HEAT & THERMODYNAMICS

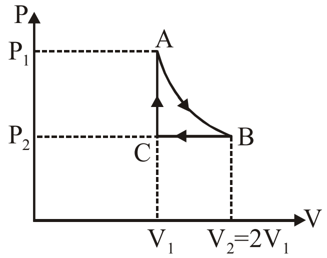
1. n mole a perfect gas undergoes a cyclic process ABCA (see figure) consisting of the following processes.

$A \to B$: Isothermal expansion at temperature T so that the volume is doubled from V_1 to $V_2 = 2V_1$ and pressure changes from P_1 to P_2.

$B \to C$: Isobaric compression at pressure P_2 to initial volume V_1.

$C \to A$: Isochoric change leading to change of pressure from P_2 to P_1.

Total workdone in the complete cycle ABCA is :



(1) 0 (2) $nRT\left(\ln 2 + \frac{1}{2}\right)$

(3) nRTln2 (4) $nRT\left(\ln 2 - \frac{1}{2}\right)$

2. Match List-I with List-II :

List-I	**List-II**
(a) Isothermal	(i) Pressure constant
(b) Isochoric	(ii) Temperature constant
(c) Adiabatic	(iii) Volume constant
(d) Isobaric	(iv) Heat content is constant

Choose the correct answer from the options given below :

(1) (a) → (i), (b) → (iii), (c) → (ii), (d) → (iv)
(2) (a) → (ii), (b) → (iii), (c) → (iv), (d) → (i)
(3) (a) → (ii), (b) → (iv), (c) → (iii), (d) → (i)
(4) (a) → (iii), (b) → (ii), (c) → (i), (d) → (iv)

3. Each side of a box made of metal sheet in cubic shape is 'a' at room temperature 'T', the coefficient of linear expansion of the metal sheet is 'α'. The metal sheet is heated uniformly, by a small temperature ΔT, so that its new temperature is T + ΔT. Calculate the increase in the volume of the metal box.

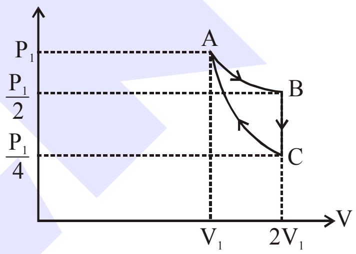
(1) $3a^3\alpha\Delta T$ (2) $4a^3\alpha\Delta T$

(3) $4\pi a^3\alpha\Delta T$ (4) $\frac{4}{3}\pi a^3\alpha\Delta T$

4. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules :

(1) continuously lose their energy till it reaches wall.
(2) are attracted by the walls of container.
(3) continuously stick to the walls of container.
(4) suffer change in momentum when impinge on the walls of container.

5. If one mole of an ideal gas at (P_1, V_1) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to one-half of the original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of the initial value (B→C). Then it is restored to its initial state by a reversible adiabatic compression (C to A). The net workdone by the gas is equal to :



(1) $RT\left(\ln 2 - \frac{1}{2(\gamma-1)}\right)$ (2) $-\frac{RT}{2(\gamma-1)}$

(3) 0 (4) RT ln 2

6. The root mean square speed of molecules of a given mass of a gas at 27°C and 1 atmosphere pressure is 200 ms^{-1}. The root mean square speed of molecules of the gas at 127°C and 2 atmosphere pressure is $\frac{x}{\sqrt{3}} ms^{-1}$. The value of x will be ______.

7. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : When a rod lying freely is heated, no thermal stress is developed in it.

Reason R : On heating the length of the rod increases.

In the light of the above statements, choose the correct answer from the options given below:

(1) Both A and R are true but R is NOT the correct explanation of A
(2) A is false but R is true
(3) A is true but R is false
(4) Both A and R are true and R is the correct explanation of A

8. A diatomic gas, having $C_p = \frac{7}{2}R$ and $C_v = \frac{5}{2}R$, is heated at constant pressure. The ratio dU : dQ : dW :

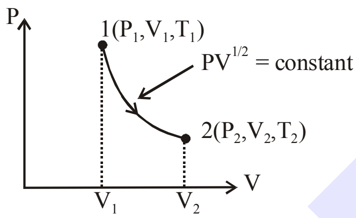
(1) 5 : 7 : 3 (2) 5 : 7 : 2

(3) 3 : 7 : 2 (4) 3 : 5 : 2

9. In a certain thermodynamical process, the pressure of a gas depends on its volume as kV^3. The work done when the temperature changes from 100°C to 300°C will be ___ nR, where n denotes number of moles of a gas.

10. A monoatomic gas of mass 4.0 u is kept in an insulated container. Container is moving with velocity 30 m/s. If container is suddenly stopped then change in temperature of the gas (R = gas constant) is $\frac{x}{3R}$. Value of x is ____.

11. Thermodynamic process is shown below on a P-V diagram for one mole of an ideal gas. If $V_2 = 2V_1$ then the ratio of temperature T_2/T_1 is :



(1) $\frac{1}{2}$ (2) 2 (3) $\sqrt{2}$ (4) $\frac{1}{\sqrt{2}}$

12. Given below are two statements :

Statement I : In a diatomic molecule, the rotational energy at a given temperature obeys Maxwell's distribution.

Statement II : In a diatomic molecule, the rotational energy at a given temperature equals the translational kinetic energy for each molecule.

In the light of the above statements, choose the correct answer from the options given below :

(1) Statement I is false but Statement II is true.

(2) Both Statement I and Statement II are false.

(3) Both Statement I and Statement II are true.

(4) Statement I is true but Statement II is false.

13. A reversible heat engine converts one-fourth of the heat input into work. When the temperature of the sink is reduced by 52 K, its efficiency is doubled. The temperature in Kelvin of the source will be _________.

14. A container is divided into two chambers by a partition. The volume of first chamber is 4.5 litre and second chamber is 5.5 litre. The first chamber contain 3.0 moles of gas at pressure 2.0 atm and second chamber contain 4.0 moles of gas at pressure 3.0 atm. After the partition is removed and the mixture attains equilibrium, then, the common equilibrium pressure existing in the mixture is $x \times 10^{-1}$ atm. Value of x is_.

15. The internal energy (U), pressure (P) and volume (V) of an ideal gas are related as U = 3PV + 4. The gas is :

(1) Diatomic only

(2) Polyatomic only

(3) Either monoatomic or diatomic

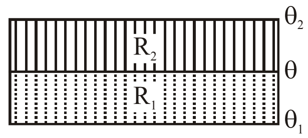
(4) Monoatomic only

16. The volume V of a given mass of monoatomic gas changes with temperature T according to the relation $V = KT^{2/3}$. The workdone when temperature changes by 90 K will be xR. The value of x is [R = universal gas constant]

17. 1 mole of rigid diatomic gas performs a work of Q/5 when heat Q is supplied to it. The molar heat capacity of the gas during this transformation is $\frac{xR}{8}$, The value of x is ....

[K = universal gas constant]

18. The temperature θ at the junction of two insulating sheets, having thermal resistances R_1 and R_2 as well as top and bottom temperatures θ_1 and θ_2 (as shown in figure) is given by :



(1) $\frac{\theta_2 R_2 - \theta_1 R_1}{R_2 - R_1}$ (2) $\frac{\theta_1 R_2 - \theta_2 R_1}{R_2 - R_1}$

(3) $\frac{\theta_1 R_2 + \theta_2 R_1}{R_1 + R_2}$ (4) $\frac{\theta_1 R_1 + \theta_2 R_2}{R_1 + R_2}$

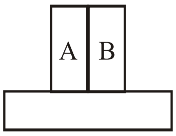
19. The volume V of an enclosure contains a mixture of three gases, 16 g of oxygen, 28 g of nitrogen and 44 g of carbon dioxide at absolute temperature T. Consider R as universal gas constant. The pressure of the mixture of gases is:

(1) $\frac{88RT}{V}$ (2) $\frac{3RT}{V}$ (3) $\frac{5}{2}\frac{RT}{V}$ (4) $\frac{4RT}{V}$

20. In thermodynamics, heat and work are :
(1) Path functions
(2) Intensive thermodynamic state variables
(3) Extensive thermodynamic state variables
(4) Point functions

21. Calculate the value of mean free path (λ) for oxygen molecules at temperature 27°C and pressure 1.01×10^5 Pa. Assume the molecular diameter 0.3 nm and the gas is ideal. ($k = 1.38 \times 10^{-23}$ JK^{-1})
(1) 58 nm (2) 32 nm
(3) 86 nm (4) 102 nm

22. A bimetallic strip consists of metals A and B. It is mounted rigidly as shown. The metal A has higher coefficient of expansion compared to that of metal B. When the bimetallic strip is placed in a cold both, it will :



(1) Bend towards the right
(2) Not bend but shrink
(3) Neither bend nor shrink
(4) Bend towards the left

23. For an ideal heat engine, the temperature of the source is 127°C. In order to have 60% efficiency the temperature of the sink should be ________°C. (Round off to the Nearest Integer)

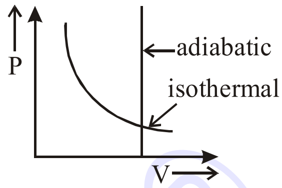
24. A polyatomic ideal gas has 24 vibrational modes. What is the value of γ ?
(1) 1.03 (2) 1.30
(3) 1.37 (4) 10.3

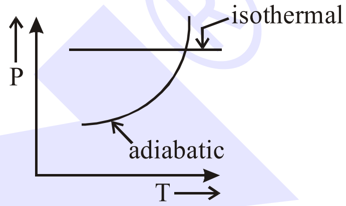
25. A Carnot's engine working between 400 K and 800 K has a work output of 1200 J per cycle. The amount of heat energy supplied to the engine from the source in each cycle is :
(1) 3200 J (2) 1800 J
(3) 1600 J (4) 2400 J

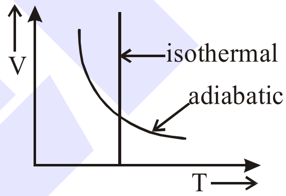
26. Two ideal polyatomic gases at temperatures T_1 and T_2 are mixed so that there is no loss of energy. If F_1 and F_2, m_1 and m_2, n_1 and n_2 be the degrees of freedom, masses, number of molecules of the first and second gas respectively, the temperature of mixture of these two gases is :
(1) $\dfrac{n_1T_1 + n_2T_2}{n_1 + n_2}$ (2) $\dfrac{n_1F_1T_1 + n_2F_2T_2}{n_1F_1 + n_2F_2}$
(3) $\dfrac{n_1F_1T_1 + n_2F_2T_2}{F_1 + F_2}$ (4) $\dfrac{n_1F_1T_1 + n_2F_2T_2}{n_1 + n_2}$

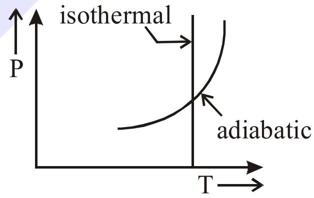
27. If one mole of the polyatomic gas is having two vibrational modes and β is the ratio of molar specific heats for polyatomic gas $\left(\beta = \dfrac{C_P}{C_V}\right)$ then the value of β is :
(1) 1.02 (2) 1.2 (3) 1.25 (4) 1.35

28. Which one is the correct option for the two different thermodynamic processes ?

(a)


(b)


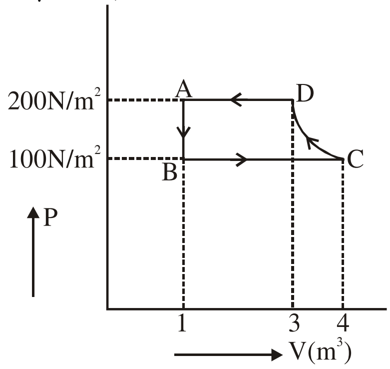
(c)


(d)


(1) (c) and (a) (2) (c) and (d)
(3) (a) only (4) (b) and (c)

29. What will be the average value of energy along one degree of freedom for an ideal gas in thermal equilibrium at a temperature T ? (k_B is Boltzmann constant)
(1) $\dfrac{1}{2}k_BT$ (2) $\dfrac{2}{3}k_BT$
(3) $\dfrac{3}{2}k_BT$ (4) k_BT

30. The P-V diagram of a diatomic ideal gas system going under cyclic process as shown in figure. The work done during an adiabatic process CD is (use $\gamma = 1.4$) :



(1) –500 J (2) –400 J
(3) 400 J (4) 200 J

31. An ideal gas in a cylinder is separated by a piston in such a way that the entropy of one part is S_1 and that of the other part is S_2. Given that $S_1 > S_2$. If the piston is removed then the total entropy of the system will be :

(1) $S_1 \times S_2$ (2) $S_1 - S_2$
(3) $\frac{S_1}{S_2}$ (4) $S_1 + S_2$

32. Consider a sample of oxygen behaving like an ideal gas. At 300 K, the ratio of root mean square (rms) velocity to the average velocity of gas molecule would be :
(Molecular weight of oxygen is 32 g/mol; $R = 8.3\ J\ K^{-1}\ mol^{-1}$)

(1) $\sqrt{\frac{3}{3}}$ (2) $\sqrt{\frac{8}{3}}$
(3) $\sqrt{\frac{3\pi}{8}}$ (4) $\sqrt{\frac{8\pi}{3}}$

33. Two identical metal wires of thermal conductivities K_1 and K_2 respectively are connected in series. The effective thermal conductivity of the combination is :

(1) $\frac{2K_1K_2}{K_1+K_2}$ (2) $\frac{K_1+K_2}{2K_1K_2}$
(3) $\frac{K_1+K_2}{K_1K_2}$ (4) $\frac{K_1K_2}{K_1+K_2}$

34. For an adiabatic expansion of an ideal gas, the fractional change in its pressure is equal to (where γ is the ratio of specific heats):

(1) $-\gamma\frac{dV}{V}$ (2) $-\gamma\frac{V}{dV}$
(3) $-\frac{1}{\gamma}\frac{dV}{V}$ (4) $\frac{dV}{V}$

35. The amount of heat needed to raise the temperature of 4 moles of a rigid diatomic gas from 0°C to 50°C when no work is done is _______. (R is the universal gas constant)

(1) 250 R (2) 750 R
(3) 175 R (4) 500 R

36. Consider a mixture of gas molecule of types A, B and C having masses $m_A < m_B < m_C$. The ratio of their root mean square speeds at normal temperature and pressure is :

(1) $v_A = v_B = v_C = 0$ (2) $\frac{1}{v_A} > \frac{1}{v_B} > \frac{1}{v_C}$
(3) $v_A = v_B \neq v_C$ (4) $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$

37. The entropy of any system is given by

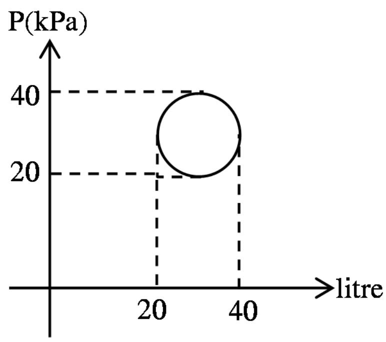
$$S = \alpha^2\beta \ln\left[\frac{\mu kR}{J\beta^2} + 3\right]$$

where α and β are the constants. μ, J, k and R are no. of moles, mechanical equivalent of heat, Boltzmann constant and gas constant respectively.

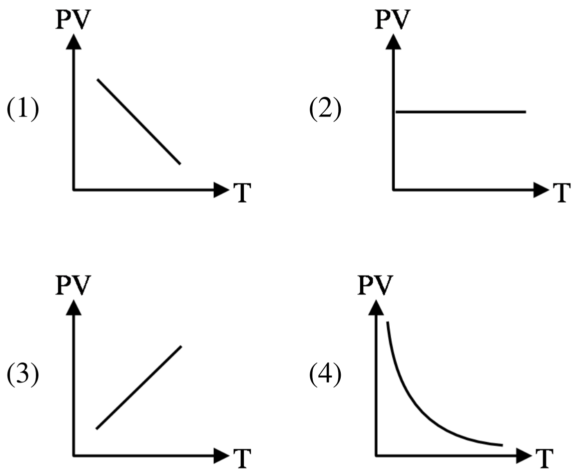
$$\left[\text{Take } S = \frac{dQ}{T}\right]$$

Choose the incorrect option from the following :
(1) α and J have the same dimensions.
(2) S, β, k and μR have the same dimensions.
(3) S and α have different dimensions.
(4) α and k have the same dimensions.

38. In the reported figure, heat energy absorbed by a system in going through a cyclic process is ______ πJ.



39. Which of the following graphs represent the behavior of an ideal gas ? Symbols have their usual meaning.

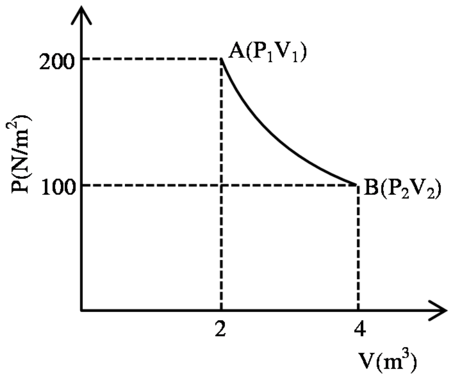


40. The correct relation between the degrees of freedom f and the ratio of specific heat γ is :

(1) $f=\dfrac{2}{\gamma-1}$ (2) $f=\dfrac{2}{\gamma+1}$

(3) $f=\dfrac{\gamma+1}{2}$ (4) $f=\dfrac{1}{\gamma+1}$

41. One mole of an ideal gas at 27ºC is taken from A to B as shown in the given PV indicator diagram. The work done by the system will be____ $\times 10^{-1}$ J. [Given : R = 8.3 J / mole K, ln2 = 0.6931] (Round off to the nearest integer)



42. What will be the average value of energy for a monoatomic gas in thermal equilibrium at temperature T ?

(1) $\dfrac{2}{3}k_BT$ (2) k_BT

(3) $\dfrac{3}{2}k_BT$ (4) $\dfrac{1}{2}k_BT$

43. In 5 minutes, a body cools from 75°C to 65°C at room temperature of 25°C. The temperature of body at the end of next 5 minutes is _______°C.

44. For a gas $C_P - C_V = R$ in a state P and $C_P - C_V = 1.10\,R$ in a state Q, T_P and T_Q are the temperatures in two different states P and Q respectively. Then

(1) $T_P = T_Q$ (2) $T_P < T_Q$

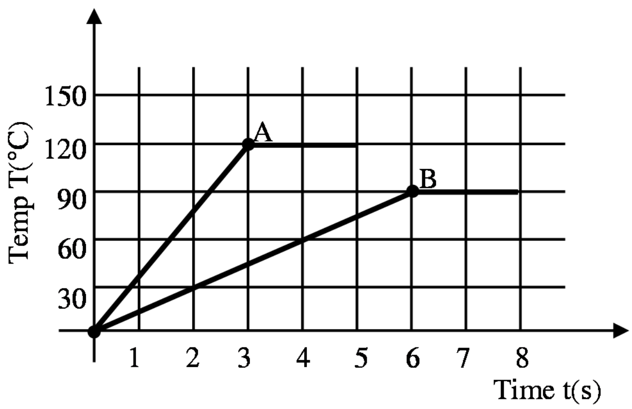
(3) $T_P = 0.9\,T_Q$ (4) $T_P > T_Q$

45. 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 piston suddenly. If l_1 and l_2 are the lengths of the gas column, before and after the expansion respectively, then the value of $\dfrac{T_1}{T_2}$ will be :

(1) $\left(\dfrac{l_1}{l_2}\right)^{\frac{2}{3}}$ (2) $\left(\dfrac{l_2}{l_1}\right)^{\frac{2}{3}}$

(3) $\dfrac{l_2}{l_1}$ (4) $\dfrac{l_1}{l_2}$

46. Two different metal bodies A and B of equal mass are heated at a uniform rate under similar conditions. The variation of temperature of the bodies is graphically represented as shown in the figure. The ratio of specific heat capacities is :



(1) $\dfrac{8}{3}$ (2) $\dfrac{3}{8}$ (3) $\dfrac{3}{4}$ (4) $\dfrac{4}{3}$

47. A heat engine has an efficiency of $\dfrac{1}{6}$. When the temperature of sink is reduced by 62°C, its efficiency get doubled. The temperature of the source is :

(1) 124°C (2) 37°C

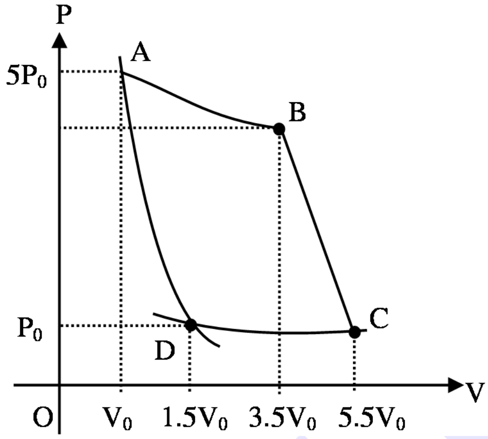
(3) 62°C (4) 99°C

48. A system consists of two types of gas molecules A and B having same number density 2×10^{25} / m^3. The diameter of A and B are 10 Å and 5 Å respectively. They suffer collision at room temperature. The ratio of average distance covered by the molecule A to that of B between two successive collision is ______ $\times 10^{-2}$

49 The number of molecules in one litre of an ideal gas at 300 K and 2 atmospheric pressure with mean kinetic energy 2×10^{-9} J per molecules is :

(1) 0.75×10^{11} (2) 3×10^{11}
(3) 1.5×10^{11} (4) 6×10^{11}

50. In the reported figure, there is a cyclic process ABCDA on a sample of 1 mol of a diatomic gas. The temperature of the gas during the process $A \rightarrow B$ and $C \rightarrow D$ are T_1 and T_2 ($T_1 > T_2$) respectively.



Choose the correct option out of the following for work done if processes BC and DA are adiabatic.

(1) $W_{AB} = W_{DC}$ (2) $W_{AD} = W_{BC}$
(3) $W_{BC} + W_{DA} > 0$ (4) $W_{AB} < W_{CD}$

51. A body takes 4 min. to cool from 61° C to 59°C. If the temperature of the surroundings is 30°C, the time taken by the body to cool from 51°C to 49° C is :

(1) 4 min. (2) 3 min.
(3) 8 min. (4) 6 min.

52. One mole of an ideal gas is taken through an adiabatic process where the temperature rises from 27°C to 37°C. If the ideal gas is composed of polyatomic molecule that has 4 vibrational modes, which of the following is true?
[$R = 8.314$ J mol^{-1} k^{-1}]

(1) work done by the gas is close to 332 J
(2) work done on the gas is close to 582 J
(3) work done by the gas is close to 582 J
(4) work done on the gas is close to 332 J

53. Two Carnot engines A and B operate in series such that engine A absorbs heat at T_1 and rejects heat to a sink at temperature T. Engine B absorbs half of the heat rejected by Engine A and rejects heat to the sink at T_3. When workdone in both the cases is equal, to value of T is :

(1) $\frac{2}{3}T_1 + \frac{3}{2}T_3$ (2) $\frac{1}{3}T_1 + \frac{2}{3}T_3$
(3) $\frac{3}{2}T_1 + \frac{1}{3}T_3$ (4) $\frac{2}{3}T_1 + \frac{1}{3}T_3$

54. An electric appliance supplies 6000 J/min heat to the system. If the system delivers a power of 90W. How long it would take to increase the internal energy by 2.5×10^3 J ?

(1) 2.5×10^2 s (2) 4.1×10^1s
(3) 2.4×10^3 s (4) 2.5×10^1s

55. The rms speeds of the molecules of Hydrogen, Oxygen and Carbondioxide at the same temperature are V_H, V_O and V_C respectively then :

(1) $V_H > V_O > V_C$ (2) $V_C > V_O > V_H$
(3) $V_H = V_O > V_C$ (4) $V_H = V_O = V_C$

56. The temperature of equal masses of three different liquids x,y and z are 10ºC, 20ºC and 30ºC respectively. The temperature of mixture when x is mixed with y is 16ºC and that when y is mixed with z is 26ºC. The temperature of mixture when x and z are mixed will be :

(1) 28.32º C (2) 25.62º C
(3) 23.84ºC (4) 20.28ºC

57. A cylindrical container of volume 4.0×10^{-3} m^3 contains one mole of hydrogen and two moles of carbon dioxide. Assume the temperature of the mixture is 400 K. The pressure of the mixture of gases is : [Take gas constant as 8.3 J mol^{-1} K^{-1}]

(1) 249×10^1 Pa (2) 24.9×10^3 Pa
(3) 24.9×10^5 Pa (4) 24.9 Pa

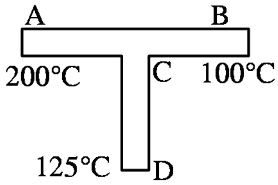
58. A refrigerator consumes an average 35 W power to operate between temperature –10°C to 25°C. If there is no loss of energy then how much average heat per second does it transfer ?

(1) 263 J/s (2) 298 J/s
(3) 350 J/s (4) 35 J/s

59. A balloon carries a total load of 185 kg at normal pressure and temperature of 27°C. What load will the balloon carry on rising to a height at which the barometric pressure is 45 cm of Hg and the temperature is –7°C. Assuming the volume constant ?

(1) 181.46 kg (2) 214.15 kg.
(3) 219.07 kg (4) 123.54 kg

60. A rod CD of thermal resistance 10.0 KW^{-1} is joined at the middle of an identical rod AB as shown in figure, The end A, B and D are maintained at 200°C, 100°C and 125°C respectively. The heat current in CD is P watt. The value of P is ....



61. If the rms speed of oxygen molecules at 0°C is 160 m/s, find the rms speed of hydrogen molecules at 0°C.

(1) 640 m/s (2) 40 m/s
(3) 80 m/s (4) 332 m/s

62. The height of victoria falls is 63 m. What is the difference in temperature of water at the top and at the bottom of fall ?

[Given 1 cal = 4.2 J and specific heat of water = 1 cal g^{-1} $°C^{-1}$]

(1) 0.147° C (2) 14.76° C
(3) 1.476° (4) 0.014° C

63. A heat engine operates between a cold reservoir at temperature T_2 = 400 K and a hot reservoir at temperature T_1. It takes 300 J of heat from the hot reservoir and delivers 240 J of heat to the cold reservoir in a cycle. The minimum temperature of the hot reservoir has to be _________K.

64. A reversible engine has an efficiency of $\frac{1}{4}$. If the temperature of the sink is reduced by 58°C, its efficiency becomes double. Calculate the temperature of the sink :

(1) 174°C (2) 280°C
(3) 180.4°C (4) 382°C

65. For an ideal gas the instantaneous change in pressure 'p' with volume 'v' is given by the equation $\frac{dp}{dv} = -ap$. If $p = p_0$ at v = 0 is the given boundary condition, then the maximum temperature one mole of gas can attain is :

(Here R is the gas constant)

(1) $\frac{p_0}{aeR}$ (2) $\frac{ap_0}{eR}$
(3) infinity (4) 0°C

66. Two thin metallic spherical shells of radii r_1 and r_2 ($r_1 < r_2$) are placed with their centres coinciding.

A material of thermal conductivity K is filled in the space between the shells. The inner shell is maintained at temperature θ_1 and the outer shell at temperature $\theta_2(\theta_1<\theta_2)$. The rate at which heat flows radially through the material is :-

(1) $\frac{4\pi K r_1 r_2(\theta_2-\theta_1)}{r_2-r_1}$ (2) $\frac{\pi r_1 r_2(\theta_2-\theta_1)}{r_2-r_1}$

(3) $\frac{K(\theta_2-\theta_1)}{r_2-r_1}$ (4) $\frac{K(\theta_2-\theta_1)(r_2-r_1)}{4\pi r_1 r_2}$

67. A mixture of hydrogen and oxygen has volume 500 cm^3, temperature 300 K, pressure 400 kPa and mass 0.76 g. The ratio of masses of oxygen to hydrogen will be :-

(1) 3 : 8 (2) 3 : 16 (3) 16 : 3 (4) 8 : 3

68. A sample of gas with γ = 1.5 is taken through an adiabatic process in which the volume is compressed from 1200 cm^3 to 300 cm^3. If the initial pressure is 200 kPa. The absolute value of the workdone by the gas in the process = _____ J.

69. Due to cold weather a 1 m water pipe of cross–sectional area 1 cm^2 is filled with ice at –10°C. Resistive heating is used to melt the ice. Current of 0.5 A is passed through 4 kΩ resistance. Assuming that all the heat produced is used for melting, what is the minimum time required ? (Given latent heat of fusion for water/ice = 3.33×10^5 J kg^{-1}, specific heat of ice = 2×10^3 J kg^{-1} and density of ice = 10^3 kg / m^3

(1) 0.353 s (2) 35.3 s
(3) 3.53 s (4) 70.6 s

70. An ideal gas is expanding such that PT^3 = constant. The coefficient of volume expansion of the gas is :

(1) $\frac{1}{T}$ (2) $\frac{2}{T}$ (3) $\frac{4}{T}$ (4) $\frac{3}{T}$

71. The temperature of 3.00 mol of an ideal diatomic gas is increased by 40.0 °C without changing the pressure of the gas. The molecules in the gas rotate but do not oscillate. If the ratio of change in internal energy of the gas to the amount of workdone by the gas is $\frac{x}{10}$. Then the value of x (round off to the nearest integer) is _______. (Given R = 8.31 J mol^{-1} K^{-1})

72. The average translational kinetic energy of N_2 gas molecules at ....°C becomes equal to the K.E. of an electron accelerated from rest through a potential difference of 0.1 volt.
(Given $k_B = 1.38 \times 10^{-23}$ J/K)
(Fill the nearest integer).

73. A steel rod with y = 2.0×10^{11} Nm^{-2} and $\alpha = 10^{-5}$ $°C^{-1}$ of length 4 m and area of cross-section 10 cm^2 is heated from 0° C to 400°C without being allowed to extend. The tension produced in the rod is $x \times 10^5$ N where the value of x is ....

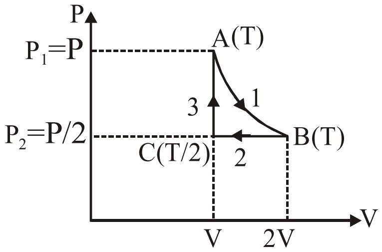
SOLUTION

1. Official Ans. by NTA (4)

Sol. $W_{Isothermal} = nRT\ln\left(\frac{v_2}{v_1}\right)$

$W_{Isobaric} = P\Delta V = nR\Delta T$

$W_{Isochoric} = 0$



$W_1 = nRT\ln\left(\frac{2V}{V}\right) = nRT\ln 2$

$W_2 = nR\left(\frac{T}{2} - T\right) = -nR\frac{T}{2}$

$W_3 = 0 \Rightarrow W_{net} = W_1 + W_2 + W_3$

$W_{net} = nRT\left(\ln 2 - \frac{1}{2}\right)$

2. Official Ans. by NTA (2)

Sol. (a) Isothermal $\Rightarrow$ Temperature constant

(a) $\rightarrow$ (ii)

(b) Isochoric $\Rightarrow$ Volume constant

(a) $\rightarrow$ (iii)

(c) Adiabatic $\Rightarrow \Delta Q = 0$

$\Rightarrow$ Heat content is constant

(c) $\rightarrow$ (iv)

(d) Isobaric $\Rightarrow$ Pressure constant

(d) $\rightarrow$ (i)

3. Official Ans. by NTA (1)

Sol. $\Delta V = V\gamma\Delta T$

$\Delta V = 3a^3\alpha\Delta T$

4. Official Ans. by NTA (4)

Sol. From the assumption of KTG, the molecules of gas collide with the walls and suffers momentum change which results in force on the wall and hence pressure.

Hence option (4) is correct

5. Official Ans. by NTA (1)

Sol. A – B = isothermal process

$W_{AB} = P_1V_1\ \ln\left[\frac{2V_1}{V_1}\right] = P_1V_1\ln(2)$

B – C $\rightarrow$ Isochoric process

$W_{BC} = 0$

C – A $\rightarrow$ Adiabatic process

$$W_{CA} = \frac{P_1V_1 - \frac{P_1}{4}\times 2V_1}{1-\gamma} = \frac{P_1V_1\left[1-\frac{1}{2}\right]}{1-\gamma} = \frac{P_1V_1}{2(1-\gamma)}$$

$W_{net} = W_{AB} + W_{BC} + W_{CA} \quad \{P_1V_1 = RT\}$

$= P_1V_1\ln(2) + 0 + \frac{P_1V_1}{2(1-\gamma)}$

$W_{net} = RT\left[\ln(2) - \frac{1}{2(\gamma-1)}\right]$

Option (1) is correct.

6. Official Ans. by NTA (400)

Sol. $v_{rms} = \sqrt{\frac{3RT}{M}}$

$v_{rms} \propto \sqrt{T}$

$\frac{(v_{rms})_2}{(v_{rms})_1} = \sqrt{\frac{T_2}{T_1}}$

$= \sqrt{\frac{400}{300}} = \frac{2}{\sqrt{3}}$

$(v_{rms})_2 = \frac{2}{\sqrt{3}}(v_{rms})_1$

$= \frac{2}{\sqrt{3}}\times 200$

$(v_{rms})_2 = \frac{400}{\sqrt{3}}\ m/s$

$\boxed{\text{Ans. } 400}$

7. Official Ans. by NTA (1)

Sol. A and R are true but R is not the correct explanation of A.

8. Official Ans. by NTA (2)

Sol. $dU = nC_vdT$

$dQ = nC_pdT$

$dW = PdV = nRdT$ (isobaric process)

$dU : dQ : dW \ :\ C_v : C_p : R$

$= \frac{5R}{2} : \frac{7R}{2} : R = 5 : 7 : 2$

9. Official Ans. by NTA (50)

Sol. $P = kV^3$

$T_i = 100°C$ & $T_f = 300°C$

$\Delta T = 300 - 100$

$\Delta T = 200°C$

$P = kV^3$

now $PV = nRT$

$\therefore kV^4 = nRT$

now $4kV^3\, dV = nRdT$

$\therefore PdV = nRdT/4$

$$\therefore \text{Work} = \int PdV = \int \frac{nRdT}{4} = \frac{nR}{4}\Delta T$$

$$= \frac{200}{4} \times nR = 50nR$$

10. Official Ans. by NTA (3600)

Sol. Given that mass of gas is 4u hence its molar mass M is 4g/mol

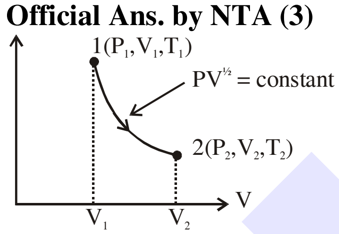
$$\therefore \frac{1}{2}mv^2 = nC_v\Delta T$$

$$\frac{1}{2}m\times(30)^2 = \frac{m}{M}\times\frac{3R}{2}\times\Delta T$$

$$\therefore \Delta T = \frac{3600}{3R}$$

11. Official Ans. by NTA (3)

Sol.



$PV^{1/2} = c$

$$\frac{nRT}{V} V^{1/2} = c$$

$T = c^1 V^{1/2}$

$$\frac{T_2}{T_1} = \left(\frac{V_2}{V_1}\right)^{1/2} = \left(\frac{2V_1}{V_1}\right)^{1/2}$$

$$\frac{T_2}{T_1} = \sqrt{2}$$

12. Official Ans. by NTA (4)

Sol. (4) Translational degree of freedom = 3

Rotational degree of freedom = 2

13. Official Ans. by NTA (208)

Sol. $\eta = \frac{1}{4} = 1 - \frac{T_2}{T_1}$

$$\frac{T_2}{T_1} = \frac{3}{4};\quad \frac{T_2 - 52}{T_1} = \frac{1}{2}$$

14. Official Ans. by NTA (26)

Sol. Let common equilibrium pressure of mixture is P atmp. then

$U_1 + U_2 = U_{mixutre}$

$$\frac{f}{2}P_1V_1 + \frac{f}{2}P_2V_2 = \frac{f}{2}P(V_1 + V_2)$$

$$\frac{f}{2}(2)(4.5) + \frac{f}{2}(3)(5.5) = \frac{f}{2}P(4.5 + 5.5)$$

$\Rightarrow P = 2.55 \;= x \times 10^{-1}$ atmp

So $x = 25.5 \approx 26$ (Nearest integer)

15. Official Ans. by NTA (2)

Sol. $U = 3PV + 4$

$$\frac{nf}{2}RT = 3PV + 4$$

$$\frac{f}{2}PV = 3PV + 4$$

$$f = 6 + \frac{8}{PV}$$

Since degree of freedom is more than 6 therefore gas is polyatomic

16. Official Ans. by NTA (60)

Sol. We know that work done is

$W = \int PdV$ ... (1)

$\Rightarrow P = \frac{nRT}{V}$ ... (2)

$\Rightarrow W = \int \frac{nRT}{V}dv$ ... (3)

and $V = KT^{2/3}$ ... (4)

$\Rightarrow W = \int \frac{nRT}{KT^{2/3}} \cdot dv$ ... (5)

$$\Rightarrow \text{from (4)}:\ dv = \frac{2}{3}KT^{-1/3}dT$$

$$\Rightarrow W = \int_{T_1}^{T_2} \frac{nRT}{KT^{2/3}}\frac{2}{3}K\frac{1}{T^{1/3}}dT$$

$\Rightarrow W = \frac{2}{3}nR \times (T_2 - T_1)$ ... (6)

$\Rightarrow T_2 - T_1 = 90$ K ... (7)

$$\Rightarrow W = \frac{2}{3}nR \times 90 \Rightarrow W = 60\,nR$$

Assuming 1 mole of gas

n = 1

So W = 60R

17. Official Ans. by NTA (25)

Sol. $Q = \Delta U + W$

$$Q = \Delta U + \frac{Q}{5}$$

$$\Delta U = \frac{4Q}{5}$$

$$nC_v\Delta T = \frac{4}{5}nC\Delta T$$

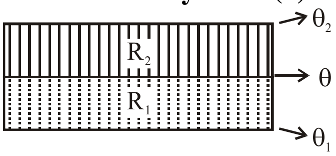
$$\frac{5}{4}C_V = C$$

$$C = \frac{5}{4}\left(\frac{f}{2}\right)R = \frac{5}{4}\left(\frac{5}{2}\right)R$$

$$C = \frac{25}{8}R \qquad x = 25$$

18. Official Ans. by NTA (3)

Sol.



Heat flow rate will be same through both

$$\therefore \quad \frac{\theta_1 - \theta}{R_1} = \frac{\theta - \theta_2}{R_2}$$

$$R_2\theta_1 - R_2\theta = R_1\theta - R_1\theta_2$$

$$\theta = \frac{R_2\theta_1 + R_1\theta_2}{R_1 + R_2}$$

Ans. (3)

19. Official Ans. by NTA (3)

Sol. $PV = (n_1 + n_2 + n_3)RT$

$$P \times V = \left[\frac{16}{32} + \frac{28}{28} + \frac{44}{44}\right]RT$$

$$PV = \left[\frac{1}{2} + 1 + 1\right]RT$$

$$P = \frac{5}{2}\frac{RT}{V}$$

20. Official Ans. by NTA (1)

Sol. Heat and work are treated as path functions in thermodynamics.

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

Since work done by gas depends on type of process i.e. path and ΔU depends just on initial and final states, so ΔQ i.e. heat, also has to depend on process is path.

21. Official Ans. by NTA (4)

Sol. $$\lambda = \frac{RT}{\sqrt{2}\pi d^2 N_A P}$$

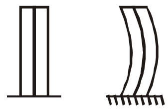
$\lambda = 102$ nm

22. Official Ans. by NTA (4)

Sol. $\alpha_A > \alpha_B$

Length of both strips will decrease

$\Delta L_A > \Delta L_B$



23. Official Ans. by NTA (113)

Official Ans. by ALLEN (–113)

Sol. Ans. (–113)

$$n = 0.60 = 1 = \frac{T_L}{T_H}$$

$$\frac{T_L}{T_H} = 0.4 \Rightarrow T_L = 0.4 \times 400$$

$= 160\text{ K} = -113°C$

24. Official Ans. by NTA (1)

Sol. Since each vibrational mode has 2 degrees of freedom hence total vibrational degrees of freedom = 48

$f = 3 + 3 + 48 = 54$

$$\gamma = 1 + \frac{2}{f} = \frac{28}{27} = 1.03$$

25. Official Ans. by NTA (4)

Sol. $$\eta = \frac{T_2}{T_1} = \frac{Q_2}{Q_1} = \frac{Q_1 - W}{Q_1} \qquad (\because W = Q_1 - Q_2)$$

$$\frac{400}{800} = 1 - \frac{W}{Q_1}$$

$$\frac{W}{Q_1} = 1 - \frac{1}{2} = \frac{1}{2} \qquad Q_1 = 2W = 2400\text{ J}$$

26. Official Ans. by NTA (2)

Sol. Let the final temperature of the mixture be T. Since, there is no loss in energy.

$\Delta U = 0$

$$\Rightarrow \frac{F_1}{2}n_1R\,\Delta T + \frac{F_2}{2}n_2R\Delta T = 0$$

$$\Rightarrow \frac{F_1}{2}n_1R\,(T_1 - T) + \frac{F_2}{2}n_2R\,(T_2 - T) = 0$$

$$\Rightarrow T = \frac{F_1n_1RT_1 + F_2n_2RT_2}{F_1n_1R + F_2n_2R} \Rightarrow \frac{F_1n_1T_1 + F_2n_2T_2}{F_1n_1 + F_2n_2}$$

27. Official Ans. by NTA (2)

Sol. (2) $f = 4 + 3 + 3 = 10$

assuming non linear

$$\beta = \frac{C_p}{C_v} = 1 + \frac{2}{f} = \frac{12}{10} = 1.2$$

28. Official Ans. by NTA (2)

Sol. (2) Option (a) is wrong ; since in adiabatic process $V \neq$ constant.

Option (b) is wrong, since in isothermal process T = constant

Option (c) & (d) matches isothermes & adiabatic formula :

$TV^{\gamma-1}$= constant & $\frac{T^{\gamma}}{p^{\gamma-1}}$ = constant

29. Official Ans. by NTA (1)

Sol. Energy associated with each degree of freedom per molecule = $\frac{1}{2}k_BT$.

30. Official Ans. by NTA (1)

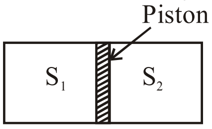
Sol. Adiabatic process is from C to D

$$WD = \frac{P_2V_2 - P_1V_1}{1-\gamma} = \frac{P_DV_D - P_CV_C}{1-\gamma}$$

$$= \frac{200(3)-(100)(4)}{1-1.4} = -500\text{ J} \quad \text{Ans. (1)}$$

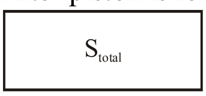
31. Official Ans. by NTA (4)

Sol.



; $S_1 > S_2$

After piston is removed



; $S_{total} = S_1 + S_2$

32. Official Ans. by NTA (3)

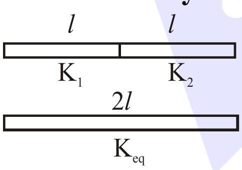
Sol. $v_{rms} = \sqrt{\frac{3RT}{M}}$

$v_{avg} = \sqrt{\frac{8}{\pi}\frac{RT}{M}}$

$\frac{v_{rms}}{v_{avg}} = \sqrt{\frac{3\pi}{8}}$

33. Official Ans. by NTA (1)

Sol.



$$R_{eff} = \frac{l}{K_1A} + \frac{l}{K_2A} = \frac{2l}{K_{eq}A}$$

$$K_{eq} = \frac{2K_1K_2}{K_1+K_2}$$

34. Official Ans. by NTA (1)

Sol. PV^{γ} = constant

Differentiating

$\frac{dP}{dV} = -\frac{\gamma P}{V}$; $\frac{dP}{P} = -\frac{\gamma dV}{V}$

35. Official Ans. by NTA (4)

Sol. $\Delta Q = \Delta U + \Delta W$

Here $\Delta W = 0$

$\Delta Q = \Delta U = nC_V\Delta T$

$$\Delta Q = 4 \times \frac{5R}{2}(50) = 500R$$

Hence option (4).

36. Official Ans. by NTA (4)

Sol. $V_{RMS} = \sqrt{\frac{3RT}{M}}$

$m_A < m_B < m_C$

$\Rightarrow V_A > V_B > V_C$

$\Rightarrow \frac{1}{V_A} < \frac{1}{V_B} < \frac{1}{V_C}$

37. Official Ans. by NTA (4)

Sol. $S = \alpha^2\beta\,\ell n\left(\frac{\mu KR}{J\beta^2}+3\right)$

$S = \frac{Q}{T}$ = joulek / k

$[\alpha^2\beta]$ = Joule/k

PV = nRT $\qquad \left[\frac{\mu KR}{J\beta^2}\right] = 1$

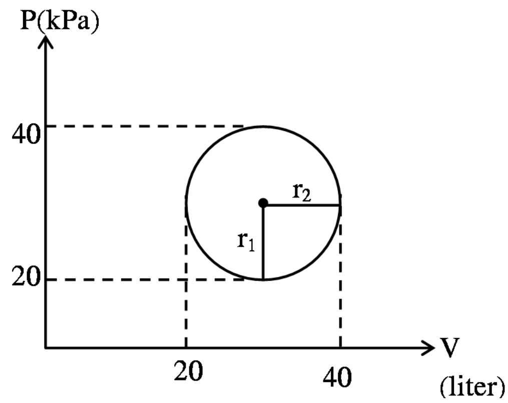
$R = \frac{\text{Joule}}{K}$

$\Rightarrow R = \frac{\text{Joule}}{K}, K = \frac{\text{Joule}}{R} \Rightarrow \beta = \left(\frac{\text{Joule}}{K}\right)$

$\alpha^2\beta = \left(\frac{\text{Joule}}{K}\right) \qquad \Rightarrow \alpha$ = dimensionless

38. Official Ans. by NTA (100)

Sol.



For complete cyclic process

$\Delta U = 0$

$\therefore$ from $\Delta Q = \Delta U + W$

$= 0 + W$

$\Delta Q = W$

$=$ Area

$= \pi r_1 \cdot r_2$

$= \pi \times (10 \times 10^3) \times (10 \times 10^{-3})$

$\Delta Q = 100\,\pi$

$\therefore$ Ans. $= 100$

39. Official Ans. by NTA (3)

Sol. $PV = nRT$

$PV \propto T$

Straight line with positive slope (nR)

40. Official Ans. by NTA (1)

Sol. $\gamma = 1 + \dfrac{2}{f}$

$f = \dfrac{2}{\gamma - 1}$

41. Official Ans. by NTA (17258)

Sol. Process of isothermal

$W = nRT\ell n\left(\dfrac{V_2}{V_1}\right)$

$= 1 \times 8.3 \times 300 \times \ln 2$

$= 17258 \times 10^{-1}$ J

42. Official Ans. by NTA (3)

Sol. As per Equi-partition law :

Each degree of freedom contributes

$\frac{1}{2}k_B T$ Average Energy

In monoatomic gas D.O.F. = 3

$\Rightarrow$ Average energy $= 3 \times \frac{1}{2}k_B T = \frac{3}{2}k_B T$

43. Official Ans. by NTA (57)

Sol. By newton's law of cooling (with approximation)

$\dfrac{\Delta T}{\Delta t} = -C\left(T_{avg} - T_s\right)$

1^{st} $\dfrac{-10°C}{5\,\text{min}} = -C(70°C - 25°C)$

$\Rightarrow$ $C = \dfrac{2}{45}\text{min}^{-1}$

2^{nd} $\dfrac{T-65}{5\,\text{min}} = -C\left(\dfrac{T+65}{2} - 25\right) = -\left(\dfrac{2}{45}\right)\left(\dfrac{T+15}{2}\right)$

$\Rightarrow$ $9\,(T - 65) = -\,(T + 15)$

$\Rightarrow$ $10T = 570$

$\Rightarrow$ $T = 57°C$

Alternate Solution :

Newton's law of cooling (without approximation)

$T_P - T_S = (T_i - T_S)e^{-Ct}$

1^{st} $65 - 25 = (75 - 25)e^{-5C} \Rightarrow e^{-5C} = \dfrac{4}{5}$

2^{nd} $T - 25 = (65 - 25)e^{-5C} = 40 \times \dfrac{4}{5} = 32$

$T = 57°C$

44. Official Ans. by NTA (4)

Sol. $C_P - C_V = R$ for ideal gas and gas behaves as ideal gas at high temperature

so $T_P > T_Q$

45. Official Ans. by NTA (2)

Sol. $PV^r = \text{const.}$

$TV^{r-1} = \text{const.}$

$T(\ell)^{3^{\frac{5}{3}-1}} = \text{const.}$

$\dfrac{T_1}{T_2} = \left(\dfrac{\ell_2}{\ell_1}\right)^{2/3}$

46. Official Ans. by NTA (2)

Sol. $\left(\dfrac{\Delta Q}{\Delta t}\right)_A = \left(\dfrac{\Delta Q}{\Delta t}\right)_B$

$mS_A\left(\dfrac{\Delta T}{\Delta t}\right)_A = mS_B\left(\dfrac{\Delta T}{\Delta t}\right)_B$

$\dfrac{S_A}{S_B} = \dfrac{\left(\dfrac{\Delta T}{\Delta t}\right)_A}{\left(\dfrac{\Delta T}{\Delta t}\right)_B} = \dfrac{90/6}{120/3} = \dfrac{15}{40} = \dfrac{3}{8}$

47. Official Ans. by NTA (4)

Sol. $\eta = 1 - \dfrac{T_L}{T_H}$ … (i)

$2\eta = 1 - \dfrac{(T_L - 62)}{T_H} = 1 - \dfrac{T_L}{T_H} + \dfrac{62}{T_H}$

$\Rightarrow \eta = \dfrac{62}{T_H} \Rightarrow \dfrac{1}{6} = \dfrac{62}{T_H} \Rightarrow T_H = 6 \times 62 = 372K$

In °C $\Rightarrow 372 - 273 = 99°C$

48. Official Ans. by NTA (25)

Sol. $\because$ mean free path

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{d_2^2 n_2}{d_1^2 n_1}$$

$$= \left(\frac{5}{10}\right)^2 = 0.25 = 25 \times 10^{-2}$$

49 Official Ans. by NTA (3)

Sol. $KE = \frac{3}{2}kT$

$$PV = \frac{N}{N_A}RT$$

$$N = \frac{PV}{kT}$$

$$= N = 1.5 \times 10^{11}$$

50. Official Ans. by NTA (2)

Sol. Work done in adiabatic process $= \frac{-nR}{\gamma - 1}(T_f - T_i)$

$$\therefore W_{AD} = \frac{-nR}{\gamma - 1}(T_2 - T_1)$$

and $W_{BC} = \frac{-nR}{\gamma - 1}(T_2 - T_1)$

$$\therefore W_{AD} = W_{BC}$$

51. Official Ans. by NTA (4)

Sol. $\frac{\Delta T}{\Delta t} = K(T_t - T_S)$ $\quad T_t$ = average temp.

T_S = surrounding temp.

$$\frac{61-59}{4} = K\left(\frac{61+59}{2} - 30\right) \quad ....(1)$$

$$\frac{51-49}{t} = K\left(\frac{51+49}{2} - 30\right) \quad ....(2)$$

Divide (1) & (2)

$$\frac{t}{4} = \frac{60-30}{50-30} = \frac{30}{20}$$

so, $t = 6$ minutes

52. Official Ans. by NTA (2)

Sol. Since, each vibrational mode, corresponds to two degrees of freedom, hence, f = 3 (trans.) + 3(rot.) + 8 (vib.) = 14

& $\quad \gamma = 1 + \frac{2}{f}$

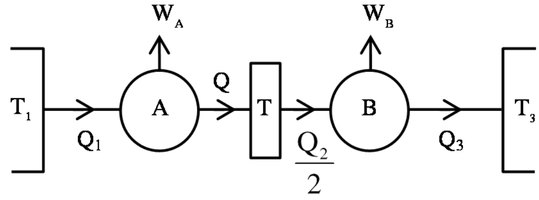
$$\gamma = 1 + \frac{2}{14} = \frac{8}{7}$$

$$W = \frac{nR\Delta T}{\gamma - 1} = -582$$

As W < 0. work is done on the gas.

53. Official Ans. by NTA (4)

Sol.



$$W_A = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T}{T_1} \Rightarrow \frac{Q_2}{Q_1} = \frac{T}{T_1}$$

$$W_B = 1 - \frac{Q_3}{(Q_2/2)} = 1 - \frac{T_3}{T} \Rightarrow \frac{2Q_3}{Q_2} = \frac{T_3}{T}$$

Now, $W_A = W_B$

$$Q_1 - Q_2 = \frac{Q_2}{2} - Q_3$$

$$\Rightarrow \frac{2Q_1}{Q_2} + \frac{2Q_3}{Q_2} = 3$$

$$\Rightarrow \frac{2T_1}{T} + \frac{T_3}{T} = 3$$

$$\frac{2T_1}{3} + \frac{T_3}{3} = T$$

54. Official Ans. by NTA (1)

Sol. $\Delta Q = \Delta U + \Delta W$

$$\frac{\Delta Q}{\Delta t} = \frac{\Delta U}{\Delta t} + \frac{\Delta W}{\Delta t}$$

$$\frac{6000}{60}\frac{J}{sec} = \frac{2.5 \times 10^3}{\Delta t} + 90$$

$\Delta t = 250$ sec

Option (1)

55. Official Ans. by NTA (1)

Sol. $V_{RMS} = \sqrt{\frac{3RT}{M_W}}$

At the same temperature $V_{RMS} \propto \frac{1}{\sqrt{M_w}}$

$$\Rightarrow V_H > V_O > V_C$$

Option (1)

56. Official Ans. by NTA (3)

Sol. X Y Z

$m_1 = m$ $m_2 = m$ $m_3 = m$

$T_1 = 10°C$ $T_2 = 20°C$ $T_3 = 30°C$

s_1 s_2 s_3

when x & y are mixed, $T_{f_1} = 16°C$

$m_1s_1T + m_2s_2T_2 = (m_1s_1 + m_2s_2)Tf_1$

$s_1 \times 10 + s_2 \times 20 = (s_1 + s_2) \times 16$

$s_1 = \frac{2}{3}s_2$ ....(i)

when y & z are mixex, $T_{f_2} = 26°C$

$m_2s_2T + m_3s_3T_3 = (m_3s_3 + m_3s_3)Tf_2$

$s_2 \times 20 + s_3 \times 30 = (s_2 + s_3) \times 26$

$s_3 = \frac{3}{2}s_2$ .....(ii)

when x & z are mixex

$m_1s_1T_1 + m_3s_3T_3 = (m_1s_1 + m_3s_3)Tf$

$$\frac{2}{3}s_2 \times 10 + \frac{2}{3}s_2 \times 20 = \left(\frac{2}{3}s_2 + \frac{3}{2}s_2\right)T_f$$

$T_f = 23.84°C$

Ans (3)

57. Official Ans. by NTA (3)

Sol. $V = 4 \times 10^{-3}\ m^3$

n = 3 moles

T = 400K

$$PV = nRT \Rightarrow P = \frac{nRT}{V}$$

$$P = \frac{3 \times 8.3 \times 400}{4 \times 10^{-3}} = 24.9 \times 10^5\ Pa$$

Ans 3

58. Official Ans. by NTA (1)

Sol. $$\frac{T_L}{T_H - T_L} = C.O.P. = \frac{\frac{dH}{dt}}{\frac{dW}{dt}}$$

$$\frac{263}{35} \times 35 = \frac{dH}{dt}$$

$$\frac{dH}{dt} = 263\ \text{watts}$$

Ans.1

59. Official Ans. by NTA (4)

Sol. $P_m = \rho RT$

$$\therefore \frac{P_1}{P_2} = \frac{\rho_1 T_1}{\rho_2 T_2}$$

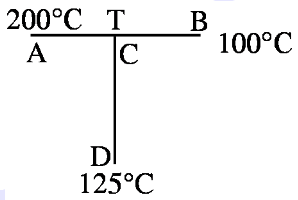
$$\frac{\rho_1}{\rho_2} \Rightarrow \frac{P_1T_2}{P_2T_1} = \left(\frac{76}{45}\right) \times \frac{266}{300}$$

$$\frac{\rho_1}{\rho_2} \Rightarrow \frac{M_1}{M_2} = \frac{76 \times 266}{45 \times 300}$$

$$\therefore M_2 \Rightarrow \frac{45 \times 300 \times 185}{76 \times 266} = 123.54\ kg$$

60. Official Ans. by NTA (2)

Sol.



Rods are identical so

$R_{AB} = R_{CD} = 10\ Kw^{-1}$

C is mid-point of AB, so

$R_{AC} = R_{CB} = 5\ Kw^{-1}$

at point C

$$\frac{200 - T}{5} = \frac{T - 125}{10} + \frac{T - 100}{5}$$

$2(200 - T) = T - 125 + 2(T - 100)$

$400 - 2T = T - 125 + 2T - 200$

$$T = \frac{725}{5} = 145°C$$

$$I_h = \frac{145 - 125}{10}w = \frac{20}{10}w$$

$$\boxed{I_h = 2w}$$

61. Official Ans. by NTA (1)

Sol. $$V_{rms} = \sqrt{\frac{3KT}{M}}$$

$$\frac{(V_{rms})_{O_2}}{(V_{rms})_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{2}{32}}$$

$$(V_{rms})_{H_2} = 4 \times (V_{rms})_{O_2}$$

$= 4 \times 160 = 640\ m/s$

62. Official Ans. by NTA (1)

Sol. Change in P.E. = Heat energy

$mgh = mS\Delta T$

$$\Delta T = \frac{gh}{S}$$

$$= \frac{10 \times 63}{4200 J / kgC} = 0.147°C$$

63. Official Ans. by NTA (500)

Sol. $Q_{in} = 300$ J ; $Q_{out} = 240$ J

Work done = $Q_{in} - Q_{out} = 300 - 240 = 60$ J

Efficiency = $\frac{W}{Q_{in}} = \frac{60}{300} = \frac{1}{5}$

efficiency = $1 - \frac{T_2}{T_1}$

$$\frac{1}{5} = 1 - \frac{400}{T_1} \Rightarrow \frac{400}{T_1} = \frac{4}{5}$$

$T_1 = 500$ k

64. Official Ans. by NTA (1)

Sol. T_2 = sink temperature

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\frac{1}{4} = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = \frac{3}{4} \quad \dots \text{(i)}$$

$$\frac{1}{2} = 1 - \frac{T_2 - 58}{T_1}$$

$$\frac{T_2}{T_1} - \frac{58}{T_1} = \frac{1}{2}$$

$$\frac{3}{4} = \frac{58}{T_1} + \frac{1}{2}$$

$$\frac{1}{4} = \frac{58}{T_1} \Rightarrow T_1 = 232$$

$$T_2 = \frac{3}{4} \times 232$$

$T_2 = 174$ K

65. Official Ans. by NTA (1)

Sol. $$\int_{p_0}^{p} \frac{dp}{P} = -a\int_0^v dv$$

$$\ell n\left(\frac{p}{p_0}\right) = -av$$

$$p = p_0 e^{-av}$$

For temperature maximum p-v product should be maximum

$$T = \frac{pv}{nR} = \frac{p_0 v e^{-av}}{R}$$

$$\frac{dT}{dv} = 0 \Rightarrow \frac{p_0}{R}\{e^{-av} + ve^{-av}(-a)\}$$

$$\frac{p_0 e^{-av}}{R}\{1 - av\} = 0$$

$$v = \frac{1}{a}, \infty$$

$$T = \frac{p_0 1}{Rae} = \frac{p_0}{Rae}$$

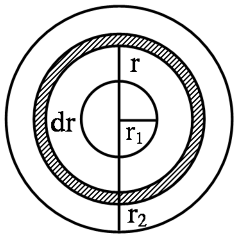
at $v = \infty$

$T = 0$

Option (1)

66. Official Ans. by NTA (1)

Sol.



Thermal resistance of spherical sheet of thickness dr and radius r is

$$dR = \frac{dr}{K(4\pi r^2)}$$

$$R = \int_{r_1}^{r_2} \frac{dr}{K(4\pi r^2)}$$

$$R = \frac{1}{4\pi K}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = \frac{1}{4\pi K}\left(\frac{r_2 - r_1}{r_1 r_2}\right)$$

Thermal current (i) = $\frac{\theta_2 - \theta_1}{R}$

$$i = \frac{4\pi K r_1 r_2}{r_2 - r_1}(\theta_2 - \theta_1)$$

67. Official Ans. by NTA (3)

Sol. PV = nRT

$$400 \times 10^3 \times 500 \times 10^{-6} = n\left(\frac{25}{3}\right)(300)$$

$$n = \frac{2}{25}$$

$n = n_1 + n_2$

$$\frac{2}{25} = \frac{M_1}{2} + \frac{M_2}{32}$$

Also $M_1 + M_2 = 0.76$ gm

$$\frac{M_2}{M_1} = \frac{16}{3}$$

68. Official Ans. by NTA (480)

Sol. $\nu = 1.5$

$p_1 v_1^{\nu} = p_2 v_2^{\nu}$

$(200)(1200)^{1.5} = P^2 (300)^{1.5}$

$P_2 = 200\,[4]^{3/2} = 1600$ kPa

$$|W.D.| = \frac{p_2 v_2 - p_1 v_1}{\nu - 1} = \left(\frac{480 - 240}{0.5}\right) = 480 \text{ J}$$

69. Official Ans. by NTA (2)

Sol. mass of ice $m = \rho A\ell = 10^3 \times 10^{-4} \times 1 = 10^{-1}$ kg

Energy required to melt the ice

$Q = ms\Delta T + mL$

$= 10^{-1} (2 \times 10^3 \times 10 + 3.33 \times 10^5) = 3.53 \times 10^4$ J

$Q = i^2RT \Rightarrow 3.53 \times 10^4 = \left(\frac{1}{2}\right)^2 \left(4\times10^3\right)(t)$

Time = 35.3 sec

Option (2)

70. Official Ans. by NTA (3)

Sol. PT^3 = constant

$\left(\frac{nRT}{v}\right)T^3$ = constant

$T^4\,V^{-1}$ = constant

$T^4 = kV$

$\Rightarrow 4\frac{\Delta T}{T} = \frac{\Delta V}{V}$ ....(1)

$\Delta V = V\gamma\Delta T$.............(2)

comparing (1) and (2)

we get

$\gamma = \frac{4}{T}$

71. Official Ans. by NTA (25)

Sol. Pressure is not changing $\Rightarrow$ isobaric process

$\Rightarrow \Delta U = nC_v\Delta T = \frac{5nR\Delta T}{2}$

and $W = nR\Delta T$

$\frac{\Delta U}{W} = \frac{5}{2} = \frac{x}{10} \Rightarrow x = 25.00$

72. Official Ans. by NTA (500)

Sol. Given

Translation K.E. of N_2 = K.E. of electron

$\frac{3}{2}kT = eV$

$\frac{3}{2}\times1.38\times10^{-23}T = 1.6\times10^{-19}\times0.1$

$\Rightarrow T = 773k$

$T = 773 - 273 = 500°C$

73. Official Ans. by NTA (8)

Sol. Thermal force $F = Ay\alpha\Delta T$

$F = (10 \times 10^{-4})\,(2 \times 10^{11})\,(10^{-5})(400)$

$F = 8 \times 10^5$ N

$\Rightarrow x = 8$