DPP - Daily Practice Problems

Chapter-wise Sheets

Date : ☐ **Start Time :** ☐ **End Time :** ☐

PHYSICS

CP12

SYLLABUS : Kinetic Theory

Max. Marks : 180 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. 4.0 g of a gas occupies 22.4 litres at NTP. The specific heat capacity of the gas at constant volume is $5.0 JK^{-1}$. If the speed of any quantity x in this gas at NTP is $952 ms^{-1}$, then the heat capacity at constant pressure is (Take gas constant $R = 8.3 JK^{-1} mol^{-1}$)

(a) $7.5 JK^{-1} mol^{-1}$ (b) $7.0 JK^{-1} mol^{-1}$

(c) $8.5 JK^{-1} mol^{-1}$ (d) $8.0 JK^{-1} mol^{-1}$

2. A fixed mass of gas at constant pressure occupies a volume V. The gas undergoes a rise in temperature so that the root mean square velocity of its molecules is doubled. The new volume will be

(a) V/2 (b) $V/\sqrt{2}$ (c) 2V (d) 4V

3. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_p}{C_v}$ of the mixture is

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

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

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

5. The rms speed of the particles of fume of mass 5×10^{-17} kg executing Brownian motion in air at N.T.P. is ($k = 1.38 \times 10^{-23}$ J/K)

(a) 1.5 m/s (b) 3.0 m/s (c) 1.5 cm/s (d) 3 cm/s

6. One mole of an ideal monoatomic gas requires 207 J heat to raise the temperature by 10 K when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by the same 10 K, the heat required is [Given the gas constant R = 8.3 J/ mol. K]

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

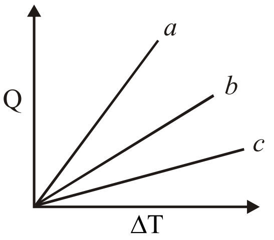
RESPONSE GRID

1. ⓐⓑⓒⓓ **2.** ⓐⓑⓒⓓ **3.** ⓐⓑⓒⓓ **4.** ⓐⓑⓒⓓ **5.** ⓐⓑⓒⓓ

6. ⓐⓑⓒⓓ

Space for Rough Work

7. Figure shows the variation in temperature (ΔT) with the amount of heat supplied (Q) in an isobaric process corresponding to a monoatomic (M), diatomic (D) and a polyatomic (P) gas. The initial state of all the gases are the same and the scales for the two axes coincide. Ignoring vibrational degrees of freedom, the lines *a*, *b* and *c* respectively correspond to



(a) P, M and D

(b) M, D and P

(c) P, D and M

(d) D, M and P

8. 1 mole of a monatomic and 2 mole of a diatomic gas are mixed. The resulting gas is taken through a process in which molar heat capacity was found 3R. Polytropic constant in the process is

(a) –1/5 (b) 1/5 (c) 2/5 (d) –2/5

9. The density of a gas is 6×10^{-2} kg/m^3 and the root mean square velocity of the gas molecules is 500 m/s. The pressure exerted by the gas on the walls of the vessel is

(a) 5×10^3 N/m^2 (b) 1.2×10^{-4} N/m^2

(c) 0.83×10^{-4} N/m^2 (d) 30 N/m^2

10. The absolute temperature of a gas is increases 3 times. The root mean square velocity of the moelcules will be

(a) 3 times (b) 9 times

(c) 1/3 times (d) √3 times

11 Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increases as V^q, where V is the volume of the gas. The value of q is : $\left(\gamma = \frac{C_p}{C_v}\right)$

(a) $\frac{\gamma+1}{2}$ (b) $\frac{\gamma-1}{2}$ (c) $\frac{3\gamma+5}{6}$ (d) $\frac{3\gamma-5}{6}$

12. One kg of a diatomic gas is at a pressure of 8×10^4 N/m^2. The density of the gas is 4kg/m^3. What is the energy of the gas due to its thermal motion?

(a) 5×10^4 J (b) 6×10^4 J

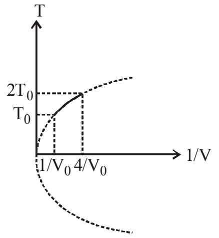
(c) 7×10^4 J (d) 3×10^4 J

13. A thermally insulated vessel contains an ideal gas of molecular mass *M* and ratio of specific heats γ. It is moving with speed *v* and it suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by

(a) $\frac{(\gamma-1)}{2\gamma R}Mv^2K$ (b) $\frac{\gamma Mv^2}{2R}K$

(c) $\frac{(\gamma-1)}{2R}Mv^2K$ (d) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2K$

14. Figure shows a parabolic graph between T and 1/V for a mixture of a gases undergoing an adiabatic process. What is the ratio of V_{rms} of molecules and speed of sound in mixture?



(a) $\sqrt{3/2}$

(b) $\sqrt{2}$

(c) $\sqrt{2/3}$

(d) $\sqrt{3}$

15. The work of 146 kJ is performed in order to compress one kilomole of gas adiabatically and in this process the temperature of the gas increases by 7°C. The gas is ($R = 8.3$ J mol^{-1} K^{-1})

(a) diatomic

(b) triatomic

(c) a mixture of monatomic and diatomic

(d) monatomic

16. At what temperature is root mean square velocity of gaseous hydrogen molecules equal to that of oxygen molecules at 47°C?

(a) 40K (b) 80K (c) – 73K (d) 3K

17. The kinetic theory of gases states that the average squared velocity of molecules varies linearly with the mean molecular weight of the gas. If the root mean square (rms) velocity of oxygen molecules at a certain temperature is 0.5 km/sec. The rms velocity for hydrogen molecules at the same temperature will be :

(a) 2 km/sec (b) 4 km/sec (c) 8 km/sec (d) 16 km/sec

18. If 2 moles of an ideal monatomic gas at temperature T_0 is mixed with 4 moles of another ideal monatomic gas at temperature $2T_0$, then the temperature of the mixture is

(a) $\frac{5}{3}T_0$ (b) $\frac{3}{2}T_0$ (c) $\frac{4}{3}T_0$ (d) $\frac{5}{4}T_0$

19. From the following statements, concerning ideal gas at any given temperature *T*, select the incorrect one(s)

(a) The coefficient of volume expansion at constant pressure is same for all ideal gas

(b) The average translational kinetic energy per molecule of oxygen gas is 3 *KT* (*K* being Boltzmann constant)

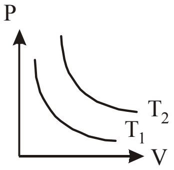
(c) In a gaseous mixture, the average translational kinetic energy of the molecules of each component is same

(d) The mean free path of molecules increases with decrease in pressure

RESPONSE GRID					
	7. ⓐⓑⓒⓓ	**8.** ⓐⓑⓒⓓ	**9.** ⓐⓑⓒⓓ	**10.** ⓐⓑⓒⓓ	**11.** ⓐⓑⓒⓓ
	12. ⓐⓑⓒⓓ	**13.** ⓐⓑⓒⓓ	**14.** ⓐⓑⓒⓓ	**15.** ⓐⓑⓒⓓ	**16.** ⓐⓑⓒⓓ
	17. ⓐⓑⓒⓓ	**18.** ⓐⓑⓒⓓ	**19.** ⓐⓑⓒⓓ		

Space for Rough Work

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



(a) $T_1 > T_2$
(b) $T_1 = T_2$
(c) $T_1 < T_2$
(d) None of these

21. The molecules of a given mass of gas have a root mean square velocity of 200m s^{-1} at 27°C and 1.0×10^5 N m^{-2} pressure. When the temperature is 127°C and the pressure 0.5×10^5 Nm^{-2}, the root mean square velocity in ms^{-1}, is

(a) $\frac{400}{\sqrt{3}}$ (b) $100\sqrt{2}$ (c) $\frac{100\sqrt{2}}{3}$ (d) $\frac{100}{3}$

22. A graph is plotted with PV/T on y-axis and mass of the gas along x-axis for different gases. The graph is
(a) a straight line parallel to x-axis for all the gases
(b) a straight line passing through origin with a slope having a constant value for all the gases
(c) a straight line passing through origin with a slope having different values for different gases
(d) a straight line parallel to y-axis for all the gases

23. At identical temperatures, the rms speed of hydrogen molecules is 4 times that for oxygen molecules. In a mixture of these in mass ratio $H_2 : O_2 = 1:8$, the rms speed of all molecules is n times the rms speed for O_2 molecules, where n is
(a) 3 (b) 4/3 (c) $(8/3)^{1/2}$ (d) $(11)^{1/2}$

24. Work done by a system under isothermal change from a volume V_1 to V_2 for a gases which obeys Vander Waal's equation $(V - \beta n)\left(P + \frac{\alpha n^2}{V}\right) = nRT$ is

(a) $nRT \log_e\left(\frac{V_2 - n\beta}{V_1 - n\beta}\right) + \alpha n^2\left(\frac{V_1 - V_2}{V_1 V_2}\right)$

(b) $nRT \log_{10}\left(\frac{V_2 - n\beta}{V_1 - n\beta}\right) + \alpha n^2\left(\frac{V_1 - V_2}{V_1 V_2}\right)$

(c) $nRT \log_e\left(\frac{V_2 - n\beta}{V_1 - n\beta}\right) + \beta n^2\left(\frac{V_1 - V_2}{V_1 V_2}\right)$

(d) $nRT \log_e\left(\frac{V_1 - n\beta}{V_2 - n\beta}\right) + \alpha n^2\left(\frac{V_1 V_2}{V_1 - V_2}\right)$

25. Two vessels separately contain two ideal gases A and B at the same temperature. The pressure of A being twice that of B. Under such conditions, the density of A is found to be 1.5 times the density of B. The ratio of molecular weight of A and B is :

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

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

27. If the intermolecular forces vanish away, the volume occupied by the molecules contained in 4.5 g water at standard temperature and pressure will be
(a) 5.6 litre (b) 4.5 litre (c) 11.2 litre (d) 6.5 litre

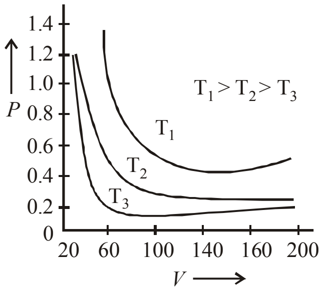
28. A gas mixture consists of 2 moles of oxygen and 4 moles of Argon at temperature T. Neglecting all vibrational moles, the total internal energy of the system is
(a) 4 RT (b) 15 RT (c) 9 RT (d) 11RT

29. A vessel has 6g of hydrogen at pressure P and temperature 500K. A small hole is made in it so that hydrogen leaks out. How much hydrogen leaks out if the final pressure is P/2 and temperature falls to 300 K ?
(a) 2g (b) 3g (c) 4g (d) 1g

30. For a gas if ratio of specific heats at constant pressure and volume is γ then value of degrees of freedom is

(a) $\frac{3\gamma - 1}{2\gamma - 1}$ (b) $\frac{2}{\gamma - 1}$ (c) $\frac{9}{2}(\gamma - 1)$ (d) $\frac{25}{2}(\gamma - 1)$

31. The given *P*-*V* curve is predicted by



(a) Boyle's law
(b) Charle's law
(c) Avogadro's law
(d) Gaylussac's law

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

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

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

33. A gas is enclosed in a cube of side *l*. What will be the change in momentum of the molecule, if it suffers an elastic collision with the plane wall parallel to *yz*-plane and rebounds with the same velocity ? [(V_x, V_y & V_z) initial velocities of the gas molecules]
(a) mv_x (b) zero (c) $-mv_x$ (d) $-2mv_x$.

RESPONSE GRID

20. ⓐⓑⓒⓓ 21. ⓐⓑⓒⓓ 22. ⓐⓑⓒⓓ 23. ⓐⓑⓒⓓ 24. ⓐⓑⓒⓓ
25. ⓐⓑⓒⓓ 26. ⓐⓑⓒⓓ 27. ⓐⓑⓒⓓ 28. ⓐⓑⓒⓓ 29. ⓐⓑⓒⓓ
30. ⓐⓑⓒⓓ 31. ⓐⓑⓒⓓ 32. ⓐⓑⓒⓓ 33. ⓐⓑⓒⓓ

Space for Rough Work

34. What will be the ratio of number of molecules of a monoatomic and a diatomic gas in a vessel, if the ratio of their partial pressures is 5 : 3 ?

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

35. The average transitional energy and the rms speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J and 484 m/s respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour)

(a) 12.42×10^{-21} J, 968 m/s (b) 8.78×10^{-21} J, 684 m/s

(c) 6.21×10^{-21} J, 968 m/s (d) 12.42×10^{-21} J, 684 m/s

36. At 10° C the value of the density of a fixed mass of an ideal gas divided by its pressure is x. At 110°C this ratio is:

(a) x (b) $\frac{383}{283}x$ (c) $\frac{10}{110}x$ (d) $\frac{283}{383}x$

37. If the potential energy of a gas molecule is $U = M/r^6 - N/r^{12}$, M and N being positive constants. Then the potential energy at equilibrium must be

(a) zero (b) $M^2/4N$ (c) $N^2/4M$ (d) $MN^2/4$

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

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

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

39. How is the mean free path (λ) in a gas related to the interatomic distance?

(a) λ is 10 times the interatomic distance

(b) λ is 100 times the interatomic distance

(c) λ is 1000 times the interatomic distance

(d) λ is $\frac{1}{10}$ times of the interatomic distance

40. Four molecules have speeds 2 km/sec, 3 km/sec, 4 km/sec and 5 km/sec. The root mean square speed of these molecules (in km/sec) is

(a) $\sqrt{54/4}$ (b) $\sqrt{54/2}$ (c) 3.5 (d) $3\sqrt{3}$

41. If R is universal gas constant, the amount of heat needed to raise the temperature of 2 moles of an ideal monoatomic gas from 273 K to 373 K, when no work is done, is

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

42. N molecules, each of mass m, of gas A and 2 N molecules, each of mass 2 m, of gas B are contained in the same vessel which is maintained at a temperature T. The mean square velocity of molecules of B type is denoted by V_2 and the mean square velocity of A type is denoted by V_1, then $\frac{V_1}{V_2}$ is

(a) 2 (b) 1 (c) 1/3 (d) 2/3

43. The root mean square value of the speed of the molecules in a fixed mass of an ideal gas is increased by increasing

(a) the volume while keeping the temperature constant

(b) the pressure while keeping the volume constant

(c) the temperature while keeping the pressure constant

(d) the pressure while keeping the temperature constant

44. The P-V diagram of a diatomic gas is a straight line passing through origin. The molar heat capacity of the gas in the process will be

(a) 4 R (b) 2.5 R (c) 3 R (d) $\frac{4R}{3}$

45. For a gas, difference between two specific heats is 5000 J/mole°C. If the ratio of specific heats is 1.6, the two specific heats in J/mole-°C are

(a) $C_P = 1.33 \times 10^4, C_V = 2.66 \times 10^4$

(b) $C_P = 13.3 \times 10^4, C_V = 8.33 \times 10^3$

(c) $C_P = 1.33 \times 10^4, C_V = 8.33 \times 10^3$

(d) $C_P = 2.6 \times 10^4, C_V = 8.33 \times 10^4$

RESPONSE GRID	34. ⓐⓑⓒⓓ	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	37. ⓐⓑⓒⓓ	38. ⓐⓑⓒⓓ
	39. ⓐⓑⓒⓓ	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ
	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ			

DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP12 - PHYSICS			
Total Questions	45	Total Marks	180
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	50	Qualifying Score	70
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

1. **(d)** Molar mass of the gas = 4g/mol

Speed of any quantity x

$$V=\sqrt{\frac{\gamma RT}{m}}\Rightarrow 952=\sqrt{\frac{\gamma\times 3.3\times 273}{4\times 10^{-3}}}$$

$$\Rightarrow \gamma=1.6=\frac{16}{10}=\frac{8}{5}$$

Also, $\gamma=\frac{C_P}{C_V}=\frac{8}{5}$

So, $C_P=\frac{8\times 5}{5}=8JK^{-1}mol^{-1}$

2. **(d)** Since v_{rms} is doubled by increasing the temp. so by

$v_{rms}=\sqrt{\frac{3KT}{m}}$, the temp. increase by four times.

Now for constant pressure $\frac{V_1}{T_1}=\frac{V_2}{T_2}$

$V_1=V$, $T_1=T°K$, $T_2=4T°K$, $V_2=?$

$V_2=4V$

3. **(a)** For mixture of gas, $C_v=\frac{n_1C_{v_1}+n_2C_{v_2}}{n_1+n_2}$

$$=\frac{4\times\frac{3}{2}R+\frac{1}{2}\times\frac{5}{2}R}{\left(4+\frac{1}{2}\right)}=\frac{6R+\frac{5}{4}R}{\frac{9}{2}}=\frac{29R\times 2}{9\times 4}=\frac{29R}{18}$$

and $C_p=\frac{n_1C_{p_1}+n_2C_{p_2}}{(n_1+n_2)}=\frac{4\times\frac{5R}{2}+\frac{1}{2}\times\frac{7R}{2}}{\left(4+\frac{1}{2}\right)}$

$$=\frac{10R+\frac{7}{4}R}{\frac{9}{2}}=\frac{47R}{18}$$

$$\therefore\ \frac{C_p}{C_v}=\frac{47R}{18}\times\frac{18}{29R}=1.62$$

4. **(b)** $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$ Here, $P_1=200kPa$

$T_1=22°C=295\,K$, $T_2=42°C=315K$

$$V_2=V_1+\frac{2}{100}V_1=1.02V_1$$

$$\therefore\ P_2=\frac{200\times 315V_1}{295\times 1.02V_1}=209.37kPa$$

5. **(c)** By kinetic theory of gases,

rms (root mean square) velocity of gas

$$V_{rms}=\sqrt{\frac{3RT}{M}}=\sqrt{\frac{3KT}{m}}$$

Where M and m are mol. wt and mass of gas respectively

$$V_{rms}=\sqrt{\frac{3\times 1.38\times 10^{-23}\times 273}{5\times 10^{-17}}}$$

$$=1.5\times 10^{-2}\,m/s=1.5\text{ cm/s}$$

6. **(d)** $C_p=\frac{5}{2}R$ and $C_v=\frac{3}{2}R$

We know that $Q_v=nC_v\Delta T$ and $Q_p=nC_p\Delta T$

$$\Rightarrow \frac{Q_v}{Q_p}=\frac{3}{5}.$$

Given $Q_p=207\,J\Rightarrow Q_v\cong 124\ J$

7. **(c)** On giving same amount of heat at constant pressure, there is change in temperature for mono, dia and polyatomic gas.

$$(\Delta Q)_P=\mu C_p\Delta T\left(\mu=\frac{\text{No. of molecules}}{\text{Avogadro's no.}}\right)$$

or $\Delta T\propto\frac{1}{\text{no. of molecules}}$

8. **(a)** $C=C_{v\,mix}+\frac{R}{1-n}$ .....(1)

Now, $C_{vmix}=\frac{n_1C_{v1}+n_2C_{v2}}{n_1+n_2}$

$$=\frac{1\times\frac{3R}{2}+2\times\frac{5R}{2}}{1+2}=\frac{13R}{6}$$

From (1), $3R=\frac{13R}{6}+\frac{R}{1-n}\Rightarrow n=-\frac{1}{5}$

9. **(a)** $P=\frac{1}{3}\rho\bar{v}^2=\frac{1}{3}\times(6\times 10^{-2})\times(500)^2$

$$=5\times 10^3\ N/m^2$$

10. **(d)** $v_{rms}=\sqrt{\frac{3kT}{m}}$ ....(1)

$v'_{rms}=\sqrt{\frac{3k\times 3T}{m}}$ ....(2)

Equ. (2) is dividing by equ. (1)

$$\frac{v'_{rms}}{v_{rms}} = \sqrt{\frac{3k.3T.m}{m.3kT}} = \sqrt{3}$$

$$v'_{rms} = \sqrt{3}v_{rms}$$

11. **(a)** $$\tau = \frac{1}{\sqrt{2}\pi d^2\left(\frac{N}{V}\right)\sqrt{\frac{3RT}{M}}}$$

$$\tau \propto \frac{V}{\sqrt{T}}$$

As, $TV^{\gamma-1} = K$

So, $\tau \propto V^{\gamma+1/2}$

Therefore, $q = \frac{\gamma+1}{2}$

12. **(a)** Volume $= \frac{\text{mass}}{\text{density}} = \frac{1}{4}\ m^3$

$$K.E = \frac{5}{2}PV = \frac{5}{2} \times 8 \times 10^4 \times \frac{1}{4} = 5 \times 10^4\,J$$

13. **(c)** As no heat is lost,

Loss of kinetic energy = gain of internal energy of gas

$$\frac{1}{2}mv^2 = nC_V\Delta T \Rightarrow \frac{1}{2}mv^2 = \frac{m}{M}\cdot\frac{R}{\gamma-1}\Delta T$$

$$\Rightarrow \quad \Delta T = \frac{Mv^2(\gamma-1)}{2R}K$$

14. **(b)** From graph, $T^2V = \text{const.}$ .....(1)

As we know that $TV^{\gamma-1} = \text{const}$

$\Rightarrow VT^{\frac{1}{\gamma-1}} = \text{const.}$ ....(2)

On comparing (1) and (2), we get

$\Rightarrow \gamma = 3/2$

Also $v_{rms} = \sqrt{\frac{3P}{\rho}}$ and $v_{sound} = \sqrt{\frac{P\gamma}{\rho}}$

$$\Rightarrow \frac{v_{rms}}{v_{sound}} = \sqrt{\frac{3}{\gamma}} = \sqrt{2}$$

15. **(a)** $$W = \frac{nR\Delta T}{1-\gamma} \Rightarrow -146000 = \frac{1000 \times 8.3 \times 7}{1-\gamma}$$

or $1-\gamma = -\frac{58.1}{146} \Rightarrow \gamma = 1 + \frac{58.1}{146} = 1.4$

Hence the gas is diatomic.

16. **(a)** $C_{rms} = \sqrt{\frac{3RT}{M}}$

M is molecular wt.

$$= \sqrt{\frac{3R(273+47)}{16}} = \sqrt{\frac{3RT}{2}}$$

$\Rightarrow T = 40\,K.$

17. **(a)** When temperature is same according to kinetic theory of gases, kinetic energy of molecules will be same.

$$K.E. = \frac{1}{2} \times 32 \times \left(\frac{1}{2}\right)^2 = \frac{1}{2} \times 2 \times v^2$$

RMS velocity of hydrogen molecules = 2 km/sec.

18. **(a)** Let T be the temperature of the mixture, then

$U = U_1 + U_2$

$$\Rightarrow \frac{f}{2}(n_1 + n_2)\,RT$$

$$= \frac{f}{2}(n_1)\,(R)\,(T_0) + \frac{f}{2}(n_2)\,(R)\,(2T_0)$$

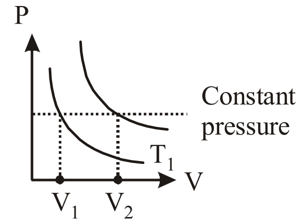
$$\Rightarrow (2+4)T = 2T_0 + 8T_0 \quad (\because\ n_1 = 2, n_2 = 4)$$

$$\therefore\ T = \frac{5}{3}T_0$$

19. **(b)** Coefficient of volume expansion at constant pressure is $\frac{1}{273}$ for all gases. The average transnational K.E. is same for molecules of all gases and for each molecules it is $\frac{3}{2}kT$

Mean free path $\lambda = \frac{kT}{\sqrt{2}\,\pi d^2 P}$ (as P decreases, λ increases)

20. **(c)** For a given pressure, volume will be more if temperature is more (Charle's law)



From the graph it is clear that $V_2 > V_1 \Rightarrow T_2 > T_1$

21. **(a)** $$\frac{c_2}{c_1} = \sqrt{\frac{400}{300}} = \frac{2}{\sqrt{3}} \Rightarrow c_2 = \frac{2}{\sqrt{3}} \times 200 = \frac{400}{\sqrt{3}}\ ms^{-1}$$

22. **(c)** $$\frac{PV}{T} = nR = \left(\frac{m}{M}\right)R \quad \text{or} \quad \frac{PV}{T} = \left(\frac{R}{M}\right)m$$

i.e., $\frac{PV}{T}$ versus m graph is straight line passing through origin with slope R/M, i.e. the slope depends on molecular mass of the gas M and is different for different gases.

23. **(d)** Molecule number ratio is $H_2 : O_2 = \frac{2}{3} : \frac{1}{3}$.

That gives $(c_{rms})^2 = 16\left(\frac{2}{3}\right) + 1\left(\frac{1}{3}\right)$ times the value for O_2.

24. **(a)** According to Vander Waal's equation

$$P = \frac{nRT}{V - n\beta} - \frac{\alpha n^2}{V^2}$$

Work done,

$$W = \int_{V_1}^{V_2} PdV = nRT\int_{V_1}^{V_2} \frac{dV}{V-n\beta} - \alpha n^2 \int_{V_1}^{V_2} \frac{dV}{V^2}$$

$$= nRT\left[\log_e (V-n\beta)\right]_{V_1}^{V_2} + \alpha n^2 \left[\frac{1}{V}\right]_{V_1}^{V_2}$$

$$= nRT\log_e\left(\frac{V_2-n\beta}{V_1-n\beta}\right) + \alpha n^2\left[\frac{V_1-V_2}{V_1V_2}\right]$$

25. (a) From PV = nRT

$$P_A = \frac{\rho_A M_A}{RT} \text{ and } P_B = \frac{\rho_B M_B}{RT}$$

From question,

$$\frac{P_A}{P_B} = \frac{\rho_A}{\rho_B}\frac{M_A}{M_B} = 2\frac{M_A}{M_B} = \frac{3}{2}$$

So, $\frac{M_A}{M_B} = \frac{3}{4}$

26. (b) $(C_p)_{mix} = \frac{\mu_1 C_{p_1} + \mu_2 C_{p_2}}{\mu_1 + \mu_2}$

$(C_{p_1}(He) = \frac{5}{2}R$ and $C_{p_2}(H_2) = \frac{7}{2}R)$

$$(C_p)_{\text{mix}} = = \frac{1\times\frac{5}{2}R + 1\times\frac{7}{2}R}{1+1} \quad 3R = 3\times 2 = 6 \text{ cal/mol.°C}$$

∴ Amount of heat needed to raise the temperature from 0°C to 100°C

$$(\Delta Q)_p = \mu C_p \Delta T = 2\times 6\times 100 = 1200\,cal$$

27. (a) 1 mole = 22.4 L at S.T.P.

$$\frac{4.5\text{g}}{18\text{g}} = 22.4\times\frac{4.5}{18} = 5.6\text{ L}$$

28. (d) Internal energy of 2 moles of oxygen

$$U_{O_2} = \mu\left(\frac{5}{2}RT\right) = 2.\frac{5}{2}RT = 5RT$$

Internal energy of 4 moles of Argon.

$$U_{Ar} = \mu\left(\frac{3}{2}RT\right) = 4.\frac{3}{2}RT = 6RT$$

∴ Total internal energy

$$U = U_{O_2} + U_{Ar} = 11RT$$

29. (d) $PV = \frac{m}{M}RT$

Initially, $PV = \frac{6}{M}R\times 500$

Finally, $\frac{P}{2}V = \frac{(6-x)}{M}R\times 300$ (if x g gas leaks out)

Hence, $2 = \frac{6}{6-x}\times\frac{5}{3}$ ∴ x = 1 gram

30. (b) $\gamma = 1+\frac{2}{f}, \Rightarrow \gamma - 1 = \frac{2}{f} \Rightarrow \frac{f}{2} = \frac{1}{\gamma-1} \Rightarrow f = \frac{2}{\gamma-1}$

31. (a)

32. (a) Number of moles of first gas $= \frac{n_1}{N_A}$

Number of moles of second gas $= \frac{n_2}{N_A}$

Number of moles of third gas $= \frac{n_3}{N_A}$

If there is no loss of energy then

$P_1V_1 + P_2V_2 + P_3V_3 = PV$

$$\frac{n_1}{N_A}RT_1 + \frac{n_2}{N_A}RT_2 + \frac{n_3}{N_A}RT_3 = \frac{n_1+n_2+n_3}{N_A}RT_{mix}$$

$$\Rightarrow T_{\text{mix}} = \frac{n_1T_1 + n_2T_2 + n_3T_3}{n_1+n_2+n_3}$$

33. (d) Since it hits the plane wall parallel to *y z* – plane and it rebounds with same velocity, its *y* and *z* components of velocity do not change, but the *x*-component reverses the sign.

∴ Velocity after collision is $(-v_x, v_y$ and $v_z)$.

The change in momentum is

$$-mv_x - mv_x = -2mv_x$$

34. (c) *V* and *T* will be same for both gases.

$P_1V = \mu_1 RT$ and $P_2V = \mu_2 RT$

$(P_1/P_2) = \frac{5}{3}$ ∴ $\left(\frac{\mu_1}{\mu_2}\right) = \frac{5}{3}$

By definition, $\mu_1 = \frac{N_1}{N_A}$ and $\mu_2 = \frac{N_2}{N_A}$

∴ $\frac{N_1}{N_2} = \frac{\mu_1}{\mu_2} = \frac{5}{3}$

35. (d) $E = \frac{3}{2}\times 300$; $E' = \frac{3}{2}R(600) = 2E = 2\times 6.21\times 10^{-21}$

$= 12.42 \times 10^{-21}$ J.

$$v_{rms} = \sqrt{\frac{3R\times 300}{M}}\,;\; v'_{rms} = \sqrt{\frac{3R\times 600}{M}} = \sqrt{2}\,v_{rms}$$

$= 684.44$ m/s

36. (d) Let the mass of the gas be m.

At a fixed temperature and pressure, volume is fixed.

Density of the gas, $\rho = \frac{m}{V}$

Now $\frac{\rho}{P} = \frac{m}{PV} = \frac{m}{nRT}$

$\Rightarrow \frac{m}{nRT} = x$ (By question)

$\Rightarrow xT = \text{constant} \Rightarrow x_1T_1 = x_2T_2$

$$\Rightarrow x_2 \Rightarrow \frac{x_1T_1}{T_2} = \frac{283}{383}x \quad \left[\begin{array}{lcl} \therefore & & \\ T_1 & = & 283\text{K} \\ T_2 & = & 383\text{K} \end{array}\right]$$

37. (b) $F = \frac{dU}{dr} = -\frac{d}{dr}\left[\frac{M}{r^3} - \frac{N}{R^{12}}\right] = -\left[\frac{-6M}{r^2} + \frac{12N}{r^{13}}\right]$

In equilibrium position, F = 0

$$\therefore\ \frac{6M}{r^2} - \frac{12N}{r^{13}} = 0 \quad \text{or,} \quad r^6 = \frac{2N}{M}$$

∴ Potential energy at equilibrium position

$$U = \frac{M}{(2N/M)} = \frac{N}{(2N/M)^2} = \frac{M^2}{2N} - \frac{M^2}{4N} = \frac{M^2}{4N}$$

38. **(a)** Pressure of the gas will not be affected by motion of the system, hence by

$$v_{rms} = \sqrt{\frac{3P}{\rho}} \Rightarrow \bar{c}^2 = \frac{3P}{\rho} \Rightarrow P = \frac{1}{3}\rho\bar{c}^2$$

39. **(b)** Mean free path in a gas is 100 times the interatomic distance.

40. **(a)** $v_{rms} = \left[\frac{(2)^2 + (3)^2 + (4)^2 + (5)^2}{4}\right]^{1/2} = \sqrt{\left[\frac{54}{4}\right]}$

41. **(c)** If a gas is heated at constant volume then no work is done. The heat supplied is given by

$dQ = nC_v dT$

But $C_v = \frac{f}{2}R$ where f is the degree of freedom of the gas

$$\therefore\ dQ = \frac{nfRdT}{2}$$

$$= \frac{2 \times 3 \times R \times (373 - 273)}{2} = 300\,R$$

42. **(b)** For 1 molecule of a gas, $V_{rms} = \sqrt{\frac{3KT}{m}}$

where m is the mass of one molecule

For N molecule of a gas, $V_1 = \sqrt{\frac{3KT \times N}{m}}$

For 2N molecule of a gas $V_2 = \sqrt{\frac{3KT \times 2N}{(2m)}}$

$$\therefore\ \frac{V_1}{V_2} = 1$$

43. **(c)**

44. **(c)** P-V diagram of the gas is a straight line passing through origin. Hence P ∝ V or PV^{-1} = constant

Molar heat capacity in the process PV^x = constant

$C = \frac{R}{\gamma - 1} + \frac{R}{1 - x}$; Here $\gamma = 1.4$ (For diatomic gas)

$$\Rightarrow C = \frac{R}{1.4 - 1} + \frac{R}{1 + 1} \Rightarrow C = 3R$$

45. **(c)** Given

$C_P - C_V = 5000$ J/mole°C ....(i)

$\frac{C_P}{C_V} = 1.6$ ....(ii)

From Equation (i) & (ii),

$$\Rightarrow \frac{C_P}{C_V} - \frac{C_V}{C_V} = \frac{5000}{C_V}$$

$$\Rightarrow 1.6 - 1 = \frac{5000}{C_V}$$

$$\Rightarrow C_V = \frac{5000}{0.6} = 8.33 \times 10^3$$

Hence $C_P = 1.6\,C_V = 1.6 \times 8.33 \times 10^3$

$C_P = 1.33 \times 10^4$