 5 : 2 : 3 c) 7 : 5 : 2 d) 7 : 2 : 5

54. A Carnot's engine working between 300 K and 600 K has a work output of 800 J per cycle. How much heat energy is supplied to the engine from the source in each cycle?
a) 1400 J b) 1500 J c) 1600 J d) 1700 J

Multiple Correct Answers Type

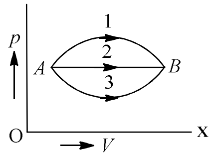
55. Figure shows the $P - V$ diagram of a cyclic process $ABCA$



a) Work done in process $A \to B$ is 0.036 J
b) Work done in process $B \to C$ is -0.024 J
c) Work done in process $C \to A$ is zero
d) Work done in cycle $ABCA$ is 0.06 J

56. An ideal gas is taken through a cyclic thermodynamic process involving four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J, $Q_2 = -5585$ J, $Q_3 = -2980$ J, and $Q_4 = 3645$ J respectively. The corresponding amounts of work done are $W_1 = 2200$ J, $W_2 = -825$ J and $W_3 = -1100$ J, and W_4 respectively. The efficiency of the cycle is η. Then
a) $W_4 = 765$ J
b) $W_4 = 275$ J
c) $\eta \simeq 11\%$
d) $\eta \simeq 16\%$

57. A gas undergoes a change in its state from position A to position B *via* three different paths as shown in figure. Select the correct statement



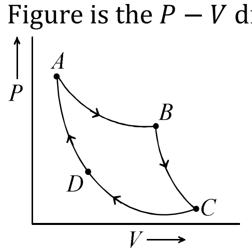
a) Heat is absorbed by the gas in all the three paths
b) Heat absorbed/released by the gas is maximum in path 1
c) Temperature of the gas increases first and then decreases continuously in path 1
d) Change in internal energy of the gas is same along all the three paths

58. n moles of an ideal monoatomic gas is kept in a closed vessel of volume 0.0083 m^3 at a temperature of 300 K and a pressure of 1.6×10^6 Pa. Heat energy of 2.49×10^4 J is supplied to the gas. Given $R = 8.3\ \text{J mol}^{-1}\text{K}^{-1}$
a) The value of $n = 5$
b) For the gas $C_p = 20.75\ \text{J mol}^{-1}\text{K}^{-1}$
c) The final temperature of the gas is 402°C
d) The Final pressure of the gas is 3.6×10^6 Pa

59. If ΔQ represents the heat energy supplied to a system, ΔU the increase in internal energy and ΔW the work done by the system, then which of the following are correct?
a) $\Delta Q = \Delta W$ for an isothermal process
b) $\Delta U = -\Delta W$ for an adiabatic process
c) $\Delta U = \Delta Q$ for an isochoric process
d) $\Delta U = -\Delta Q$ for an isobaric process

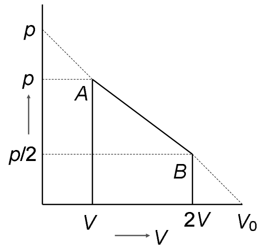
60. An ideal gas is undergoing an adiabatic change. Which of the following pressure-temperature relations is true?
a) $p\gamma^{-1}T^{\gamma}$=constant
b) $p\gamma\, T^{1-\gamma}$= constant
c) $p\gamma\, T^{1-\gamma}$ = constant
d) $p^{1-\gamma}T^{\gamma}$ = constant

61. Figure is 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

62. An ideal gas is taken from the state $A(p, V)$ to the state $B(p/2, 2V)$ along a straight line path as shown in figure. select the correct statement from the following



a) Work done by the gas in going from A to B exceeds the work done in going from A to B under isothermal conditions

b) In the $T-V$ diagram, path AB would become a parabola,

c) In the $p-T$ diagram, path AB would be part of hyperbola

d) In going from A to B, the temperature T of gas first increases to a maximum value 1 and then decreases

63. An ideal gas has pressure P, volume V and temperature T. The ratio $C_p/C_v = \gamma$ and U is the internal energy. If R is the gas constant, then

a) $C_v = \dfrac{R}{\gamma - 1}$ b) $U = nC_v T$ c) $U = \dfrac{PV}{(\gamma - 1)}$ d) $U = nC_pT$

64. The initial state of n moles of an ideal gas is represented by P_1, V_1, T_1 and the final state by P_2, V_2, T_2. W_i is the work done by the gas in an isothermal process ($T_1 = T_2 = T$) and W_a in an adiabatic process, then

a) $W_i = nRT \log_e\left(\dfrac{V_2}{V_1}\right)$ b) $W_i = nRT \log_e\left(\dfrac{P_1}{P_2}\right)$

c) $W_a = \dfrac{1}{(\gamma - 1)}(P_1V_1 - P_2V_2)$ d) $W_a = \dfrac{nR}{(\gamma - 1)}(T_1 - T_2)$

65. An ideal gas having initial pressure P, volume V and temperature T is allowed to expand adiabatically until its volume becomes 5.66 V while its temperature falls to $T/2$. If f is the number of degree of freedom of gas molecules and W is the work done by the gas during the expansion, then

a) $f = 3$ b) $f = 5$ c) $W = \dfrac{5PV}{4}$ d) $W = \dfrac{3PV}{2}$

66. Which of the following is equation of state for an adiabatic process?

a) $pV^{\gamma} = \text{constant}$ b) $p/\rho^{\gamma} = \text{constant}$ c) $TV^{\gamma-1} = \text{constant}$ d) $T^{\gamma}/p^{\gamma-1} = \text{constant}$

67. An ideal gas is taken from state A (pressure P, volume V) to state B (pressure $P/2$, volume $2V$) along a straight line in the $P-V$ diagram as shown in fig. Then

a) The work done by the gas in the 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 becomes 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 and then decreases

68. During the melting of a slab of ice at 273 K at atmospheric pressure

a) Positive work is done by 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 fusion of ice is 80 cal/g

a) Heat extracted from water is 3.36×10^5 J

b) The coefficient of performance is nearly equal to 10

c) The work done by the motor is nearly 3.36×10^4 J

d) The power of the momter is nearly 20 kW

70. A carnot's engine whose sink is at 27°C has an efficiency of 25%

a) The temperature of the source is 400 K

b) To increase efficiency by 20%, the temperature of the source should be increased by 28.6°C

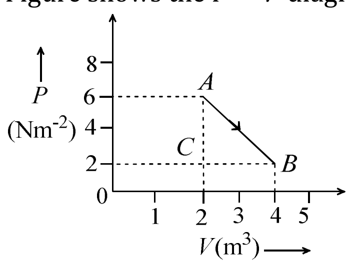
c) To increase efficiency by 20%, the temperature of the sink should be decreased by 28.6°C

d) If the heat energy supplied to the engine is 800 J per cycle the work output per cycle is 200 J

71. One mole of oxygen at 27°C is inclosed in a vessel which is thermally insulated. The vessel is moved with a constant speed v and is then suddenly stopped. The process results in a rise of temperature of the gas by 1°C. Then, if $M =$ Molecular mass of oxygen

a) $\gamma(= C_p/C_v) = \frac{5}{3}$ b) $\gamma = \frac{7}{5}$ c) $v = \sqrt{\frac{R}{M(\gamma+1)}}$ d) $v = \sqrt{\frac{2R}{M(\gamma-1)}}$

72. Figure shows the $P - V$ diagram for an ideal gas. From the graph we conclude that



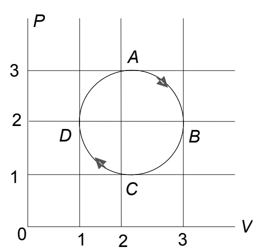
a) The process $A \to B$ is adiabatic

b) The internal energy of the gas increases in this process

c) The work done by the gas = area of triangle ABC

d) The heat energy absorbed by the gas is zero in the process

73. The figure shows the p-V plot of an ideal gas taken through a cycle $ABCDA$. The part ABC is a semi-circle and CDA is half of an ellipse. Then,



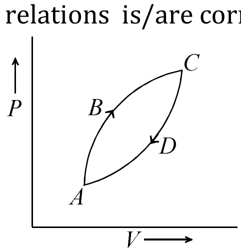
a) The process during the path $A \to B$ is isothermal

b) Heat flows out of the gas during the path $B \to C \to D$

c) Work done during the path $A \to B \to C$ is zero

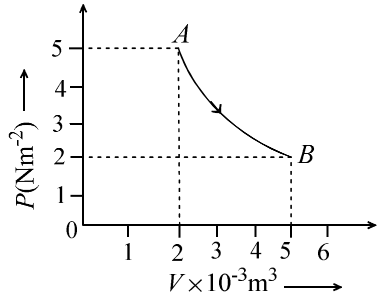
d) Positive work is done by the gas in the cycle $ABCDA$

74. Figure shows the $P - V$ diagram of a cyclic process. If dQ is the heat energy supplied to the system, dU is the internal energy of the system and dW is the work done by the system, then which of the following relations is/are correct



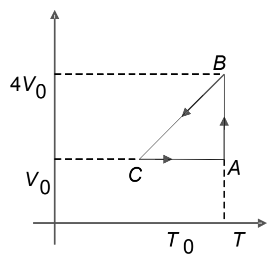
a) $dQ = dUdW$ b) $dU = 0$ c) $dQ = dW$ d) $dQ = -dW$

75. Figure shows the $P - V$ diagram for an ideal gas. From the graph, we conclude that



a) The process is isothermal
b) The internal energy of the gas remains constant
c) The work done in the process is positive
d) The heat energy absorbed in the process is zero

76. One mole of an ideal gas initial state A undergoes a cyclic process $ABCA$, as shown in the figure. Its pressure at A is p_0. Choose the correct option (s) from the following.

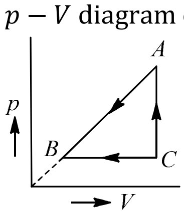


a) Internal energies at A and B are the same
b) Work done by the gas in process AB is p_0V_0 In 4
c) Pressure at C is $\frac{p_0}{4}$
d) Temperature at C is $\frac{T_0}{4}$

77. Which of the following is incorrect regarding the first law of thermodynamics?
a) It is not applicable to any cyclic process
b) It is a restatement of the principle of conservation of energy
c) It introduces the concept of the internal energy
d) It introduces the concept of the entropy

78. For an ideal gas
a) The change in internal energy at constant pressure when the temperature of n moles of the gas changes by ΔT is $n\,C_v\,\Delta T$
b) The change in internal energy of the gas in an adiabatic process is equal in magnitude to the work done by the gas
c) The internal energy does not change in an isothermal process
d) No heat is added or removed in an adiabatic process

79. $p - V$ diagram of a cyclic process $ABCA$ is shown in figure. Choose the correct statements.



a) $\Delta Q_{A\to B}$ =negative b) $\Delta U_{C\to A}$ =negative c) ΔQ_{CBA} =negative d) $\Delta Q_{B\to}C$ =positive

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 80 to 79. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

80

Statement 1: In isothermal process whole of the heat energy supplied to the body is converted into internal energy

Statement 2: According to the first law of thermodynamics $\Delta Q = \Delta U + P\Delta V$

81

Statement 1: The entropy of the solids is the highest

Statement 2: Atoms of the solids are arranged in orderly manner

82

Statement 1: Efficiency of a Carnot engine increased on reducing the temperature of sink

Statement 2: The efficiency of a Carnot engine is defined as ratio of net mechanical work done per cycle by the gas to the amount of heat energy absorbed per cycle from the source

83

Statement 1: First law of thermodynamics is re-statement of the principle of conservation of energy

Statement 2: Energy is something fundamental

84

Statement 1: A reversible engine working between 127°C and 227°C cannot have efficiency more than 20%

Statement 2: Under ideal conditions $\eta = 1 - \frac{T_2}{T_1}$

85

Statement 1: The heat supplied to a system is always equal to the increase in its internal energy

Statement 2: When a system changes from one thermal equilibrium to another, some heat is absorbed by it

86

Statement 1: It is impossible for a ship to use the internal energy of sea water to operate its engine.

Statement 2: A heat engine is different from a refrigerator.

87

Statement 1: The Carnot cycle is useful in understanding the performance of heat engines

Statement 2: The Carnot cycle provides a way of determining the maximum possible efficiency achievable with reservoirs of given temperatures

88

Statement 1: If two bodies of equal mass and made of the same material at different temperature T_1 and T_2 are brought in thermal contact, the temperature of each body will be $(T_1 + T_2)/2$ when thermal equilibrium is attained

Statement 2: They have the same thermal capacity

89

Statement 1: Specific heat capacity is the cause of formation of land and sea breeze.

Statement 2: The specific heat of water is more than land.

90

Statement 1: Change of state is an example of isothermal process

Statement 2: Change of state from solid to liquid occurs only at melting point of solid and change of state from liquid to gas occurs only at boiling point of liquid. Thus, there is no change of temperature during change of state

91

Statement 1: Two vessels A and B of equal capacity are connected to each other by a stopcock. Vessel A contains a gas at 0°C and 1 atmosphere pressure and vessel B is evacuated. If the stopcock is suddenly opened, the final pressure in A and B will be 0.5 atmosphere

Statement 2: If the temperature is kept constant, the pressure of a gas is inversely proportional to its volume

92

Statement 1: The temperature of the surface of the sun is approximately 6000 K. If we take a big lens and focus the sunrays, we can produce a temperature of 8000 K

Statement 2: The highest temperature can be produced according to second law of thermodynamics

93

Statement 1: Work done by a gas in isothermal expansion is more than the work done by the gas in the same expansion, adiabatically

Statement 2: Temperature remains constant in isothermal expansion, and not is adiabatic expansion

94

Statement 1: Two vessels A and B are connected to each other by a stopcock. Vessel A contains a gas at 0°C and 1 atmosphere pressure and vessel B is evaluated. The two vessels are thermally insulated from the surroundings. If the stopcock is suddenly opened, there will be no change in the internal energy of the gas

Statement 2: NO transfer of heat energy takes place between the system and the surroundings

95

Statement 1: In an isolated system the entropy increases

Statement 2: The processes in an isolated system are adiabatic

96

Statement 1: Heating system based on circulation of steam are more efficient in warming a house than those based or circulation of hot water

Statement 2: The latest heat of steam is high

97

Statement 1: Reversible systems are difficult to find in real world

Statement 2: Most processes are dissipative in nature

98

Statement 1: Efficiency of a Carnot engine decreases with decrease in temperature difference between the source and the sink.

Statement 2: $\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_2}$

99

Statement 1: In an adiabatic process, change in internal energy of a gas is equal to work done on or by the gas in the process

Statement 2: Temperature of gas remains constant in a adiabatic process

100

Statement 1: It is not possible for a system, unaided by an external agency to transfer heat from a body at a lower temperature to another at a higher temperature

Statement 2: It is not possible to violate the second law of thermodynamics

101

Statement 1: Thermodynamic processes in nature are irreversible

Statement 2: Dissipative effects can not be eliminated

102

Statement 1: A Carnot engine working between 100 K and 400 K has an efficiency of 75%

Statement 2: If follows from $\eta = 1 - \frac{T_2}{T_1}$

103

Statement 1: When a glass of hot milk is placed in a room and allowed to cool, its entropy decreases

Statement 2: Allowing hot object to cool does not violate the second law of thermodynamics

104

Statement 1: In adiabatic compression, the internal energy and temperature of the system get decreased.

Statement 2: The adiabatic compression is a slow process.

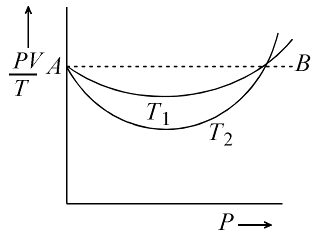
105

Statement 1: When a bottle of cold carbonated drink is opened, a slight fog forms around the opening

Statement 2: Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapours

106

Statement 1: Figure shows $\frac{PV}{T}$ versus P graph for a certain mass of oxygen gas at two temperatures T_1 and T_2. It follows from the graph that $T_1 > T_2$



Statement 2: At higher temperatures, real gas behaves more like an ideal gas

107

Statement 1: The isothermal curves intersect each other at a certain point

Statement 2: The isothermal change takes place slowly, so the isothermal curves have very little slope

108

Statement 1: Air quickly leaking out of a balloon becomes cooler

Statement 2: The leaking air undergoes adiabatic expansion

109

Statement 1: We can not change the temperature of a body without giving (or taking) heat to (or from) it

Statement 2: According to principle of conservation of energy, total energy of a system should remain conserved

110

Statement 1: The isothermal curves intersect each other at a certain point

Statement 2: The isothermal changes takes place rapidly, so the isothermal curves have very little slope

111

Statement 1: Internal energy of an ideal gas depends only on temperature and not on volume

Statement 2: Temperature is more important than volume

112

Statement 1: If an electric fan be switched on in a closed room, the air of the room will be cooled

Statement 2: Fan air decreases the temperature of the room

113

Statement 1: Zeroth law of thermodynamic explains the concept of energy

Statement 2: Energy is dependent on temperature

114

Statement 1: An adiabatic process is an isotropic process

Statement 2: $\Delta S = \frac{\Delta Q}{T} = 0 \therefore \ \Delta Q = 0$, Which represents an adiabatic process

115

Statement 1: First law of thermodynamic does not forbid flow of heat from lower temperature to higher temperature.

Statement 2: Heat supplied to a system is always equal to the increase in its internal energy at constant volume.

116

Statement 1: Two vessels A and B are connected to each other by a stopcock. Vessel A contains a gas at 300 K and 1 atmosphere pressure and vessel B is evacuated. The two vessel are thermally insulated from the surroundings. If the stopcock is suddenly opened, the expanding gas does no work

Statement 2: Since $\Delta Q = 0$ and $\Delta U = 0$, it follows from the first law of thermodynamics thet $\Delta W = 0$

117

Statement 1: The specific heat of a gas in an adiabatic process is zero and in an isothermal process is infinite

Statement 2: Specific heat of a gas is directly proportional to change of heat in system and inversely proportional to change in temperature

118

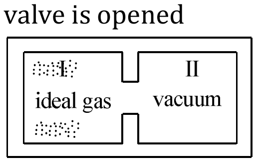
Statement 1: It is not possible for a system, unaided by an external agency to transfer heat from a body at lower temperature to another body at higher temperature

Statement 2: According to Clausius statement, “No process is possible whose sole result is the transfer of heat from a cooled object to a hotter object

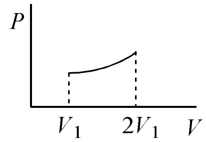
Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II.**

119. Column I contains a list of processes involving expansion of an ideal gas. Match this with Column II describing the thermodynamic change during this process

Column-I	Column- II
(A) An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the Chamber II has vacuum. The valve is opened 	(p) The temperature of the gas decreases
(B) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^2}$, where V is the volume of the gas	(q) The temperature of the gas increases or remains constant
(C) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$, where V, is its volume	(r) The gas loses heat

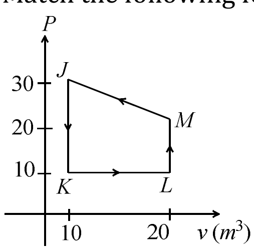
(D) An ideal monoatomic gas expands such that its pressure P and volume V follows the behavior shown in the graph | (s) The gas gains heat



CODES :

	A	B	C	D
a)	P,r	q	q,s	p,s
b)	q	p,r	p,s	q,s
c)	p,s	q,s	q	p,r
d)	q,s	p,s	p,r	q

120. Match the following for the given process

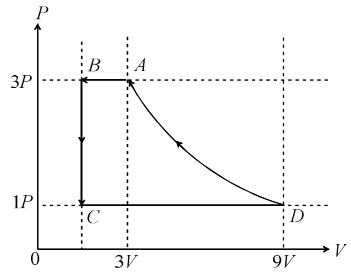


Column-I	Column- II
(A) Process $J \to K$	(p) $Q > 0$
(B) Process $K \to L$	(q) $W < 0$
(C) Process $L \to M$	(r) $W > 0$
(D) Process $M \to J$	(s) $Q < 0$

CODES :

	A	B	C	D
a)	s	p,r	r	q,s
b)	p,r	q,s	s	r
c)	q,s	s	p,r	r
d)	s	r	q,s	p,r

121. One mole of a monoatomic ideal gas is taken through a cycle $ABCDA$ as shown in the P-V diagram. Column-II given the characteristics involved in the cycle. Match them with each of the processes given in Column-I



	Column-I		Column- II
(A)	Process A → B	(p)	Internal energy decreases
(B)	Process B → C	(q)	Internal energy increases
(C)	Process C → D	(r)	Heat is lost
(D)	Process D → A	(s)	Heat is gained
		(t)	Work is done on the gas

CODES :

	A	B	C	D
a)	P,r	q,s	r,t	p,r,t
b)	r,t	p,r,t	p,r	q,s
c)	p,r,t	p,r	q,s	r,t
d)	q,s	r,t	p,r,t	p,r

Linked Comprehension Type

This section contain(s) 16 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

Paragraph for Question Nos. 122 to -122

The efficiency of a Carnot engine working between source temperature T_1 and sink temperature T_2 is $\eta = 1 - \frac{T_2}{T_1}$. The efficiency cannot be 100% as we cannot maintain $T_2 = 0$. Coefficient of performance of a refrigerator working between the same two temperature is

Coefficient of performance $\frac{T_2}{T_1 - T_2} = \frac{1-\eta}{\eta}$

122. The efficiency of a Carnot engine working between 27°C and −73°C is

a) 100% b) 60% c) 33% d) Zero

Paragraph for Question Nos. 123 to - 123

The changes in pressure and volume of a gas when heat content of the gas remains constant are called adiabatic changes. The equation of such changes is $pV^{\gamma} =$ constant. The changes must be sudden and the container must be perfectly insulting to disallow any exchange of heat with the surrounding. In such changes, $dQ = 0$. As per first law of thermodynamics, $dQ = dU + W = 0$. Therefore, $dU = -dW$.

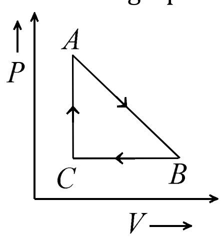
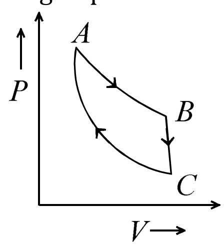
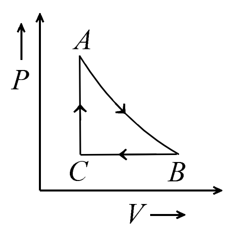
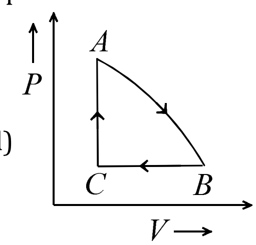
123. A gas in a container is compressed suddenly. Its temperature would

a) Increase
b) Decrease
c) Stay constant
d) Change depending upon surrounding temperature.

Paragraph for Question Nos. 124 to - 124

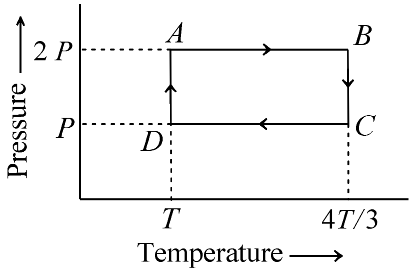
Three moles of an ideal gas $\left(C_p = \frac{7R}{2}\right)$ at pressure P_A and temperature T_A are isothermally expanded to twice the original volume. The gas is then compressed at constant pressure to its original volume. Finally the gas is heated at constant volume to its original pressure P_A

124. Which of the graphs shown in Fig. represents the $P - V$ diagram for the complete process?

a) 
b) 
c) 
d) 

Paragraph for Question Nos. 125 to - 125

Two moles of an ideal gas at volume V, pressure $2\,P$ and temperature T undergo a cyclic process $ABCDA$ as shown in Fig.



125. The volume (V_B) of the gas in state B is

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

Paragraph for Question Nos. 126 to - 126

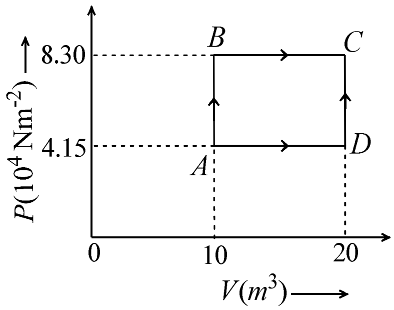
Two moles of a monoatomic ideal gas occupy a volume V at 27°C. The gas is expanded adiabatically to volume $2\sqrt{2}\,V$. Gas constant $R = 8.3\ \mathrm{JK^{-1}mol^{-1}}$

126. The final temperature of the gas is

a) $\frac{150}{\sqrt{2}}$ K b) 150 K c) $150\sqrt{2}$ K d) 13.6°C

Paragraph for Question Nos. 127 to - 127

A sample of 2 kg of monoatomic helium (assumed ideal) is taken through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC as shown in Fig. The molecular mass = 4 and $R = 8.3 \text{ J K}^{-1}\text{mol}^{-1}$

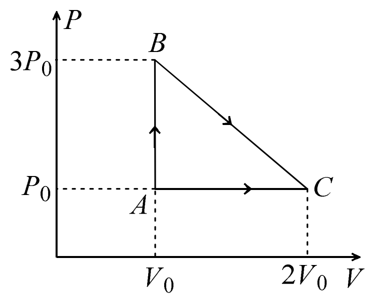


127. The temperature of state A is

a) 100 K　b) 200 K　c) 300 K　d) 415 K

Paragraph for Question Nos. 128 to - 128

One mole of an ideal monoatomic gas is taken round the cyclic process $ABCA$ as shown in Fig.



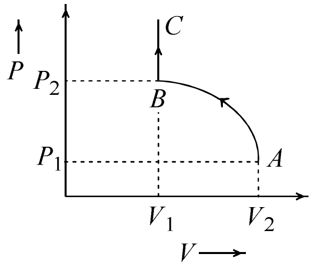
128. The work done by the gas is

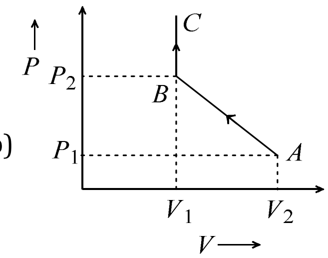
a) P_0V_0　b) $2P_0V_0$　c) $3P_0V_0$　d) $4P_0V_0$

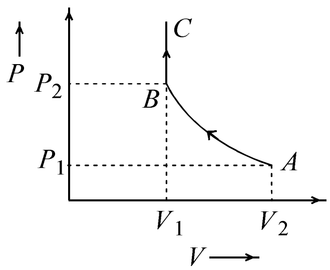
Paragraph for Question Nos. 129 to - 129

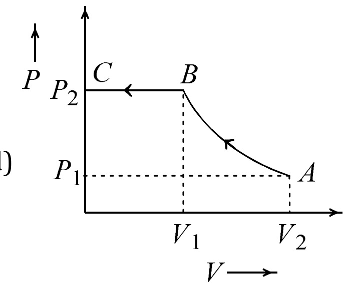
Two moles of an ideal monoatomic gas, initially at pressure $P_1 = P$ and volume $V_1 = 2\sqrt{2}\,V$, undergo an adiabatic compression until its volume is $V_2 = V$ and the pressure is P_2. Then the gas is given heat energy Q at constant volume V_2

129. Which of the graphs shown in Fig. represents the $P - V$ diagram of the complete process?

a) 

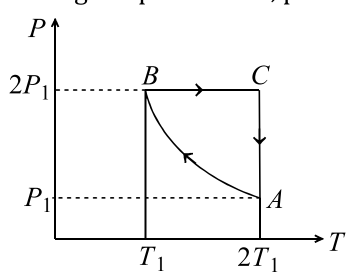
b) 

c) 

d) 

Paragraph for Question Nos. 130 to - 130

Two moles of an ideal mono-atomic gas is taken through a cycle $ABCA$ as shown in the $P-T$ diagram (Fig). During the process AB, pressure and temperature of the gas vary such that $PT=K$, where K is a constant

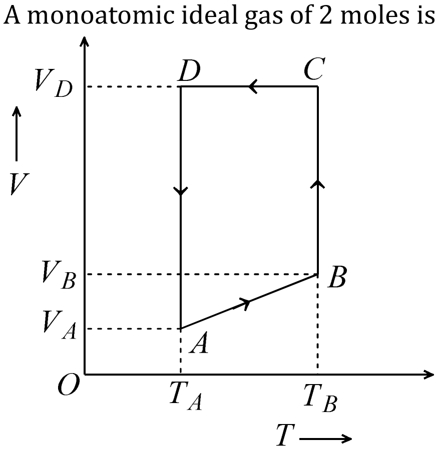


130. Constant K is given by

a) $\frac{P_1T_1}{2}$ b) P_1T_1 c) $2\ P_1T_1$ d) $\sqrt{2}P_1T_1$

Paragraph for Question Nos. 131 to - 131

A monoatomic ideal gas of 2 moles is taken through a cyclic process starting from A as shown in Fig

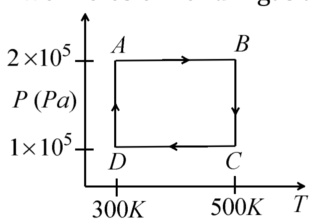


Given $\frac{V_B}{V_A} = 2$ and $\frac{V_D}{V_A}$ 4. The temperature $T_A = 27°C$.
R is the gas constant

131. The temperature of the gas at point B is
a) 400 K b) 500 K c) 600 K d) 700 K

Paragraph for Question Nos. 132 to - 132

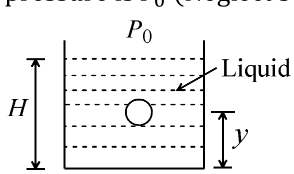
Two moles of helium gas are taken over the cycle $ABCDA$, as shown in the $P - T$ diagram



132. Assuming the gas to be ideal the work done on the gas in taking it from A to B is
a) 200 R b) 300 R c) 400 R d) 500 R

Paragraph for Question Nos. 133 to - 133

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density ρ_1 (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure is P_0 (Neglect surface tension)



133. As the bubble moves upwards, besides the buoyancy force the following forces are acting on it
a) Only the force of gravity
b) The force due to gravity and the force due to the pressure of the liquid
c) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid
d) The force due to gravity and the force due to viscosity of the liquid

: ANSWER KEY :

1)	b	2)	c	3)	d	4)	b
5)	d	6)	a	7)	b	8)	d
9)	b	10)	d	11)	c	12)	a
13)	d	14)	a	15)	a	16)	b
17)	a	18)	b	19)	c	20)	c
21)	a	22)	c	23)	b	24)	d
25)	d	26)	d	27)	a	28)	d
29)	c	30)	b	31)	a	32)	d
33)	d	34)	a	35)	c	36)	a
37)	c	38)	a	39)	a	40)	b
41)	d	42)	b	43)	d	44)	d
45)	c	46)	b	47)	d	48)	b
49)	b	50)	a	51)	b	52)	d
53)	c	54)	c	1)	a,b,c	2)	
	a,c	3)	a,b,c,d	4)	a,c,d		
5)	a,b,c	6)	d	7)	a,c	8)	
	a,b						
9)	a,b,c	10)	a,b,c,d	11)	b,c	12)	
	a,b,c,d						
13)	a,b,d	14)	b,c	15)	a,b,c,d	16)	
	a,b,d						
17)	b,d	18)	b	19)	b,d	20)	c
21)	a,b,c	22)	a,b	23)	a,d	24)	
	a,b,c,d						
25)	a,c,d	1)	d	2)	d	3)	b
	4)	c					
5)	a	6)	d	7)	b	8)	a
9)	a	10)	a	11)	a	12)	a
13)	d	14)	b	15)	a	16)	b
17)	a	18)	a	19)	a	20)	c
21)	a	22)	a	23)	a	24)	b
25)	d	26)	a	27)	a	28)	d
29)	a	30)	d	31)	d	32)	c
33)	d	34)	d	35)	a	36)	b
37)	a	38)	a	39)	a	1)	b
	2)	a	3)	c	1)	c	
	2)	a	3)	c	4)	d	
5)	b	6)	a	7)	a	8)	c
9)	c	10)	c	11)	c	12)	d

: HINTS AND SOLUTIONS :

1 **(b)**
$dQ = dU + dW$ In an adiabatic process, $dQ = 0$
Hence $dU = -dW = -4.5$ J

2 **(c)**
The two adiabatic paths ad and bc for the gas intersect the two isothermals ab and cd at temperatures T_1 and T_2 (see Fig.). Since points a and d lie on the same adiabatic path, we have
$T_1 V_a^{(\gamma-1)} = T_2 V_d^{(\gamma-1)}$
Or $\left(\frac{V_a}{V_d}\right)^{(\gamma-1)} = \frac{T_2}{T_1}$ (1)
Since points b and c also lie on the same adiabatic path,
$T_1 (V_b)^{(\gamma-1)} = T_2\, V_c^{(\gamma-1)}$
Or $\left(\frac{V_b}{V_c}\right)^{(\gamma-1)} = \frac{T_2}{T_1}$ (2)
From (1) and (2), we get
$\left(\frac{V_a}{V_d}\right)^{(\gamma-1)} = \left(\frac{V_b}{V_c}\right)^{(\gamma-1)}$
Or $\frac{V_a}{V_d} = \frac{V_b}{V_c}$

3 **(d)**
Given $C_p - C_v = 4150$ and $C_p/C_v = 1.4$or
$C_p = 1.4\, C_v$. Therefore,
$1.4\, C_v - C_v = 4150$
Or $C_v = \frac{4150}{0.4} = 10375$ J kg^{-1}K^{-1}

4 **(b)**
In process AB, the volume V increases linearly with temperature T. Hence process AB is isobaric (constant pressure). Therefore, work done in this process is
$W_{AB} = P\Delta V = nR\Delta T (\because PV = nRT)$
$= nR(T_B - T_A)$
$= 3 \times 8.3 \times (200 - 100) = 2490$ J
Process CA is isochoric (constant volume). Hence work done in this process $W_{CA} = 0$. Since the whole process $ABCA$ is cyclic, the change in internal energy in the complete cycle is zero, i.e. $\Delta U = 0$. Now, from the first law of thermodynamics, (Given $Q = -2510$J)
$Q = \Delta U + W = \Delta U + W_{AB} + W_{BC} + W_{CA}$
Or $-2510 = 0 + 2490 + W_{BC} + 0$
Or $W_{BC} = -2510 - 2490 = -5000$ J
The negative sign shows that the work is done by the gas

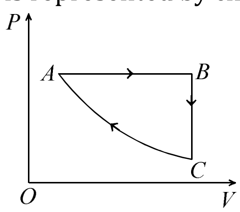
5 **(d)**
Heat produced is given by
$$dQ = \frac{V^2 t}{R} = \frac{(10)^2 \times (10 \times 60)}{50} = 1200 \text{ J}$$
Since the container is rigid, the change in volume $dV = 0$. Hence work done $dQ = PdV = 0$. From the first law of thermodynamics, the change in internal energy is $dU = dQ - dW = dQ = 1200$ J

6 **(a)**
$T_2 = 300$ K . Now $\eta = 1 - T_2/T_1$. When $\eta = 40\% = 0.4$, the value of T_1 is given by
$\frac{T_2}{T_1} = 1 - 0.4 = 0.6$
Or $T_1 = \frac{T_2}{0.6} = \frac{300}{0.6}$500K .When$\eta = 60\%$,=0.6, the value of T_2 should be
$T_2' = \frac{300}{0.4} = 750$ K
$\therefore T_2' - T_2 = 750 - 500 = 250$ K

7 **(b)**
The speed of sound in gas of bulk modulus B and density ρ is given by
$$v = \sqrt{\frac{B}{\rho}}$$
Bulk modulus B is given by $B = -\frac{V\Delta P}{\Delta V}$
Now, for a perfect gas, $PV = nRT$. Differentiating at constant T, we get
$P\Delta V + V\Delta P = 0$ or $\frac{V\Delta P}{\Delta V} = -P$
Hence $v = \sqrt{\frac{P}{\rho}}$
If m is the mass of the gas and M its molecular mass, then
$PV = \frac{m}{M} RT$ or $PM = \frac{mRT}{V} = \rho RT$
Or $\frac{P}{\rho} = \frac{RT}{M}$ or $v^2 = \frac{RT}{M}$
Or $v = \sqrt{\frac{RT}{M}}$
Hence $v_1 = \sqrt{\frac{RT}{M_1}}$ and $v_2 = \sqrt{\frac{RT}{M_2}}$ which
Give $\frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$

8 **(d)**
Since the temperature T remain constant along the path CA, P will be inversely proportional to V along this path. Hence, as P increases, V must decrease in a nonlinear fashion. This is represented by the curve CA in Fig.
Along the path BC, the volume V is constant.

Hence the graph of P against V is a straight line perpendicular to the V-axis. On a $P-V$ diagram, the corresponding path is BC as shown in Fig. For the path AB, V is directly proportional to T pressure remaining constant. The corresponding path AB is, therefore a straight line parallel to the V-axis. Thus the cyclic process on a $P-V$ diagram is represented by choice (d) in Fig.



9 **(b)**

Since the $P-V$ graph is a straight line with a positive slope, $P \propto V$

Or PV^{-1} = constant

For a process in which PV^{n} = constant, the molar heat capacity is given by

$$C=\frac{R}{(\gamma-1)}+\frac{R}{1-n}$$

Putting $n=-1$ and $\gamma=\frac{5}{3}$ (for a monoatomic gas), we have

$$C=\frac{R}{\left(\frac{5}{3}-1\right)}+\frac{R}{(1+1)}=\frac{3R}{2}+\frac{R}{2}=2\,R$$

10 **(d)**

Work done on the gas is

$\Delta W=P\Delta V=P\left(V_f-V_i\right)$

$=1\times10^5\times(25-5)\times10^{-3}$

$=2000$ J

The internal energy is given by $U=\frac{PV}{(\gamma-1)}$

$$\therefore U_i=\frac{PV_i}{(\gamma-1)},U_f=\frac{PV_f}{(\gamma-1)}$$

Therefore, change in internal energy is

$$\Delta U=U_f-U_i=\frac{P}{(\gamma-1)}(V_f-V_{\mathrm{i}})$$

$$=\frac{1\times10^5\times(25-5)\times10^{-3}}{(1.4-1)}=5000\text{ J}$$

From the first law of thermodynamics, the heat energy supplied to the gas is

$\Delta Q=\Delta W+\Delta U=2000+5000$

$=7000$ J

11 **(c)**

$p^{V^{\gamma}}$ =constant. For a given mass of gas, $V\propto\frac{1}{d}$

Hence

$\frac{p}{d^{\gamma}}$ = constant

$$\therefore\frac{p_1}{d_1^{\gamma}}=\frac{p_2}{d_2^{\gamma}}$$

Or $\frac{p_2}{p_1}=\left(\frac{d_2}{d_1}\right)^{\gamma}=(32)^{7/5}=(2)^7=128$

12 **(a)**

For a monoatomic gas, $C_v=3R/2$ and for a diatomic gas, $C_v=5R/2$. Since one mole of each gas is mixed together, the C_v of the mixture will

$$C_v=\frac{1}{2}\left[\frac{3R}{2}+\frac{5R}{2}\right]=2R$$

Now $C_p-C_v=R$. Therefore, for the mixture, $C_p=R+C_v=R+2R=3R$. Hence, the ratio of the specific heats of the mixture is

$$\gamma=\frac{C_p}{C_v}=\frac{3R}{2R}=\frac{3}{2}=1.5$$

13 **(d)**

Oxygen is diatomic gas, hence its energy of two moles

$$=2\times\frac{5}{2}RT=5RT$$

Argon is a monoatomic gas, hence its internal energy of 4 moles $=4\times\frac{3}{2}RT=6RT$

Total Internal energy $=(6+5)RT=11RT$

14 **(a)**

In the process $A\to B$, V is proportional to T. Hence pressure P remains constant. Therefore, heat energy absorbed in this process is

($\because C_p=7\,R/2$ for a diatomic gas)

$$(Q)_{A\to B}=n\,C_p\Delta T=n\times\frac{7R}{2}\times(2T_0-T_0)$$

$$=\frac{7}{2}\,n\,RT_0$$

Process $B\to C$ is isothermal in which the gas is compressed. Hence, work done on the gas in this process is

$(W)_{B\to C}=-nR(2T_0)\ln\left(\frac{V_0}{2V_0}\right)$

$=-2\,n\,RT_0\ln\left(\frac{1}{2}\right)$

$=2\,n\,RT_0\ln(2)$

$\therefore\frac{(Q)_{A\to B}}{(W)_{B\to C}}=\frac{7}{4\ln(2)}$, Which is choice (a)

16 **(b)**

Given $T_1=0°\mathrm{C}=273$ K, $T_2=400°\mathrm{C}=673$ K

Work done $W=\frac{nR}{(\gamma-1)}(T_2-T_1)=\frac{5\times8.3\times400}{\left(\frac{7}{5}-1\right)}$

$=41500$ J $=41.5$ kJ

By convention, the work done on the gas is taken to be negative, i.e. $W=-41.5$ kJ From the first law of thermodynamics $dQ=dU+dW$ For an adiabatic process, $dQ=0$ Hence $dU=-dW=-(-41.5)=41.5$ kJ The positive sign of dU implies that the internal energy increases

17 **(a)**

At STP,

22.4 L of any gas is 1 mol,

$\therefore \quad 5.6\text{ L} = \frac{5.6}{22.4} = \frac{1}{4}\text{mol} = n$

In adiabatic process,

$TV^{\gamma-1} = \text{constant}$

$\therefore \quad T_2V_2^{\gamma-1} = T_1V_1^{\gamma-1}$

or $\quad T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$

$\gamma = \frac{C_P}{C_V} = \frac{5}{3}$ for monoatomic He gas

$\therefore \quad T_2 = T_1 \left(\frac{5.6}{0.7}\right)^{\frac{5}{3}-1} = 4T_1$

Further in adiabatic process,

Q=0

$\therefore W + \Delta U = 0$

or $W = -\Delta U = -nC_V\Delta T$

$= -n\left(\frac{R}{\gamma-1}\right)(T_2 - T_1)$

$= -\frac{1}{4}\left(\frac{R}{\frac{5}{3}-1}\right)(4T_1 - T_1)$

$= -\frac{9}{8}RT_1$

18 **(b)**
For an adiabatic process, $PV^\gamma = \text{constant}$,
Differentiating, we have
$\gamma PV^{\gamma-1} + \frac{dP}{dV}V^\gamma = 0$ or $\frac{dP}{dV} = -\frac{\gamma P}{V}$
Since at any instant $PV = \text{constant}$, $\frac{dP}{dV} \propto \gamma$, i.e. the slope of $P - V$ curve is proportional to γ. Now, for a diatomic gas, $\gamma(= 7/5)$ is than that of for a monoatomic gas for which $\gamma = 5/3$. Therefore, the slope of the $P - V$ curve is less for a diatomic gas than for a monoatomic gas. Hence curve 1 corresponds to diatomic gas and curve 2 to monoatomic gas

19 **(c)**
$PV^{2/3} = k \qquad (1)$
Equation of state is $PV = n\,R\,T \Rightarrow P = \frac{n\,R\,T}{V}$
Using this in Eq. (1) we get
$\frac{n\,R\,T}{V} \times V^{2/3} = k$
Or $TV^{-1/3} = \frac{k}{n\,R} = \text{constant}$
Hence $V \propto T^3$

20 **(c)**
Heat energy supplied $dQ = C_pdT$. Change in internal energy $dU = C_vdT$. Therefore, work done $dW = dQ - dU = (C_p - C_v)dT$
$\therefore \frac{dW}{dQ} = \frac{(C_p - C_v)dT}{C_pdT} = 1 - \frac{1}{\gamma}$
$= 1 - \frac{1}{5/3} = \frac{2}{5}$
($\because\ \gamma = 5/3$ for a monoatomic gas)

21 **(a)**
Process AB is isochoric, i.e. the volume remains constant. Thus $\Delta V = 0$. Hence work done $P\Delta V = 0$. Process BC is isobaric, i.e. the pressure remains constant and external work has to be done. The work done $= P_B \times (V_D - V_A) = 8 \times 10^4 \times (5 \times 10^{-3} - 2 \times 10^{-3}) = 240$ J. Therefore, change in internal energy is
$dU = dQ - dW = 800 - 240 = 560$ J

22 **(c)**
For a gas, $PV = nRT$ Hence
$(P)_{O2} = \frac{(1\text{ mole})\,RT}{V}$
And
$(P)_{\text{He}} = \frac{(1\text{ mole})\,R(2T)}{V}$
$\therefore \frac{(P)_{\text{He}}}{(P)_{O_2}} = 2$
Or $(P)_{\text{He}} = 2(P)_{O2}$

23 **(b)**
The internal energy of n moles of an ideal gas at temperature T is given by
$U = \frac{f}{2}\,n\,R\,T$
Where f= number of degrees of freedom
For hydrogen, $f = 5$. Therefore
$U_1 = \frac{5}{2} \times 3 \times RT = \frac{15}{2}\,RT$
For helium, $f = 3$. Therefore
$U_2 = \frac{3}{2}\,n\,R\,(T/2) = \frac{3}{4}\,n\,RT$
Given $U_1 = U_2$, i.e.
$\frac{15}{2}\,RT = \frac{3}{4}\,n\,R\,T$
Which gives $n = 10$

24 **(d)**
In the process $B \to A$, work is done on the gas. Hence $(\Delta W)_{B\to A} = -50$ J. Since this process is

adiabatic, $(\Delta Q)_{B\to A} = 0$. From the first law of thermodynamics, the change in internal energy in this process is
$(\Delta U)_{B\to A} = (\Delta Q)_{B\to A} - (\Delta W)_{B\to A}$
$= 0 - (-50) = +50$ J
Since the process is cyclic, there is no net change in internal energy. Hence $(\Delta U)_{A\to B} = -(\Delta U)_{B\to A} = -50$ J

25 **(d)**
For an adiabatic process
$TP^n = k$
Where $n = \frac{(1-\gamma)}{\gamma}, \gamma = \frac{C_p}{C_v}$ and k is a constant
Therefore,
$$P = \left(\frac{k}{T}\right)^{1/n}$$
Since $n =$ constant for a given gas,
$P \propto T^{-1/n}$
Given $P \propto T^3$ Hence $-\frac{1}{n} = 3$ or $-\frac{\gamma}{1-\gamma} = 3$, Which
Gives $\gamma = \frac{3}{2}$

26 **(d)**
For adiabatic process, $T_1V_1^{(\gamma-1)} = T_2V_2^{(\gamma-1)}$
Thus, $\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{(\gamma-1)}$
For a monoatomic gas, $\gamma = 5/3$. Also $V_2/V_1 = L_2/L_1$
Hence
$$\frac{T_1}{T_2} = \left(\frac{L_2}{L_1}\right)^{\left(\frac{5}{3}-1\right)} = \left(\frac{L_2}{L_1}\right)^{2/3}$$

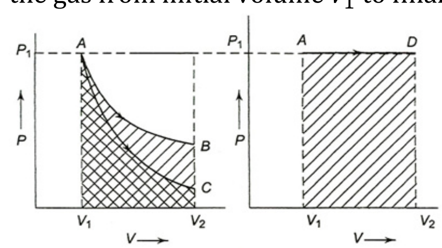
27 **(a)**
From the first law of thermodynamics, we have
$dU = dQ - dW$
Given $dW = 0$ and $dQ < 0$. Hence the change in internal energy $dU < 0$. Now, for an ideal gas, the internal energy can decrease only by decrease in temperature

28 **(d)**
Heat is given to the gas in cylinder A at constant pressure while the same amount of heat is given to the gas in cylinder B at constant volume. Heat given to gas in A is
$Q_A = n\,C_p\Delta T_A$
Heat given to gas in B is $Q_B = n\,C_v\Delta T_B$
Since $Q_A = Q_B$, we have
$nC_p\,\Delta T_A = nC_v\,\Delta T_B$
Or $\Delta T_B = \frac{C_p}{C_v}\,\Delta T_A = \frac{7}{5}\times 30\text{ K} = 42\text{ K}$
($\because$for a diatomic gas, $C_p/C_v = 7/5$)

29 **(c)**
The equation of state for an ideal gas of mass m and molecular mass M is
$PV = \frac{m}{M}RT$ (i)
For an isothermal process, $T =$ constant.
Differentiating (i) partially at constant T, we get
$P\Delta V + V\Delta P = 0$
Or $\Delta P = -P\frac{\Delta V}{V}$ (ii)
From (i), $P = \frac{mRT}{MV}$. Using this in (ii), we get
$\Delta P = -\frac{mRT}{MV} (\because \Delta V = 2V - V = V)$
$\therefore \Delta P_A = -\frac{m_ART}{MV}$ and $\Delta P_B = -\frac{m_BRT}{MV}$
Hence $\frac{\Delta P_A}{\Delta P_B} = \frac{m_A}{m_B}$
Given $\Delta P_B = 1.5\,\Delta P_A$. Therefore, $\frac{1}{1.5} = \frac{m_A}{m_B}$
Or $3\,m_A = 2\,m_B$

30 **(b)**
Number of moles in 8 g of oxygen$(n) = \frac{1}{4}$. Now the equation of state for n moles of an ideal gas is
$$PV = n\,R\,T = \frac{1}{4}\times RT = \frac{RT}{4}$$

31 **(a)**
Since the slope of the $P - V$ graph for adiabatic expansion is γ times that for isothermal expansion, curves AB and AC in Fig. respectively represent isothermal and adiabatic expansions of the gas from initial volume V_1 to final volume V_2



AS the area under curve AB between volumes V_1 and V_2 is greater than the area under curve AC between V_1 and V_2, it follows that $W_1 > W_3$
Figure (b) shows the $P - V$ graph for isobaric (at constant pressure) expansion from initial volume V_1 and pressure P_1 to final volume V_2; the pressure remaining unchanged at P_1. Comparing figures (a) and (b) we find that the area under AD between volumes V_1 and V_2 is greater than the area under curves $AB$and AC. Hence W_2 is greater than W_1 and W_3

32 **(d)**
$\Delta Q = nC_P\Delta T$
$$= 2\left(\frac{3}{2}R + R\right)\Delta T$$
$$= 2\left[\frac{3}{2}R + R\right]\times 5$$

$= 2 \times \dfrac{5}{2} \times 8.31 \times 5$
$= 208\,J$

33 **(d)**

Let L be the length (in cm) of the hollow cylinder and r its radius. Since the mass of the gas remains unchanged and the pressures of the gas in both sides are equal, we have, from Charle's law,

$\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$ (1)

Given $V_1 = \left(\frac{L}{2} - 5\right) \pi r^2, V_2 = \left(\frac{L}{2} + 5\right) \pi r^2$,

$T_1 = 0°\text{C} = 273$ Kand $T_2 = 100°\text{C} = 373$ K. Using these values in (1), we get

$\dfrac{\frac{L}{2} - 5}{273} = \dfrac{\frac{L}{2} + 5}{373}$

Which gives $L = 64.6$ cm

34 **(a)**

$E_\theta = P$

35 **(c)**

Let ΔT be the increase in temperature when the volume of the gas is changed by ΔV at constant pressure. The change in internal energy of n moles of a gas is given by

$\Delta U = n\, C_v\, \Delta T$ (i)

We know that $C_p - C_v = R$

Or $\frac{C_p}{C_v} = 1 + \frac{R}{C_v}$. But $\frac{C_p}{C_v} = \gamma$

Therefore, $\gamma = 1 + \frac{R}{C_v}$, which gives

$C_v = \dfrac{R}{(\gamma - 1)}$ (ii)

Also $PV = n\, RT$. At constant pressure, when volume changes by ΔV, the change in temperature ΔT is given by

$P\Delta V = n\, R\Delta T$

Or $\Delta T = \frac{P\Delta V}{nR} = \frac{PV}{nR}$

$(\because \Delta V = 2V - V = V)$ (iii)

Using (ii) and (iii) in (i) we have

$\Delta U = n \times \dfrac{R}{(\gamma - 1)} \times \dfrac{PV}{nR} = \dfrac{PV}{(\gamma - 1)}$

36 **(a)**

Expanding the equation of state we have

$PV^c + aT^2V^{c-1} = RT + b$

Or $P = -aT^2V^{-1} + RT\, V^{-c} + bV^{-c}$

Or $P = AV^{-c} - BV^{-1}$ (i)

Where $A = RT + b$ and $B = aT^2$. We are given that

$P = AV^m - BV^n$ (ii)

Comparing the powers of V in (i) and (ii) we get $m = -c$ and $n = -1$

37 **(c)**

Heat energy absorbed = work done = area of the loop

$= \pi r^2 = \pi d^2/4 = \frac{\pi}{4}(30 - 10)^2 = 10^2\, \pi$ joule

38 **(a)**

Let T_0 be the temperature of the mixture. Since the total internal energy remains unchanged, we have

U of mixture $= U_1 + U_2$

$\Rightarrow (n_1 + n_2)C_vT_0 = n_1C_vT_1 + n_2C_vT_2$

$\Rightarrow (n_1 + n_2)T_0 = n_1T_1 + n_2T_2$

$\Rightarrow (2 + 3)T_0 = 2T + 3 \times (2T) = 8T$

Which gives $T_0 = \frac{8T}{5}$

39 **(a)**

For an ideal gas, $PV = nRT$. Since pressure P is kept constant,

$P\Delta V = n\, R\Delta T$

Or $\frac{\Delta V}{\Delta T} = \frac{nR}{P} = \frac{n\, RV}{nRT} = \frac{V}{T}\left(\because P = \frac{n\, RT}{V}\right)$

Or $\frac{1}{V}\frac{\Delta V}{\Delta T} = \frac{1}{T}$ or $\delta = \frac{1}{T}$

Thus, the value of δ decreases as T is increased

Hence the correct choice is (c)

40 **(b)**

Given $V = \frac{kT^n}{P}$. Since $P =$ constant,

$dV = \dfrac{kn}{P} T^{(n-1)}\, dT$

Work done $W = \int P\, d\, V = kn \int T^{(n-1)}\, dT$

$= kT^n + c$

Where $c =$ constant of integration

41 **(d)**

Heat energy required to raise the temperature of n moles of a gas by ΔT at constant pressure is

$Q_p = n\, C_p\, \Delta t$

Heat energy required to raise the temperature n moles of a gas by ΔT at constant volume is

$Q_v = n\, C_v\, \Delta T, \therefore \frac{Q_v}{Q_p} = \frac{C_v}{C_p}$

Or $Q_v = \frac{C_v}{C_p} \times Q_p = \frac{3\, R/2}{3\, R/2} \times Q_p$

$= \frac{3}{5} \times 207 = 124.2 = 124$ J

42 **(b)**
For monoatomic gas,

$$C_P = \frac{5}{2}R$$

And $C_V = \frac{3}{2}R$

For diatomic gas,

$$C_P = \frac{7}{2}R$$

and $C_V = \frac{5}{2}R$

43 **(d)**
Since the volume of the gas is constant,
$\frac{P_1}{P_2} = \frac{T_1}{T_2}$ (1)
Now $P_2 = P_1 + 0.02\ P_1 = 1.02\ P_1$ and $T_2 = T_1 + 5$
Using these values in Eq. (1), we have
$\frac{P_1}{1.02\ P_1} = \frac{T_1}{T_1+5} \Rightarrow T_1 = 250$ K

44 **(d)**
$PV = \frac{m}{M}\ RT$. Therefore, the density of the gas is
$\rho = \frac{m}{V} = \frac{P\ M}{RT} = \frac{PmN}{RT} = \frac{mP}{kT}$

45 **(c)**
Volume $\propto$ (diameter)^3. Since the diameter of the bubble is doubled in rising from the bottom to the top of the lake, its volume becomes 8 times. Now PV = constant. Therefore, the pressure at the bottom of lake = 8 times that at the top. Let H be the depth of the lake
$H\ \rho_w g = (8h - h)\rho_m g$
Or $H = 7h\frac{\rho_m}{\rho_w} = 7\ h\rho\left(\because \rho = \frac{\rho_m}{\rho_w}\right)$

46 **(b)**
$\Delta U = C_v \Delta T$. Now $C_p - C_v = R$ or $\frac{C_p}{C_v} - 1 = \frac{R}{C_v}$
Or $C_v = \frac{R}{\gamma-1}$, where $\gamma = \frac{C_p}{C_v}$. Hence
$\Delta U = \frac{R\Delta T}{(\gamma - 1)} = \frac{8.3 \times 8}{(1.4 - 1)} = 166$ J

47 **(d)**
When work is converted into heat at a constant temperature, the entropy of the system remains constant

48 **(b)**
Now $Q_p = n\ C_p\ \Delta T$ and $Q_v = n\ C_v\ \Delta T$. But Q_v gives the heat energy which increases the internal energy of the gas. Thus the required fraction is
$\frac{Q_v}{Q_p} = \frac{C_v}{C_p} = \frac{1}{\gamma} = \frac{1}{5/3} = \frac{3}{5}$
$\left(\because \text{ for monoatomic gas } \gamma = \frac{5}{3}\right)$

49 **(b)**
Work done = area enclosed by the indicator diagram ABC
$= \frac{1}{2} \times BC \times AC$
$= \frac{1}{2} \times (4P - P) \times (3V - V)$
$= 3\ PV$

50 **(a)**
Given $T = kV^2$. Therefore $dT = 2\ kV\ dV$ or
$dV = \frac{dT}{2kV}$
Also $PV = n\ R\ T \Rightarrow P = \frac{n\ R\ T}{V}$
$\therefore$ Work done $w = \int_T^{3T} PdV$
$= \int_T^{3T} \left(\frac{n\ R\ T}{V}\right) \times \left(\frac{d\ T}{2kV}\right)$
$= \int_T^{3T} \frac{n\ R\ T\ d\ T}{2\ k\ V^2}$
$= \frac{n\ R}{2} \int_T^{3T} d\ T \quad (\because kV^2 = T)$
$= n\ R\ T$

51 **(b)**
Work done ($P\Delta V$) = area under the $(P - V)$ curve, which is the largest for curve 3 and the smallest for curve 1

52 **(d)**
In adiabatic process

$$\Delta Q = 0$$

Therefore, first law of thermodynamics becomes

$$dU + dW = 0$$

53 **(c)**
For a diatomic gas $C_p = \frac{7R}{2}$ and $C_v = \frac{5R}{2}$
$\Delta Q = n\ C_p\ \Delta T = \frac{7}{2}\ nR\Delta T$
$\Delta U = n\ C_v\ \Delta T = \frac{5}{2}\ nR\Delta T$
From the first law of thermodynamics
$\Delta W = \Delta Q - \Delta U = \frac{7}{2}\ n\ R\Delta\ T - \frac{5}{2}\ n\ R\Delta\ T$
$= n\ R\Delta\ T$
$\therefore \Delta Q : \Delta U : \Delta W = 7 : 5 : 2$

54 **(c)**
$\frac{W}{Q} = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{600} = 0.5$ Therefore $Q = 2W$
$= 2 \times 800 = 1600$ J

55 **(a,b,c)**

$W_{A\to B}$ = Area of $ABED = \frac{1}{2}\, BC \times AC + CD \times DE$

$= \frac{1}{2}(6 \times 10^{-3}\text{m}^3) \times 4\ \text{Nm}^{-2} + 4\ \text{Nm}^{-2} \times 6 \times 10^{-3}\text{m}^3$

$= 0.012 + 0.024 = 0.036$ J

$W_{B\to C}$ = Area of $BCDE = -0.024$ J. The negative sign shows that the work is done on the gas

$W_{C\to A} = P\Delta V = 0$ because $\Delta V = 0$

Work done in complete cycle $= 0.036 - 0.024 + 0 = 0.012$ J

56 **(a,c)**

Since W_2 and W_3 are negative, it means that the work is done on the gas. Hence Q_2 and Q_3 are negative which implies that heat is evolved in processes 2 and 3. Since Q_1 and Q_4 are positive, heat I absorbed by the gas in processes 1 and 4. As $(Q_1 + Q_4)$ is greater than $(Q_2 + Q_3)$, the gas absorbs a net amount of heat energy in a complete cycle, which is given by

$\Delta Q = Q_1 + Q_2 + Q_3 + Q_4$

$= 5960 - 5585 - 2980 + 3645$

$= 1040$ joule

The net work done by the gas is

$\Delta W = W_1 + W_2 + W_3 + W_4$

$= 2200 - 825 - 1100 + W_4$

$= (275 + W_4)$ joule

Since the process is cyclic, the change in internal energy $\Delta U = 0$. From the first law of thermodynamics,

We have

$\Delta W = \Delta Q - \Delta U = \Delta Q$

Or $275 + W_4 = 1040$ or $W_4 = 1040 - 275$

$= 765$ J

Efficiency of the cycle is defined as

$h = \frac{\text{net work done by the gas}}{\text{total heat absorbed by the gas}}$

$= \frac{\Delta W}{Q_1 + Q_4} = \frac{275 + 765}{5960 + 3645}$

$= \frac{1040}{9605} = 0.1083 = 10.83\%$

$\simeq 11\%$

57 **(a,b,c,d)**

Along all the three paths, volume of gas is increasing.

Therefore, heat is absorbed by the gas in all the three paths. As ΔU is independent of path, change in internal energy of the gas is same along all the three paths.

As area under path 1 is maximum therefore ΔW is maximum in path 1.

$\Delta Q = (\Delta U + \Delta W)$ must be maximum in path 1

58 **(a,c,d)**

(a) $PV = nRT \Rightarrow n = \frac{PV}{RT}$

$= \frac{(1.6 \times 10^6) \times 0.0083}{8.3 \times 300} = \frac{16}{3}$

(b) For a monoatomic gas $C_p = \frac{5R}{2} = \frac{5}{2} \times 8.3$

$= 20.75$ J mol^{-1}K^{-1}

(c)$\Delta Q = n\, C_v\, \Delta T$; $C_v = \frac{3R}{2}$

$\therefore \Delta T = \frac{\Delta Q}{nC_v} = \frac{2\Delta Q}{3nR} = \frac{2 \times 2.49 \times 10^4}{3 \times \frac{16}{3} \times 8.3}$

$= 375$ K

$\therefore$ Final temperature $= 300 + 375 = 675$ K

(a)$\frac{P_2}{T_2} = \frac{P_1}{T_1} \Rightarrow P_2 \frac{P_1 \times T_2}{T_1} = \frac{1.6 \times 10^6 \times 675}{300}$

$= 3.6 \times 10^6$ Pa

59 **(a,b,c)**

$\Delta W = P\Delta V$ and $\Delta U = nC_v\Delta T$ and $\gamma = C_p/C_v$. Also $\Delta Q = \Delta U + \Delta W$

For an isothermal process, $\Delta T = 0$. Therefore $\Delta U = 0$. Hence $\Delta Q = \Delta W$, which is choice (a). For an adiabatic process $\Delta Q = 0$. So $\Delta U = -\Delta W$, which is choice (b). For an isochoric process, $\Delta W = 0$, so $\Delta Q = \Delta U$, which is choice (c). For an isobaric process, $\Delta Q = \Delta U + \Delta W$. So choice (d) is wrong

60 **(d)**

For adiabatic changes ,

pV^{γ} = constant

$P\left(\frac{RT}{P}\right)^{\gamma}$ =constant

$\therefore\ P^{1-\gamma}T^{\gamma} = \frac{\text{constant}}{R_{\gamma}}$ another constant

61 **(a,c)**

For 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)

62 **(a,b)**

Isothermal curve from A to B will be parabolic with lesser area under the curve than the area under straight line AB. Therefore, work done by the gas in going straight from A to B is more.

Temperature (a) in correct

If p_0, V_0 be the intercepts of curve on p and V axes, then its equation is obtained from $y = mx + c$

$ie\ \ p = \frac{p_0}{V_0} V + p_0$

or $\frac{RT}{V} = \frac{p_0 V}{V_0} + p_0$

or $T = \frac{p_0}{V_0 R} V^2 + \frac{p_0 V}{R}$

Which is the equation of a parabola. Hence $T-V$ curve is parabolic. Therefore (b) is correct.

Also $(p/2) \times (2V) = pV =$ constant ie process is isothermal

63 **(a,b,c)**

The internal energy of n moles of an ideal gas at absolute temperature T is given by

$U = nC_v T \qquad (1)$

Where C_v is the molar specific heat at constant volume. We know that

$C_p - C_v = R$ or $\frac{C_p}{C_v} - 1 = \frac{R}{C_v}$

Or $\gamma - 1 = \frac{R}{C_v}$ or $C_v = \frac{R}{\gamma-1} \qquad (2)$

Now, the ideal gas equation for n nodes is

$PV = nRT$ or $n\frac{PV}{RT} \qquad (3)$

Using (2) and (3) in (1), we have

$$U = \frac{PV}{RT} \times \frac{R}{\gamma - 1} \times T = \frac{PV}{(\gamma - 1)}$$

64 **(a,b,c,d)**

All the four choices are correct

65 **(b,c)**

For an adiabatic change the relation between T and V is

$TV^{(\gamma-1)}$ =constant; $\gamma = \frac{C_p}{C_v}$

$TV^{(\gamma-1)} = T'V'^{(\gamma-1)}$ or $\left(\frac{V'}{V}\right)^{(\gamma-1)} = \frac{T}{T'}$

Given $V' = 5.66\ V$and $T' = \frac{T}{2}$. Therefore,

$(5.66)^{(\gamma-1)} = 2$

Taking logarithm of both sides, we have

$(\gamma - 1)\log(5.66) = \log(2)$

Or $\gamma = 1 + \frac{\log(2)}{\log(5.66)} = 1 + \frac{0.3010}{0.7528}$

$= 1 + 0.4 = 1.4$

Since $\gamma = 1.4$, the gas is diatomic. For a diatomic gas, the number of degrees of freedom of the molecules = 5

We know that the work done by the gas during adiabatic expansion is given by

$$W = \frac{1}{(\gamma - 1)}(PV - P'V') \qquad (1)$$

Where pressure P' after expansion I obtained from the relation

$$\frac{P'V'}{T'} = \frac{PV}{T}$$

Or $P' = P \times \frac{V}{V'} \times \frac{T'}{T}$

$$= P \times \frac{V}{5.66V} \times \frac{T/2}{T} = \frac{T/2}{T} = \frac{P}{11.32}$$

Putting $\gamma = 1.4, V' = 5.66\ V$ and $P' = \frac{P}{11.32}$ in

In Eq. (1), we have

$$W = \frac{1}{(1.4-1)}\left(PV - \frac{P}{11.32} \times 5.66V\right)$$

$$= \frac{1}{0.4}\left(PV - \frac{1}{2}PV\right) = 1.25\ PV$$

So the correct choices are (b) and (c)

66 **(a,b,c,d)**

In an adiabatic process,

$pV^{\gamma} =$ constant

As $V \propto \frac{1}{\rho}$

$\therefore\ \frac{p}{\rho^{\gamma}}$ =constant

As $p = \frac{RT}{V}$,

$\therefore\ \left(\frac{RT}{V}\right) \times V^{\gamma} =$ constant or $TV^{\gamma-1} =$ constant

As $V = \frac{RT}{p}$,

$\therefore\ p\left(\frac{RT}{p}\right)^{\gamma} =$ constant or $\frac{T^{\gamma}}{p^{\gamma-1}} =$ constant

All the four choices are correct

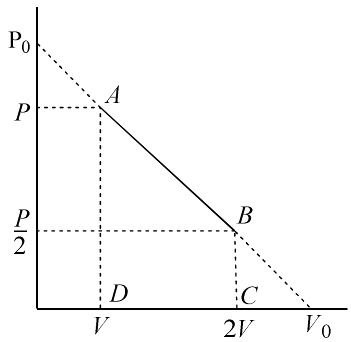
67 **(a,b,d)**

(a) Work done in process A to B is (see fig.)

$W_1 =$ area of trapezium $ABCD$

$$= \left(P + \frac{P}{2}\right)V = \frac{3\ PV}{2}$$

$= \frac{3\ RT}{2}$ (for 1 mole)



If the process A to B were isothermal, the work done would be

$W_2 = RT\log_e\left(\frac{V_2}{V_1}\right) = RT\log_e(2) = 0.69\,RT$

Thus $W_1 > W_2$. So choice (a) is correct

(b) Let P_0 and V_0 be the intercepts on the P and V axes. The equation of straight line AB is

$$P = -\frac{P_0}{V_0}(V - V_0)$$

$$\Rightarrow \frac{P}{P_0} + \frac{V}{V_0} = 1 \qquad (1)$$

Since $P = \frac{RT}{V}$, Eq. (1) becomes

$$\frac{RT}{V\,P_0} + \frac{V}{V_0} = 1 \Rightarrow T = \frac{P_0 V}{R} - \frac{P_0 V^2}{RV_0}$$

Which represents a parabola on the T-V graph

So choice (b) is also correct

(c) Since $V = \frac{RT}{P}$, Eq. (1) becomes

$$\frac{P}{P_0} + \frac{RT}{PV_0} = 1 \Rightarrow T = V_0\,P - \frac{V_0 P^2}{RP_0} \quad (2)$$

Which does not represent a hyperbola. So choice (c) is incorrect

(d) If follows from Eq. (2) above that choice (d) is correct

68 **(b,c)**

There is a decrease in volume during melting of an ice slab at $273K$. 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. Secondly heat is absorbed during melting ($i.e.\,\Delta Q$ is positive) and as we have seen, work done by ice-water system is negative (ΔW is negative). Therefore, from first law of thermodynamics

$\Delta U = \Delta Q - \Delta W$

Change in internal energy of ice-water system, ΔU will be positive or internal energy will increase

69 **(a,b,c,d)**

(a)Heat extracted from water is $Q_2 = mL = 10^3 \times 80 = 80{,}000\text{ J} = 80{,}000 \times 4.2 = 3.36 \times 10^5\text{J}$. So choice (a) is correct

(b)$\beta = \frac{T_2}{T_1 - T_2} = \frac{273}{300-273} \simeq 10$. Choice (b) is correct

(c)$W = \frac{Q_2}{\beta} = \frac{3.36\times10^5}{10} \simeq 3.36 \times 10^4$ J, which is choice (c)

(d) $Q_1 = Q_2 + W = 3.36 \times 10^5 + 3.36 \times 10^4$

$\simeq 37 \times 10^4$ J

Power $= \frac{Q_1}{t} = \frac{37\times10^4\text{J}}{180\text{s}} \simeq 20$ kW. So choice (d) is also correct

70 **(a,b,d)**

(a)$T_2 = 27°\text{C} = 300$ K, efficiency $\eta = 0.25$

$\eta = 1 - \frac{T_2}{T_1} \Rightarrow 0.25 = 1 - \frac{300}{T_1}$ which gives

$T_1 = 400$ K. So choice (a) is correct

(b) Increase in effieciency = 20% of 0.25=0.05. So new efficiency is $\eta' = 0.25 + 0.05 = 0.30$. The new temperature of the source should be T_1' so that

$$0.30 = 1 - \frac{T_2}{T_1'} = 1 - \frac{300}{T_1'}$$

Which gives $T_1' = 428.6$ K. So, increase in temperature of the source $= T_1' - T_1 = 428.6 - 400 = 28.6$ K or °C. So choice (b) is also correct

(c) The new temperature T_2' of the sink should be such that

$$0.30 = 1 - \frac{T_2'}{T_1} = 1 - \frac{T_2'}{400}$$

Which gives $T_2' = 280\text{ K} = 7°\text{C}$. Decrease in temperature of the sink is $27°\text{C} - 7°\text{C} = 20°\text{C}$, Choice (c) is wrong

(d) Work output $= Q\eta = 800 \times 0.25 = 200$ J

71 **(b,d)**

Oxygen is diatomic; it has 5 degrees of freedom. Therefore, $C_v = 5\,R/2$ and $C_p = 7\,R/2$. So $\gamma = C_p/C_v = 7/5$. The kinetic energy of oxygen molecules with a velocity $v_0 = \frac{1}{2}\,Mv^2$, where $M =$ molecular weight of oxygen

Now heat energy $= C_v\,dT = C_v \times 1 = C_v$

But $C_p - C_v = R$ or $\frac{C_p}{C_v} - 1 = \frac{R}{C_v}$

Or $(\gamma - 1) = \frac{R}{C_v}$ or $C_v = \frac{R}{(\gamma-1)}$

Therefore, $\frac{1}{2}Mv^2 = \frac{R}{(\gamma-1)}$

Or $v = \sqrt{\frac{2\,R}{M(\gamma-1)}}$

So the correct choices are (b) and (d)

72 **(b)**

The $P - V$ graph for an adiabatic process is not a

straight-line. Hence choice (a) is wrong.
$P_A V_A = n\,R\,T_A$ and $P_B V_B = n\,RT_B$. Therefore
$\frac{P_A V_A}{P_B V_B} = \frac{T_A}{T_B} \Rightarrow \frac{6\times1}{2\times4} \Rightarrow \frac{T_A}{T_B} = \frac{3}{4}$,
i.e. $T_B > T_A$. Hence the internal energy increases.
Work done = area under AB upto the volume axis.
Heat energy is absorbed in the process

73 **(b,d)**
(a)p-Vgraph is not rectangular hyperbola.
Therefore, process $A \rightarrow B$ is not isothermal.

(b)In process BCD, product of pV(therefore temperature and internal energy) is decreasing. Further, volume is decreasing. Hence, work done is also negative. Hence, Qwill be negative or heat will flow out of the gas.

W_{ABC} = positive

(d)For clockwise cycle on p-Vdiagram with p on y-axis, net work done is positive.

74 **(c)**
In a cyclic process, the system returns to its initial state. Hence the change in internal energy $dU = 0$. Therefore, choice (b) is correct. From the first law of thermodynamics,
$dQ = dU + dW = dW \quad (\because dU = 0)$
Hence choice (c) is also correct

75 **(a,b,c)**
For point A, $PV = 5 \times (2 \times 10^{-3}) = 10 \times 10^{-3}$ J
For point B, $PV = 2 \times (5 \times 10^{-3}) = 10 \times 10^{-3}$ J
Since PV = constant, the process is isothermal.
For an isothermal process, $\Delta U = 0$.
Since the gas undergoes expansion ΔW is positive and $\Delta Q = \Delta W$.

76 **(a,b)**
$T_A = T_B \quad \therefore U_A = U_B$

$$W_{AB} = (1)(R)T_0\,\text{In}\left(\frac{V_f}{V_i}\right)$$

$$= RT_0\text{In}\left(\frac{4V_0}{V_0}\right)$$

$$= p_0V_0\text{In}\,(4)$$

Information regarding p and Tat Ccannot be obtained from the given graph. Unless it is mentioned that line BCpasses through origin or not.

Hence, the correct options are (a) and (b).

77 **(a,d)**
Statements (a) and (d) are wrong. Concept of entropy is associated with second law of thermodynamics.

78 **(a,b,c,d)**
(a) $\Delta U = n\,C_v\,\Delta T$
(b) $\Delta Q = \Delta U + \Delta W$. For an adiabatic process, $\Delta Q = 0$. Hence $0 = \Delta U + \Delta W$ or $|\Delta U| = |\Delta W|$
(c)For an isothermal process, $\Delta T = 0$, Hence $\Delta U = 0$
(d) For an adiabatic process, $\Delta Q = 0$

79 **(a,c,d)**
As shown in figure, during the process A to$B$, p and V both decrease. As $T \propto pV$, therefore, T must also be decreasing. So must be the internal energy $\therefore\ \Delta U_{A\rightarrow B}$ is negative. As volume is decreasing, therefore, $\Delta W_{A\rightarrow B}$ is also negative. Thus, $\Delta Q_{A\rightarrow B}$ = negative
During the process B to C, volume is increasing at constant pressure. Therefore, $T(\propto pV)$ must increase and so does the internal energy.
$\Delta U_{C\rightarrow A}$ = positive. During the process CAB, volume is decreasing. Therefore, ΔW_{CAB} = negative

80 **(d)**
As there is no change in internal energy of the system during an isothermal change. Hence, the energy taken by the gas is utilised by doing work against external pressure. According to FLOT
$\Delta Q = \Delta U + P\Delta V$

Hence $\Delta Q = \Delta U + P\Delta V$; $\Delta U = 0\ \therefore \Delta Q = P\Delta V$

Therefore, reason is true and assertion is false

81 **(d)**
Entropy is a measure of the disorder or randomness of the system. Greater the randomness, greater the entropy

82 **(b)**
Efficiency of carnot cycle $\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$, for Carnot engine when T_2 decreases η increases

83 **(c)**
First law of thermodynamics is a restatement of the principle of conservation of energy as applied to heat energy. Assertion is true but Reason is false.

84 **(a)**
Here, $T_1 = 227 + 273 = 500$ K

$T_2 = 127 + 273 = 400$ K

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{400}{500} = \frac{1}{5} = 20\%$$

This is the maximum value of efficiency. Both the Assertion and Reason are true and Reason is correct explanation of Assertion

85 **(d)**
According to first law of thermodynamics, $\Delta Q = \Delta U + \Delta W = \Delta U + P\Delta V$. If heat is supplied in such a manner that volume does not change $\Delta V = 0, i.e.$, isochoric process, then whole of the heat energy supplied to the system will increase internal energy only. But, in any other process it is not possible.

Also heat may be absorbed or evolved when state of thermal equilibrium changes

86 **(b)**
For using the internal energy of sea water, to operate the engine of a ship, the internal of the sea water has to be converted into mechanical energy. Since, whole of the internal energy cannot be converted into mechanical energy, a part has to be rejected to a colder body (sink). Since, no such body is available, the internal energy of the sea water cannot be used to operate the engine of the ship A refrigerator is a heat engine working in the reverse direction.

87 **(a)**
Carnot cycle has maximum efficiency

88 **(a)**
The correct choice is (a). Statement-1 is true only if the two bodies have the same thermal capacity which is equal to mass of the body × its specific heat capacity. Since two bodies have the same mass and are made of the same material, they have the same thermal capacity.

89 **(a)**
The temperature of land rises rapidly as compared to sea because of specific heat of land is five times less than that of sea water. Thus, the air above the land become hot and light so rises up because of pressure drops over land. To compensate the drop of pressure, the cooler air starts blowing towards land as well as sea radiate heat energy. The temperature of land falls more rapidly as compared to sea water, as sea water consists of higher specific heat, capacity. The air above sea water being warm and light rises up. To take its place the cold air from land starts blowing towards sea and so set-up breeze.

91 **(a)**
The correct choice is (a). Since the two vessels are of equal capacity, the volume occupied by the gas is doubled when the stop clock is opened. Hence, pressure becomes half

92 **(d)**
According to second law of thermodynamics, this is not possible to transfer heat from a body at lower temperature to a body at higher temperature without the aid of an external agent. Since, the given information produces a contradiction in second law of thermodynamics, therefore it is not possible to produce temperature of 8000 K by collecting the sun rays with a lens

93 **(b)**
Adiabatic curve is steeper than isothermal curve. Therefore, area under adiabatic curve is smaller than the area under isothermal; curve *ie*, work done by the gas in adiabatic expansion is smaller than the work done by the gas in isothermal expansion. The reverse is also true. Reason is true. Reason is also true but Reason does not explain Assertion

98 **(a)**
As $\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_2}$, therefore, η will decrease if $(T_1 - T_2)$ decreases

Both, the Assertion and Reason are true and latter is correct explanation of the former

99 **(c)**
In an adiabatic process, no exchange of heat is permissible, i.$e.$, $\Delta Q = 0$

As, $\Delta Q = \Delta U + \Delta W = 0 \Rightarrow \Delta U = -\Delta W$

Also in adiabatic process, temperature of gas changes

101 **(a)**
In reversible process, there always occurs some loss of energy. This is because energy spent in working against the dissipative force is not recovered back. Some irreversible process occurs in nature such as friction where extra work is done to cancel the effect of friction. Salt dissolves in water but a salt does not separate by itself into

pure salt and pure water

102 **(a)**

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{100}{400} = \frac{3}{4} = 75\%$$

Both, the Assertion and Reason are true and Reason is correct explanation of Assertion

103 **(b)**

When milk cools, its energy content decreases

104 **(d)**

In adiabatic process, there is no exchange of heat bet6ween the system and the surroundings. This can be possible if the gas under adiabatic process is allowed to expand or compressed very quickly. Thus, it is a quick process.

When the gas is compressed adiabatically, the heat produced cannot escape to the surroundings through the insulating walls. As a result, the temperature of the gas and hence, the internal energy increase.

105 **(a)**

When a bottle of cold carbonated drink is opened a slight fog forms around the opening. This is because adiabatic expansion of gas causes lowering of temperature and condensation of water vapours

106 **(a)**

The correct choice is (a). The line AB is parallel to the P-axis. This means that PV/T is a constant, independent of pressure. Hence line AB corresponds to an ideal gas for which $PV/T =$ constant. At higher temperatures, a real gas behaves more like an ideal gas. Hence T_1 is greater than T_2

107 **(d)**

As isothermal processes are very slow and so the different isothermal curves have different slopes so they cannot intersect each other

108 **(a)**

Adiabatic expansion produces cooling

109 **(d)**

We can change the temperature of a body without giving (or taking) heat to (or from) it. For example in an adiabatic compression temperature rises and in an adiabatic expansion temperature falls, although no heat is given or taken from the system in the respective changes

110 **(d)**

To carry out isothermal process, a perfect gas is compressed or allowed to expand very slowly.

Isothermal curves never intersect each other as they have very little slope

111 **(c)**

In an ideal gas, we assume that intermolecular force are zero. No work is done in charging the distance between the molecules. Therefore, internal energy is only kinetic and not potential. Therefore, internal energy of an ideal gas depends only on temperature and not on volume.
Assertion is true. Reason is false.

112 **(d)**

If an electric fan is switched on in a closed room, the air will be heated because due to motion of the fan, the speed of air molecules will increase. In fact, we feel cold due to evaporation of our sweat

113 **(d)**

Zeroth law of thermodynamics explains the concept of temperature. According to which there exists a scalar quantity called temperature which is property of all thermodynamic system

114 **(a)**

Change in entropy, $\Delta S = \frac{\Delta Q}{T}$. In an adiabatic change, $\Delta Q = 0$

$\therefore \ \Delta S = 0 \ \therefore S =$ constant ie, entropy remains constant, or it is an isotropic process. Choice (a) is correct

115 **(b)**

First law of thermodynamics tells only about the conversion of mechanical energy into the heat energy and vice-versa. It does not put any condition as to why heat cannot flow from lower temperature to higher temperature.

First law of thermodynamics given

dQ= dU+ dW

If heat is supplied as such its volume does not change ie, dV=0, then whole of the heat energy supplied to the system will increase in its internal energy only.

116 **(a)**

The correct choice is (a). Since the system is thermally insulated from the surroundings, no heat flows into the system or out of it, i.e. $\Delta Q = 0$. Since $\Delta U = 0;\ \Delta W = 0$

117 **(a)**

$c = \frac{\Delta Q}{m.\Delta\theta}$; a gas may be heated by putting pressure, so it can have values for 0 to ∞

C_P and C_V are it's two principle specific heats, out of infinite possible values

In adiabatic process $C = 0$, and in isothermal process $C = \infty$

118 **(a)**

Second law of thermodynamics can be explained with the help of example of refrigerator, as we know that in refrigerator, the working substance extracts heat from colder body and rejects a large amount of heat to a hotter body with the help of an external agency, i. *e*., the electric supply of the refrigerator. No refrigerator can ever work without external supply of electric energy to it

119 **(b)**

Column –I : Expansion of ideal gas

Column – II : Thermodynamic change

(A) $\Delta Q = 0$ (as boundary is non conducting) in the case of free expansion $W = 0$

$Q = \Delta U + W$

$0 = \Delta U + 0, \Delta U = 0; U =$ constant, T is constant

(A) → (q) (As temp remains constant)

$(B)\ P \propto \frac{1}{V_2}$

$PV^2 = C$

$\because PV = nRT$

$TV = C$

Since volume increases then temperature decreases.

$Q = n\,C\Delta T$, for polytropic process, $PV^x =$ constant,

$$C = C_v + \frac{R}{1-x}$$

$$C = C_v + \frac{R}{-2+1} = C_v - R \Rightarrow \frac{3}{2}R - R \Rightarrow C = \frac{R}{2}$$

$$\Rightarrow Q = n\frac{R}{2}\Delta T$$

ΔT is negative so Q is negative means heat is lost

(B) → (p,r)

(C) $PV^{4/3} = C, TV^{1/3} = C'$

So when volume increases then temperature decreases

Now $C = C_v + \frac{R}{-\frac{4}{3}+1} = \frac{3}{2}R - 3R \Rightarrow C = -\frac{3}{2}R$

$$Q = nC\Delta T \Rightarrow Q = n\left(-\frac{3}{2}R\right)(\Delta T)$$

As ΔT is negative Q will be positive

Hence (C) → p,s

(D) $T = \frac{PV}{nR}$ as product of P and V increases, so temperature increases $Q = \Delta U + W$

$\Delta U = +ve\ (\Delta T = +ve)$

$W = +ve$ (As volume increases)

So $Q = +ve$

Hence gas gains heat (D) → (q,s)

120 **(a)**

In process J → K : V is constant where as P is decreasing

Therefore, T should also decrease

$\therefore W = O, \Delta U = -ve$ and $Q < 0$

In process K → L : P is constant while V is increasing

Therefore, temperature should also increase

$\therefore W > 0, \Delta U > 0$ and $Q > 0$

In process L → M : This is inverse of process $J \to K$

$\therefore W = 0, \Delta U > 0$ and $Q > 0$

In process M → J :

V is decreasing. Therefore, $W < 0$

$(PV)_J < (PV)_M$

$\therefore T_J < T_M$

Or $\Delta U < 0$

Therefore, $Q < 0$

121 **(c)**

$A \to B \Rightarrow V \downarrow P\ const\ \Rightarrow T \downarrow U \downarrow$ (p), (r), (t)

$B \to C \Rightarrow d\omega \downarrow 0$

$P \downarrow T \downarrow$

$d\phi = du + d\omega$ (p), (r)

$C \to D \Rightarrow V \uparrow \Rightarrow T \uparrow$

$du \Rightarrow +ve$

$d\omega = +ve$ (q), (s)

$D \to A \Rightarrow d\omega \Rightarrow -ve$ (r), (t)

$dq \Rightarrow -ve$

$du = 0$

122 **(c)**

Here, $T_1 = 27°C = (27 + 273)K = 300K$

$T_2 = -73°C = (-73 + 273)K = 200K$

$$\gamma = 1 - \frac{T_2}{T_1} = 1 - \frac{200}{300} = \frac{1}{3} = 33\%$$

123 **(a)**

As compression is sudden, changes are adiabatic, $dQ = 0$. Therefore, work done gas increases the temperature

124 **(c)**

During isothermal process $A \rightarrow B, P \propto \frac{1}{V}$. During isobaric process $(B \rightarrow C), P =$constant and during isochoric process $(C \rightarrow A), V =$constant. Hence the correct $P - V$ diagram of the complete process is (c)

125 **(d)**

For isobaric process $A \rightarrow B$,

$$\frac{V_A}{T_A} = \frac{V_B}{T_B} \Rightarrow V_B = \frac{V_A T_B}{T_A} = \frac{V \times 4T/3}{T} = \frac{4V}{3}$$

126 **(b)**

$T_1 = 300\text{ K}, \mathrm{V}_1 = V, V_2 = 2\sqrt{2}\text{ V}$

Let T_2 be the final temperature of the gas. T_2 is obtained from the adiabatic relation

$$T_1 V_1^{(\gamma-1)} = T_2 V_2^{(\gamma-1)}$$

Or $T_2 = T_1 \times \left(\frac{V_1}{V_2}\right)^{(\gamma-1)}$

For a monoatomic gas $\gamma = \frac{5}{3}$. Therefore

$$T_2 = 300 \times \left(\frac{1}{2\sqrt{2}}\right)^{2/3} = 150\text{ K}$$

127 **(a)**

Number of moles of helium is

$$n = \frac{\text{mass in gram}}{\text{Molecular mass}} = \frac{2000}{4} = 500$$

From equation state at A,

$$P_A\, V_A = n\, R\, T_A \Rightarrow T_A = \frac{P_A V_A}{nR}$$

$$= \frac{4.15 \times 10^4 \times 10}{500 \times 8.3} = 100\text{K}$$

128 **(a)**

Work done by the gas in the cyclic process $ABCA$ is

$W =$ area enclosed in the $P - V$ diagram

$= $ area of triangle $ABC = \frac{1}{2} \times AB \times AC$

$$= \frac{1}{2}(3P_0 - P_0) \times (2V_0 - V_0) = P_0 V_0$$

130 **(c)**

Using the ideal gas equation $PV = nRT$, the volumes of the gas in states A, B and C are

$$V_A = \frac{n\,RT_A}{P_A} = \frac{n\,R(2T_1)}{P_1} = \frac{2\,nRT_1}{P_1} \quad (1)$$

$$V_B = \frac{n\,RT_B}{P_B} = \frac{n\,R(T_1)}{2P_1} = \frac{1}{2}\frac{nRT_1}{P_1} \quad (2)$$

and $V_C = \frac{n\,RT_C}{P_C} = \frac{n\,R(2T_1)}{2P_1} = \frac{nRT_1}{P_1} \quad (3)$

It is given that in the process $A \rightarrow B$, the pressure and temperature of the gas vary such that

$PT = K$

Where K is a constant. Thus for point A, we have

$K = P_A T_A = P_1(2\,T_1)$

$= 2\,P_1 T_1 \qquad (4)$

131 **(c)**

For process $A \rightarrow B$, the plot of Vversus T is linear Hence

$$\frac{V_A}{T_A} = \frac{V_B}{T_B}$$

$$\Rightarrow T_B = \left(\frac{V_B}{V_A}\right) T_A = 2 \times 300\text{ K} = 600\text{ K}$$

132 **(c)**

Work done in $A \rightarrow B$ Isobaric process : $W = P\Delta V$

$W = \mu R \Delta T \Rightarrow W = 2 \times R \times [T_2 - T_1]$

$W = 2 \times R \times [500 - 300] \Rightarrow W = 400R$