HEAT & THERMODYNAMICS

1. 0.08 kg air is heated at constant volume through 5°C. The specific heat of air at constant volume is 0.17 kcal/kg°C and J = 4.18 joule/cal. The change in its internal energy is approximately.

(1) 318 J (2) 298 J
(3) 284 J (4) 142 J

2. The average kinetic energy of a monatomic molecule is 0.414 eV at temperature :
(Use $K_B = 1.38 \times 10^{-23}$ J/mol-K)

(1) 3000 K (2) 3200 K
(3) 1600 K (4) 1500 K

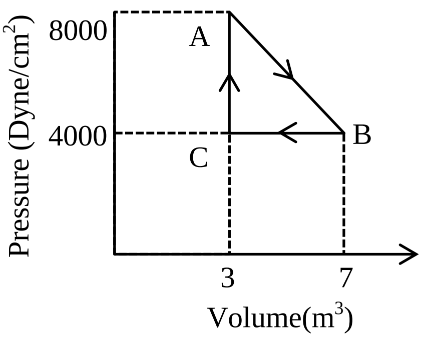
3. The total kinetic energy of 1 mole of oxygen at 27°C is :
[Use universal gas constant (R) = 8.31 J/mole K]

(1) 6845.5 J (2) 5942.0 J
(3) 6232.5 J (4) 5670.5J

4. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio of $\frac{C_p}{C_v}$ for the gas is :

(1) $\frac{5}{3}$ (2) $\frac{3}{2}$ (3) $\frac{7}{5}$ (4) $\frac{9}{7}$

5. A thermodynamic system is taken from an original state A to an intermediate state B by a linear process as shown in the figure. It's volume is then reduced to the original value from B to C by an isobaric process. The total work done by the gas from A to B and B to C would be :



(1) 33800 J (2) 2200 J
(3) 600 J (4) 1200 J

6. Two vessels A and B are of the same size and are at same temperature. A contains 1g of hydrogen and B contains 1g of oxygen. P_A and P_B are the pressures of the gases in A and B respectively, then $\frac{P_A}{P_B}$ is :

(1) 16 (2) 8 (3) 4 (4) 32

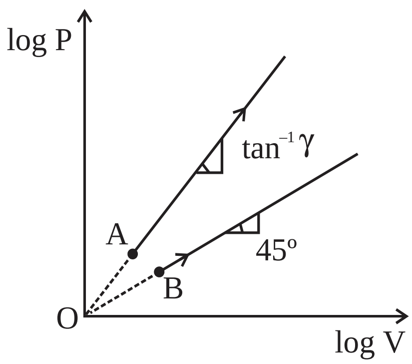
7. The temperature of a gas having 2.0×10^{25} molecules per cubic meter at 1.38 atm
(Given, $k = 1.38 \times 10^{-23}$ JK^{-1}) is :

(1) 500 K (2) 200 K
(3) 100 K (4) 300 K

8. N moles of a polyatomic gas (f = 6) must be mixed with two moles of a monoatomic gas so that the mixture behaves as a diatomic gas. The value of N is :

(1) 6 (2) 3 (3) 4 (4) 2

9. Two thermodynamical process are shown in the figure. The molar heat capacity for process A and B are C_A and C_B. The molar heat capacity at constant pressure and constant volume are represented by C_P and C_V, respectively. Choose the correct statement.



(1) $C_B = \infty, C_A = 0$

(2) $C_A = 0$ and $C_B = \infty$

(3) $C_P > C_V > C_A = C_B$

(4) $C_A > C_P > C_V$

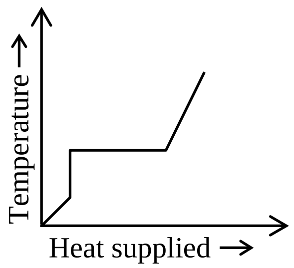
10. At which temperature the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47ºC?

(1) 80 K (2) –73 K

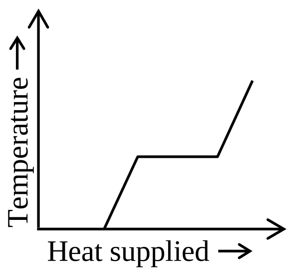
(3) 4 K (4) 20 K

11. A block of ice at –10°C is slowly heated and converted to steam at 100°C. Which of the following curves represent the phenomenon qualitatively:

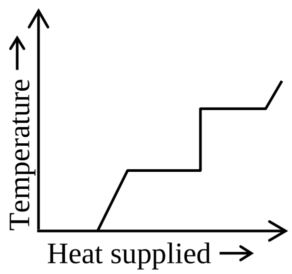
(1)



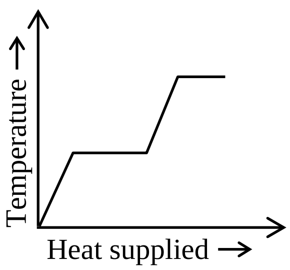
(2)



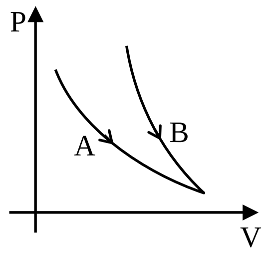
(3)



(4)



12. Choose the correct statement for processes A & B shown in figure.



(1) $PV^{\gamma} = k$ for process B and $PV = k$ for process A.

(2) $PV = k$ for process B and A.

(3) $\frac{P^{\gamma-1}}{T^{\gamma}} = k$ for process B and $T = k$ for process A.

(4) $\frac{T^{\gamma}}{P^{\gamma-1}} = k$ for process A and $PV = k$ for process B.

13. If three moles of monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with two moles of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of adiabatic exponent γ for the mixture is:

(1) 1.75 (2) 1.40

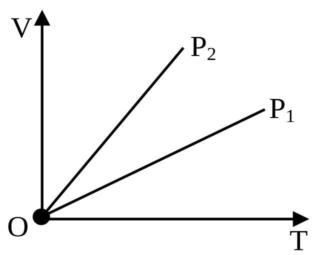
(3) 1.52 (3) 1.35

14. The parameter that remains the same for molecules of all gases at a given temperature is :

(1) kinetic energy (2) momentum

(3) mass (4) speed

15. The given figure represents two isobaric processes for the same mass of an ideal gas, then



(1) $P_2 \geq P_1$ (2) $P_2 > P_1$

(3) $P_1 = P_2$ (4) $P_1 > P_2$

16. The speed of sound in oxygen at S.T.P. will be approximately: (Given, $R = 8.3\ JK^{-1}$, $\gamma = 1.4$)

(1) 310 m/s (2) 333 m/s
(3) 341 m/s (4) 325 m/s

17. A gas mixture consists of 8 moles of argon and 6 moles of oxygen at temperature T. Neglecting all vibrational modes, the total internal energy of the system is :

(1) 29 RT (2) 20 RT
(3) 27 RT (4) 21 RT

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

(1) $\frac{9}{4}R$ (2) $\frac{7}{4}R$
(3) $\frac{3}{2}R$ (4) $\frac{5}{2}R$

19. The pressure and volume of an ideal gas are related as $PV^{3/2} = K$ (Constant). The work done when the gas is taken from state A (P_1, V_1, T_1) to state B (P_2, V_2, T_2) is :

(1) $2(P_1V_1 - P_2V_2)$
(2) $2(P_2V_2 - P_1V_1)$
(3) $2(\sqrt{P_1}V_1 - \sqrt{P_2}V_2)$
(4) $2(P_2\sqrt{V_2} - P_1\sqrt{V_1})$

20. A diatomic gas (γ = 1.4) does 200 J of work when it is expanded isobarically. The heat given to the gas in the process is :

(1) 850 J (2) 800 J
(3) 600 J (4) 700 J

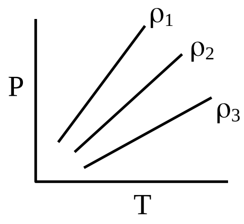
21. If the root mean square velocity of hydrogen molecule at a given temperature and pressure is 2 km/s, the root mean square velocity of oxygen at the same condition in km/s is :

(1) 2.0 (2) 0.5
(3) 1.5 (4) 1.0

22. On celcius scale the temperature of body increases by 40°C. The increase in temperature on Fahrenheit scale is:

(1) 70°F (2) 68°F
(3) 72°F (4) 75°F

23. P-T diagram of an ideal gas having three different densities ρ_1, ρ_2, ρ_3 (in three different cases) is shown in the figure. Which of the following is correct :



(1) $\rho_2 < \rho_3$ (2) $\rho_1 > \rho_2$
(3) $\rho_1 < \rho_2$ (4) $\rho_1 = \rho_2 = \rho_3$

24. The translational degrees of freedom (f_t) and rotational degrees of freedom (f_r) of CH_4 molecule are :

(1) $f_t = 2$ and $f_r = 2$
(2) $f_t = 3$ and $f_r = 3$
(3) $f_t = 3$ and $f_r = 2$
(4) $f_t = 2$ and $f_r = 3$

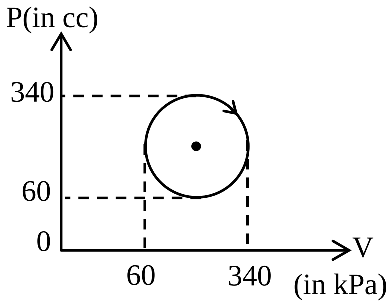
25. A sample of gas at temperature T is adiabatically expanded to double its volume. Adiabatic constant for the gas is $\gamma = 3/2$. The work done by the gas in the process is : (μ = 1 mole)

(1) $RT\left[\sqrt{2} - 2\right]$ (2) $RT\left[1 - 2\sqrt{2}\right]$
(3) $RT\left[2\sqrt{2} - 1\right]$ (4) $RT\left[2 - \sqrt{2}\right]$

26. If the collision frequency of hydrogen molecules in a closed chamber at 27°C is Z, then the collision frequency of the same system at 127° C is :

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

27. The heat absorbed by a system in going through the given cyclic process is :



(1) 61.6 J (2) 431.2 J
(3) 616 J (4) 19.6 J

28. If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e. mean free path) is represented by :

(1) $\frac{1}{\sqrt{2n\pi d^2}}$ (2) $\sqrt{2}n\pi d^2$

(3) $\frac{1}{\sqrt{2}n\pi d^2}$ (4) $\frac{1}{\sqrt{2}n^2\pi^2 d^2}$

29. During an adiabatic process, if the pressure of a gas is found to be proportional to the cube of its absolute temperature, then the ratio of $\frac{C_P}{C_V}$ for the gas is :

(1) $\frac{5}{3}$ (2) $\frac{9}{7}$

(3) $\frac{3}{2}$ (4) $\frac{7}{5}$

30. The specific heat at constant pressure of a real gas obeying $PV^2 = RT$ equation is :

(1) $C_V + R$ (2) $\frac{R}{3} + C_V$

(3) R (4) $C_V + \frac{R}{2V}$

31. A sample contains mixture of helium and oxygen gas. The ratio of root mean square speed of helium and oxygen in the sample, is :

(1) $\frac{1}{32}$ (2) $\frac{2\sqrt{2}}{1}$

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

32. A total of 48 J heat is given to one mole of helium kept in a cylinder. The temperature of helium increases by 2°C. The work done by the gas is : (Given, $R = 8.3\ J\ K^{-1} mol^{-1}$.)

(1) 72.9 J (2) 24.9 J
(3) 48 J (4) 23.1 J

33. Energy of 10 non rigid diatomic molecules at temperature T is :

(1) $\frac{7}{2}RT$ (2) $70\ K_BT$

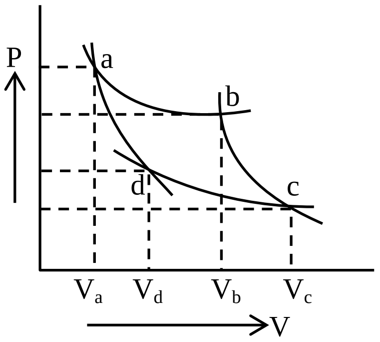
(3) 35 RT (4) $35\ K_BT$

34. A mixture of one mole of monoatomic gas and one mole of a diatomic gas (rigid) are kept at room temperature (27°C). The ratio of specific heat of gases at constant volume respectively is:

(1) $\frac{7}{5}$ (2) $\frac{3}{2}$

(3) $\frac{3}{5}$ (4) $\frac{5}{3}$

35. Two different adiabatic paths for the same gas intersect two isothermal curves as shown in P-V diagram. The relation between the ratio $\frac{V_a}{V_d}$ and the ratio $\frac{V_b}{V_c}$ is:



(1) $\frac{V_a}{V_d} = \left(\frac{V_b}{V_c}\right)^{-1}$ (2) $\frac{V_a}{V_d} \neq \frac{V_b}{V_c}$

(3) $\frac{V_a}{V_d} = \frac{V_b}{V_c}$ (4) $\frac{V_a}{V_d} = \left(\frac{V_b}{V_c}\right)^2$

36. Given below are two statements :

Statement (I) : The mean free path of gas molecules is inversely proportional to square of molecular diameter.

Statement (II) : Average kinetic energy of gas molecules is directly proportional to absolute temperature of gas.

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

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

(2) **Statement I** is true but **Statement II** is false.

(3) Both **Statement I** and **Statement II** are false

(4) Both **Statement I** and **Statement II** are true.

37. Water boils in an electric kettle in 20 minutes after being switched on. Using the same main supply, the length of the heating element should be ………….. to …………. times of its initial length if the water is to be boiled in 15 minutes.

(1) increased, $\frac{3}{4}$ (2) increased, $\frac{4}{3}$

(3) decreased, $\frac{3}{4}$ (4) decreased, $\frac{4}{3}$

38. A diatomic gas ($\gamma = 1.4$) does 100 J of work in an isobaric expansion. The heat given to the gas is :

(1) 350 J (2) 490 J

(3) 150 J (4) 250 J

39. The volume of an ideal gas ($\gamma = 1.5$) is changed adiabatically from 5 litres to 4 litres. The ratio of initial pressure to final pressure is:

(1) $\frac{4}{5}$ (2) $\frac{16}{25}$

(3) $\frac{8}{5\sqrt{5}}$ (4) $\frac{2}{\sqrt{5}}$

40. A sample of 1 mole gas at temperature T is adiabatically expanded to double its volume. If adiabatic constant for the gas is $\gamma = \frac{3}{2}$, then the work done by the gas in the process is:

(1) $RT\left[2 - \sqrt{2}\right]$ (2) $\frac{R}{T}\left[2 - \sqrt{2}\right]$

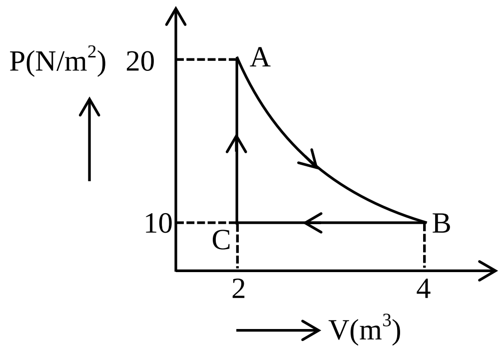
(3) $RT\left[2 + \sqrt{2}\right]$ (4) $\frac{T}{R}\left[2 + \sqrt{2}\right]$

41. The temperature of a gas is –78° C and the average translational kinetic energy of its molecules is K. The temperature at which the average translational kinetic energy of the molecules of the same gas becomes 2K is :

(1) –39°C (2) 117°C

(3) 127°C (4) –78°C

42. A real gas within a closed chamber at 27°C undergoes the cyclic process as shown in figure. The gas obeys $PV^3 = RT$ equation for the path A to B . The net work done in the complete cycle is (assuming R = 8J/molK):



(1) 225 J (2) 205 J

(3) 20 J (4) –20 J

SOLUTIONS

1. Ans. (3)

Sol. $Q = \Delta U$ as work done is zero [constant volume]

$\Delta U = ms\,\Delta T$

$= 0.08 \times (170 \times 4.18) \times 5$

$\simeq 284$ J

2. Ans. (2)

Sol. For monoatomic molecule degree of freedom = 3.

$$\therefore K_{avg} = \frac{3}{2}K_B T$$

$$T = \frac{0.414 \cdot 1.6 \cdot 10^{-19} \cdot 2}{3 \cdot 1.38 \cdot 10^{-23}}$$

= 3200 K

3. Ans. (3)

Sol. Kinetic energy = $\frac{f}{2}nRT$

$$= \frac{5}{2} \cdot 1 \cdot 8.31 \cdot 300 \text{ J}$$

= 6232.5 J

4. Ans. (2)

Sol. $P \propto T^3 \Rightarrow PT^{-3} = \text{constant}$

$PV^{\gamma} = \text{const}$

$$P\left(\frac{nRT}{P}\right)^{\gamma} = \text{const}$$

$P^{1-\gamma}T^{\gamma} = \text{const}$

$PT^{\frac{\gamma}{1-\gamma}} = \text{const}$

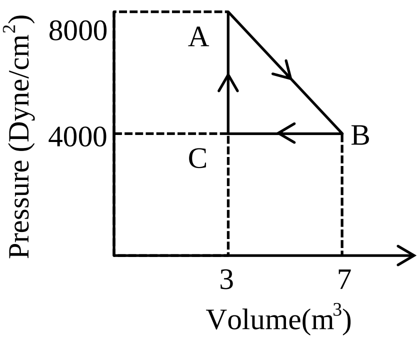
$$\frac{\gamma}{1-\gamma} = -3$$

$\gamma = -3 + 3\gamma$

$$3 = 2\gamma;\ \gamma = \frac{3}{2}$$

5. Ans. (BONUS)

Sol.



Work done AB

$$= \frac{1}{2}(8000 + 6000) \text{ Dyne/cm}^2 \times 4\text{m}^3$$

$= (6000 \text{Dyne/cm}^2) \times 4\text{m}^3$

Work done BC = $-(4000 \text{ Dyne/cm}^2) \times 4\text{m}^3$

Total work done = $2000 \text{ Dyne/cm}^2 \times 4\text{m}^3$

$$= 2 \cdot 10^3 \cdot \frac{1}{10^5}\frac{N}{cm^2} \cdot 4m^3$$

$$= 2 \cdot 10^{-2} \cdot \frac{N}{10^{-4}m^2} \cdot 4m^3$$

$= 2 \times 10^2 \times 4$ Nm = 800 J

6. Ans. (1)

Sol. $$\frac{P_A V_A}{P_B V_B} = \frac{n_A R T_A}{n_B R T_B}$$

Given $V_A = V_B$

And $T_A = T_B$

$$\frac{P_A}{P_B} = \frac{n_A}{n_B}$$

$$\frac{P_A}{P_B} = \frac{1/2}{1/32} = 16$$

7. Ans. (1)

Sol. PV = nRT

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

N = Total no. of molecules

$$P = \frac{N}{V}kT$$

$1.38 \times 1.01 \times 10^5 = 2 \times 10^{25} \times 1.38 \times 10^{-23} \times T$

$1.01 \times 10^5 = 2 \times 10^2 \times T$

$$T = \frac{1.01 \cdot 10^3}{2} \approx 500 \text{ K}$$

8. Ans. (3)

Sol. $$f_{eq} = \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2}$$

For diatomic gas $f_{eq} = 5$

$$5 = \frac{(N)(6) + (2)(3)}{N + 2}$$

5N + 10 = 6N + 6

N = 4

9. Ans. NTA (1 or 2)

Allen (Bonus)

Sol. For process A

$\log P = \gamma \log V \Rightarrow P \propto V^{\gamma}, (\gamma > 1)$

$PV^{-\gamma} = \text{Constant}$

$$C_A = C_V + \frac{R}{1+\gamma} \ \ldots. \text{(i)}$$

Likewise for process B → $PV^{-1} = \text{Constant}$

$C_B = C_v + \frac{R}{1+1}$

$C_B = C_v + \frac{R}{2}$ … (ii)

$C_P = C_v + R$ …. (iii)

By (i), (ii) & (iii)

$C_P > C_B > C_A > C_v$ **[No answer matching]**

10. Ans. (4)

Sol. $\sqrt{\frac{3RT}{2}} = \sqrt{\frac{3R(320)}{32}}$

$T = \frac{320}{16} = 20$ K

11. Ans. (4)

12. Ans. NTA (1)

Allen (1 or 3)

Sol. Steeper curve (B) is adiabatic

Adiabatic ⇒ PV^{ν} = const.

Or $P\left(\frac{T}{P}\right)^{\nu}$ = const.

$\frac{T^{\nu}}{P^{\nu-1}}$ = const.

Curve (A) is isothermal

T = const.

PV = const.

13. Ans. (3)

Sol. $f_1 = 3$, $f_2 = 5$

$n_1 = 3$, $n_2 = 2$

$f_{mixture} = \frac{n_1f_1 + n_2f_2}{n_1 + n_2} = \frac{9+10}{f} = \frac{19}{5}$

$\gamma_{mixture} = 1 + \frac{2\cdot 5}{19} = \frac{29}{19} = 1.52$

14. Ans. (1)

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

Conceptual

15. Ans. (4)

Sol. PV = nRT

$V = \left(\frac{nR}{P}\right)T$

Slope = $\frac{nR}{P}$; Slope ∝ $\frac{1}{P}$

$(Slope)_2 > (Slope)_1$

$P_2 < P_1$

16. Ans. (1)

Sol. $v = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{1.4\cdot 8.3\cdot 273}{32\cdot 10^{-3}}}$

$= 314.8541 \approx 315$ m/s

17. Ans. (3)

Sol. $U = nC_VT$

⇒ $U = n_1C_{V_1}T + n_2C_{V_2}T$

⇒ $8\cdot\frac{3R}{2}\cdot T + 6\cdot\frac{5R}{2}\cdot T = 27RT$

18. Ans. (1)

Sol. $C_V = \frac{n_1C_{v_1} + n_2C_{v_2}}{n_1 + n_2}$

$= \frac{2\cdot\frac{3}{2}R + 6\cdot\frac{5}{2}R}{2+6} = \frac{9}{4}R$

19. Ans. NTA (1)

Allen (1 or 2)

Sol. For PV^x = constant

If work done by gas is asked then

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

Here $x = \frac{3}{2}$

∴ $W = \frac{P_2V_2 - P_1V_1}{-\frac{1}{2}}$

$= 2(P_1V_1 - P_2V_2)$ ….. Option (1) is correct

If work done by external is asked then

$W = -2(P_1V_1 - P_2V_2)$ ….. Option (2) is correct

20. Ans. (4)

Sol. $\gamma = 1 + \frac{2}{f} = 1.4 \Rightarrow \frac{2}{f} = 0.4 \Rightarrow f = 5$

$W = nR\Delta T = 200J$

$Q = \left(\frac{f+2}{2}\right)nR\Delta T$

$= \frac{7}{2}\cdot 200 = 700$ J

21. Ans. (2)

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

$\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{2}{V_2} = \sqrt{\frac{32}{2}}$

$V_2 = 0.5$ km/s

22. Ans. (3)

Sol. We know that per °C change is equivalent to 1.8° change in °F.

$\therefore$ 40° change on celcius scale will corresponds to 72° change on Fahrenheit scale.

Hence option (3)

23. Ans. (2)

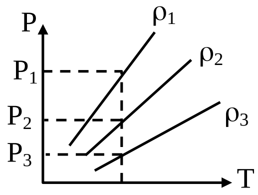
Sol. For ideal gas

PV = nRT

$$PV = \frac{m}{M}RT$$

$$P = \left(\frac{M}{V}\right)\frac{RT}{M}\ ;\ P = \frac{\rho RT}{M}$$

(Where m is mass of gas and M is molecular mass of gas)



for same temperature $P_1 > P_2 > P_3$

So $\rho_1 > \rho_2 > \rho_3$

So correct answer is (2)

24. Ans. (2)

Sol. Since CH_4 is polyatomic Non-Linear

D.O.F of CH_4

T. DOF = 3

R DOF = 3

25. Ans. (4)

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

$$TV^{\gamma-1} = \text{cons tan t} = T_f(2V)^{\gamma-1}$$

$$T_f = T\left(\frac{1}{2}\right)^{1/2} = \frac{T}{\sqrt{2}}$$

$$W = \frac{R\left(\frac{T}{\sqrt{2}} - T\right)}{1-\frac{3}{2}} = 2RT\frac{(\sqrt{2}-1)}{\sqrt{2}}$$

$$= RT(2-\sqrt{2})$$

26. Ans. (3)

Sol. Assuming mean free path constant.

$$f \propto v \propto \sqrt{T}$$

$$\frac{f_1}{f_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{300}{400}}$$

$$f_2 = \sqrt{\frac{4}{3}} = f_1 = \frac{2}{\sqrt{3}}Z$$

27. Ans. (1)

Sol. $\Delta U = 0$ (Cyclic process)

$\Delta Q = W$ = area of P-V curve.

$= \pi \times (140 \times 10^3\ Pa) \times (140 \times 10^{-6}\ m^3)$

$\Delta Q = 61.6\ J$

28. Ans. (3)

Sol. n = number of molecule per unit volume

d = diameter of the molecule

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n} \qquad \text{(By Theory)}$$

29. Ans. (3)

Sol. $P \propto T^3$

PT^{-3} = constant

$\because \frac{PV}{T} = nR$ = constant from ideal gas equation

$(P)(PV)^{-3}$ = constant

$P^{-2}V^{-3}$ = cosntant ...(1)

$\because$ Process equation for adiabatic process is

PV^{y} = constant ...(2)

Comparing equation (1) and (2)

$$\frac{C_P}{C_V} = y = \frac{3}{2}$$

30. Ans. (4)

Sol. $dQ = du + dW$

$CdT = C_V dT + PdV$ …..(1)

$\therefore\ PV^2 = RT$

P = constant

$P(2VdV) = RdT$

$$PdV = \frac{RdT}{2V}$$

Put in equation (1)

$$C = C_V + \frac{R}{2V}$$

31. Ans. (2)

Sol. $$V_{rms} = \sqrt{\frac{3RT}{M_w}}$$

$$\Rightarrow \frac{V_{O_2}}{V_{He}} = \sqrt{\frac{M_{w,He}}{M_{w,O_2}}} = \sqrt{\frac{4}{32}} = \frac{1}{2\sqrt{2}}$$

$$\frac{V_{He}}{V_{O_2}} = \frac{2\sqrt{2}}{1}$$

32. Ans. (4)

Sol. 1st law of thermodynamics

$\Delta Q = \Delta U + W$

$\Rightarrow +48 = nC_v\Delta T + W$

$\Rightarrow 48 = (1)\left(\frac{3R}{2}\right)(2) + W$

33. Ans. (4)

Sol. Degree of freedom(f) = 5 + 2(3N – 5)

f = 5 + 2(3 × 2 –1) = 7

energy of one molecule = $\frac{f}{2}K_BT$

energy of 10 molecules

$= 10\left(\frac{f}{2}K_BT\right) = 10\left(\frac{7}{2}K_BT\right) = 35\ K_BT$

34. Ans. (3)

Sol. $\frac{(C_v)_{mono}}{(C_v)_{dia}} = \frac{\frac{3}{2}R}{\frac{5}{2}R} = \frac{3}{5}$

35. Ans. (3)

Sol. For adiabatic process

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

$T_a \cdot V_a^{\gamma-1} = T_d \cdot V_d^{\gamma-1}$

$\left(\frac{V_a}{V_d}\right)^{\gamma-1} = \frac{T_d}{T_a}$

$T_b \cdot V_b^{\gamma-1} = T_c \cdot V_c^{\gamma-1}$

$\left(\frac{V_b}{V_c}\right)^{\gamma-1} = \frac{T_c}{T_b}$

$\frac{V_a}{V_d} = \frac{V_b}{V_c} \qquad \left(\because \begin{matrix} T_d = T_c \\ T_a = T_b \end{matrix}\right)$

36. Ans. (4)

Sol. $\lambda = \frac{RT}{\sqrt{2}\pi d^2 N P_A}$

$KE = \frac{f}{2}nRT$

37. Ans. (3)

Sol. $P = \frac{v^2}{R},\ R = \frac{\rho \ell}{A}$

$P \propto \frac{1}{\ell}$

$\frac{P_1}{P_2} = \frac{t_2}{t_1} = \frac{15}{20} = \frac{\ell_2}{\ell_1} \Rightarrow \ell_2 = \frac{3}{4}\ell_1$

38. Ans. (1)

Sol. For Isobaric process

$w = P\Delta v = nR\Delta T = 100\ J$

$Q = \Delta u + w$

$\Delta Q = \frac{F}{2}nR\Delta T + nR\Delta T$

$\left(\frac{f}{2}+1\right)nR\Delta T$

$\left(\frac{5}{2}+1\right)100 = 350\ J$

39. Ans. (3)

Sol. For Adiabatic process

$P_i V_i^{\gamma} = P_f V_f^{\gamma}$

$P_i (5)^{1.5} = P_f (4)^{1.5}$

$\frac{P_i}{P_f} = \left(\frac{4}{5}\right)^{\frac{3}{2}} = \frac{4}{5}\cdot\left(\frac{4}{5}\right)^{\frac{1}{2}} \Rightarrow \frac{8}{5\sqrt{5}}$

40. Ans. (1)

Sol. $TV^{\gamma-1}$ = constant

$\Rightarrow T(V)^{\frac{3}{2}-1} = T_f(2V)^{\frac{3}{2}-1}$

$\Rightarrow TV^{\frac{1}{2}} = T_f(2)^{\frac{1}{2}}(V)^{\frac{1}{2}} \Rightarrow T_f = \left(\frac{T}{\sqrt{2}}\right)$

Now, W.D. = $\frac{nR\Delta T}{1-\gamma} = \frac{1R\left[\frac{T}{\sqrt{2}} - T\right]}{1-\frac{3}{2}}$

$\Rightarrow$ W.D. = $2RT\left[1 - \frac{1}{\sqrt{2}}\right]$

$\Rightarrow$ W.D. = $RT\left[2 - \sqrt{2}\right]$

41. Ans. (2)

Sol. K.E = $\frac{nf_1RT}{2}$

T_i = –78°C → 273 + [–78°C] = 195K

K.E α T

To double the K.E energy temp also become double

T_f = 390 K

T_f = 117°C

42. Ans. (2)

Sol. $W_{AB} = \int PdV$ (Assuming T to be constant)

$= \int \frac{RTdV}{V^3}$

$= RT\int_2^4 V^{-3}dV$

$= 8 \times 300 \times \left(-\frac{1}{2}\left[\frac{1}{4^2} - \frac{1}{2^2}\right]\right)$

= 225 J

$W_{BC} = P\int_4^2 dV = 10(2-4) = -20J$

$W_{CA} = 0$

$\therefore W_{cycle}$ = 205 J

Note : Data is inconsistent in process AB. So needs to be challenged.