PHYSICAL CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 32

Total Marks : 35

Max. Time : 36 min.

Topic : Gaseous State

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.3,5,6,7	(3 marks, 3 min.)	[18, 18]
Multiple choice objective ('–1' negative marking) Q.4	(4 marks, 4 min.)	[4, 4]
Subjective Questions ('–1' negative marking) Q.8	(4 marks, 5 min.)	[4, 5]
Comprehension ('–1' negative marking) Q.9 to Q.11	(3 marks, 3 min.)	[9, 9]

1. Calculate the temperature at which the R.M.S. velocity of sulphur dioxide molecules is the same as that of oxygen gas molecules at 300 K :

(A) 600°C (B) 600 K (C) 300 K (D) 300°C

2. Suppose that we change the rms speed, v_{rms}, of the gas molecules in closed container of fixed volume from 5×10^4 cm sec^{-1} to 10×10^4 cm sec^{-1}. Which one of the following statements might correctly explain how this change was accomplished :

(A) By heating the gas, we double the temperature.

(B) By pumping out 75% of the gas at constant temperature, we decreased the pressure to one quarter of its original value.

(C) By heating the gas, we quadrupled the pressure.

(D) By pumping in more gas at constant temperature, we quadrupled the pressure.

(E) None of the above.

3. Express the average kinetic energy per mole of a monoatomic gas of molar mass M, at temperature T K in terms of the mean speed of the molecules ($\bar{c}$) :

(A) $\frac{8M}{3\pi}(\bar{c})^2$ (B) $\frac{3M}{16}(\bar{c})^2$ (C) $\left(\frac{2M}{\pi}\right)(\bar{c})^2$ (D) $\left(\frac{3\pi M}{16}\right)(\bar{c})^2$

4. At same temperature and pressure, which of the following gases will have same average translational kinetic energy per mole as N_2O :

(A) He (B) H_2S (C) CO_2 (D) NO_2

5. Which of the following statements is not true :

(A) The ratio of the mean speed to the rms speed is independent of temperature of gas.

(B) The square of the mean speed of the molecules is equal to the mean squared speed at a certain temperature.

(C) Mean translational kinetic energy of the gas molecules at any given temperature is independent of the molecular mass of gas.

(D) The difference between rms speed and mean speed at any temperature for different gases diminishes as larger and yet larger molar masses are considered.

6. A flask of 4.48 L capacity contains a mixture of N_2 and H_2 at 0ºC and 1 atm pressure. If the mixture is made to react to form NH_3 gas at the same temperature, the pressure in the flask reduces to 0.75 atm. The partial pressure of NH_3 gas in the final mixture is :

(A) 0.33 atm (B) 0.50 atm (C) 0.66 atm (D) 0.25 atm

7. If the density of a gas sample is 4 g/L at pressure 1.2×10^5 Pa, the value of V_{RMS} will be :

(A) 600 m/s (B) 300 m/s (C) 150 m/s (D) 450 m/s

8. The value of v_{rms} for a gas X at 546° C was found to be equal to the value of v_{mp} for another gas Y at 273° C. Assuming ideal behaviour, find the molecular mass of gas Y (in amu) if the molecular mass of gas X is 9 amu.

Comprehension # (Q.9 to Q.11)

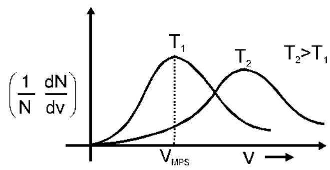
The speed of a molecule of a gas changes continuously as a result of collisions with other molecules and with the walls of the container. The speeds of individual molecules therefore change, but it is expected that the distribution of molecular speeds does not change with time.
A direct consequence of the distribution of speeds is that the average kinetic energy is constant for a given temperature.
The average K.E, is defined as

$$\overline{KE} = \frac{1}{N}\left(\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + ... + \frac{1}{2}mv_N^2\right) = \frac{1}{2N}\ m(v_1^2 + v_2^2 + ... + v_N^2) = \frac{1}{2}\ m\overline{v^2}$$

Alternatively it may be defined as $\overline{KE} = \frac{1}{N}\left(\frac{1}{2}m\sum_i dN_i v_1^2\right) = \frac{1}{2}m\left(\sum_i \frac{dN_i}{N}\cdot v_1^2\right)$

where $\frac{dN_i}{N}$ is the fraction of molecules having speeds between v_i and $v_i + dv$ and as proposed by Maxwell $\frac{dN}{N} = 4\pi\left(\frac{m}{2\pi KT}\right)^{3/2}$ exp $(-mv^2/2kT).v^2.dv$

The plot of $\left(\frac{1}{N}\frac{dN}{dv}\right)$ is plotted for a particular gas at two different temperatures against 'v' as shown.

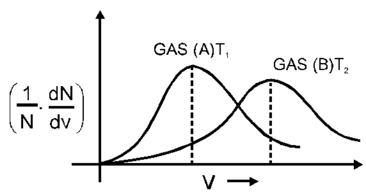


The majority of molecules have speeds which cluster around v_{MPS} in the middle of the range of v. There area under the curve between any two speeds v_1 and v_2 is the fraction of molecules having speeds between v_1 and v_2.
The speed distribution also depends on the mass of the molecule. As the area under the curve is the same (equal to unity) for all gas samples, samples which have the same v_{MPS} will have identical Maxwellian plots. On the basis of the above passage answer the questions that follow.

9. If a gas sample contains a total of 'N' molecules, the area under any given maxwellian plot is equal to:

(A) infinite (B) N (C) 1 (D) $\int_0^N \left(\frac{dN}{dv}\right)\cdot dv$

10. For the above graph drawn for two different samples of gases at two different temperatures T_1 and T_2, which of the following statements is necessarily true :



(A) If $T_2 > T_1$, M_A is necessarily greater than M_B

(B) If $T_1 > T_2$, M_B is necessarily greater than M_A

(C) $\frac{T_2}{M_B} > \frac{T_1}{M_A}$

(D) Nothing can be predicted

11. If two gases 'A' and 'B' and at temperature T_A and T_B respectively have identical Maxwellian plots, then which of the following statements are true :

(A) $T_B = T_A$

(B) $M_B = M_A$

(C) $\frac{T_A}{M_A} = \frac{T_B}{M_B}$

(D) Gases A and B may be O_2 and SO_2 at 27ºC and 327ºC respectively.

Answer Key

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1.	(B)	**2.**	(C)	**3.**	(D)	**4.**	(A,B,C,D)	**5.**	(B)
6.	(D)	**7.**	(B)	**8.**	4	**9.**	(C)	**10.**	(C)
11.	(C,D)								

Hints & Solutions

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6. $N_2 + 3H_2 \longrightarrow 2NH_3$

Initially a atm b atm

Finally $a - x$ $b - 3x$ $2x$

$\therefore$ $a + b = 1$ and $a + b - 2x = 0.75$

$\therefore$ $P_{NH_3} = 2x = 0.25$ atm

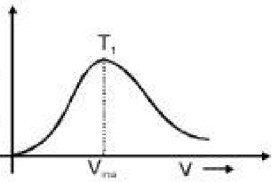
7. $v_{RMS} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3 \times 1.2 \times 10^5}{4}} = 300$ m/s

8. $[(v_{rms})_X]_{546°C} = [(v_{mp})_Y]_{273°C}$

$\sqrt{\frac{3RT_X}{M_X}} = \sqrt{\frac{2RT_Y}{M_Y}}$ $\frac{3 \times 819}{9} = \frac{2 \times 546}{M_Y}$

$\therefore M_Y = 4$ amu.

9. **(C)** Area under the curve $\left(\frac{1}{N}\frac{dN}{dv}\right)$



$= \int_0^x y\,dx = \int_0^N \left(\frac{1}{N}\frac{dN}{dV}\right) dV = \frac{1}{N}\int_0^N dN = 1.$

11. **(C,D)**

If two gases haves identical Max wellian plot then their all the speeds will also be identical.

Hence $\frac{T_A}{M_A} = \frac{T_B}{M_B}$. Since all the speeds are proportional to $\sqrt{\frac{T}{M}}$

for SO_2 – $M_1 = 64$, $T_1 = 600$ K ; O_2 – $M_2 = 32$, $T_2 = 300$ K $\Rightarrow \frac{T_1}{M_1} = \frac{T_2}{M_2}$.