CHAPTER 5

States of Matter

1. For an ideal gas, number of moles per litre in terms of its pressure P, gas constant R and temperature T is **[2002]**
   - (a) PT/R
   - (b) PRT
   - (c) P/RT
   - (d) RT/P.

2. Value of gas constant R is **[2002]**
   - (a) 0.082 litre atm
   - (b) 0.987 cal mol^{-1} K^{-1}
   - (c) 8.3 J mol^{-1} K^{-1}
   - (d) 83 erg mol^{-1} K^{-1}.

3. Kinetic theory of gases proves **[2002]**
   - (a) only Boyle's law
   - (b) only Charles' law
   - (c) only Avogadro's law
   - (d) all of these.

4. According to the kinetic theory of gases, in an ideal gas, between two successive collisions a gas molecule travels **[2003]**
   - (a) in a wavy path
   - (b) in a straight line path
   - (c) with an accelerated velocity
   - (d) in a circular path

5. As the temperature is raised from 20ºC to 40ºC, the average kinetic energy of neon atoms changes by a factor of which of the following ? **[2004]**
   - (a) $313/293$
   - (b) $\sqrt{(313/293)}$
   - (c) $1/2$
   - (d) 2

6. In van der Waals equation of state of the gas law, the constant 'b' is a measure of **[2004]**
   - (a) volume occupied by the molecules
   - (b) intermolecular attraction
   - (c) intermolecular repulsions
   - (d) intermolecular collisions per unit volume

7. Which one of the following statements is NOT true about the effect of an increase in temperature on the distribution of molecular speeds in a gas? **[2005]**
   - (a) The area under the distribution curve remains the same as under the lower temperature
   - (b) The distribution becomes broader
   - (c) The fraction of the molecules with the most probable speed increases
   - (d) The most probable speed increases

8. If 10^{-4} dm^3 of water is introduced into a 1.0 dm^3 flask at 300 K, how many moles of water are in the vapour phase when equilibrium is established ? **[2010]**
   (Given : Vapour pressure of H_2O at 300 K is 3170 Pa; $R = 8.314$ J K^{-1} mol^{-1})
   - (a) 5.56×10^{-3} mol
   - (b) 1.53×10^{-2} mol
   - (c) 4.46×10^{-2} mol
   - (d) 1.27×10^{-3} mol

9. When r, P and M represent rate of diffusion, pressure and molecular mass, respectively, then the ratio of the rates of diffusion (r_A / r_B) of two gases A and B, is given as **[2011RS]**
   - (a) $(P_A / P_B)(M_B / M_A)^{1/2}$
   - (b) $(P_A / P_B)^{1/2}(M_B / M_A)$
   - (c) $(P_A / P_B)(M_A / M_B)^{1/2}$
   - (d) $(P_A / P_B)^{1/2}(M_A / M_B)$

10. The molecular velocity of any gas is : **[2011RS]**
    - (a) inversely proportional to absolute temperature.
    - (b) directly proportional to square of temperature.
    - (c) directly proportional to square root of temperature.
   - (d) inversely proportional to the square root

of temperature.

11. The compressibility factor for a real gas at high pressure is : **[2012]**

(a) $1 + \dfrac{RT}{pb}$ (b) 1

(c) $1 + \dfrac{pb}{RT}$ (d) $1 - \dfrac{pb}{RT}$

12. For gaseous state, if most probable speed is denoted by C*, average speed by $\overline{C}$ and mean square speed by C, then for a large number of molecules the ratios of these speeds are: **[2013]**

(a) $C^* : \overline{C} : C = 1.225 : 1.128 : 1$
(b) $C^* : \overline{C} : C = 1.128 : 1.225 : 1$
(c) $C^* : \overline{C} : C = 1 : 1.128 : 1.225$
(d) $C^* : \overline{C} : C = 1 : 1.225 : 1.128$

13. If Z is a compressibility factor, van der Waals equation at low pressure can be written as: **[2014]**

(a) $Z = 1 + \dfrac{RT}{Pb}$ (b) $Z = 1 - \dfrac{a}{VRT}$

(c) $Z = 1 - \dfrac{Pb}{RT}$ (d) $Z = 1 + \dfrac{Pb}{RT}$

14. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is: **[2014]**

(a) $1 : 4$ (b) $7 : 32$
(c) $1 : 8$ (d) $3 : 16$

15. The intermolecular interaction that is dependent on the inverse cube of distance between the molecules is : **[JEE M 2015]**
(a) London force
(b) hydrogen bond
(c) ion - ion interaction
(d) ion - dipole interaction

16. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure p_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2. The final pressure p_f is : **[JEE M 2016]**

(a) $2p_i\left(\dfrac{T_2}{T_1 + T_2}\right)$ (b) $2p_i\left(\dfrac{T_1 T_2}{T_1 + T_2}\right)$

(c) $p_i\left(\dfrac{T_1 T_2}{T_1 + T_2}\right)$ (d) $2p_i\left(\dfrac{T_1}{T_1 + T_2}\right)$

Answer Key

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(c)	(c)	(d)	(b)	(a)	(a)	(c)	(d)	(a)	(c)	(c)	(c)	(b)	(b)	(b)
16														
(a)														

SOLUTIONS

1. **(c)** PV = nRT (number of moles = n/V)
∴ n/V = P/RT.

2. **(c)** Value of gas constant
(R) = 0.0821 L atm K^{-1} mol^{-1}
= 8.314×10^7 ergs K^{-1} mol^{-1}
= 8.314 JK^{-1} mol^{-1} = 1.987 cal K^{-1} mol^{-1}

3. **(d)** Kinetic theory of gases proves all the given gas laws.

4. **(b)** According to kinetic theory the gas molecules are in a state of constant rapid motion in all possible directions colloiding in a random manner with one another and

with the walls of the container and between two successive collisions molecules travel in a straight line path but show haphazard motion due to collisions.

5. **(a)** $\dfrac{\text{K.E of neon at } 40°C}{\text{K.E of neon at } 20°C} = \dfrac{\frac{3}{2}K \times 313}{\frac{3}{2}K \times 293} = \dfrac{313}{293}$

6. **(a)** In van der waals equation 'b' is for volume correction

7. **(c)** Distribution of molecular velocities at two different temperature is given shown below.
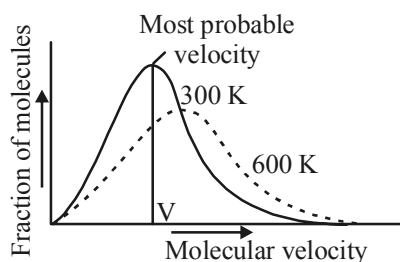
NOTE At higher temperature more molecules have higher velocities and less molecules have lower velocities.
As evident from fig. thus it is clear that With the increase in temperature the most probable velocity increase butthe fraction of such molecules decreases.

8. **(d)** From the ideal gas equation :

$$PV = nRT$$

or $n = \dfrac{PV}{RT} = \dfrac{3170 \times 10^{-3}}{8.314 \times 300} = 1.27 \times 10^{-3}$

9. **(a)** $r \propto \dfrac{P}{\sqrt{m}}$

$$\dfrac{r_A}{r_B} = \dfrac{P_A}{P_B} \sqrt{\dfrac{M_B}{M_A}}$$

10. **(c)** The different type of molecular velocities possessed by gas molecules are

(i) Most probable velocity $(\alpha) = \sqrt{\dfrac{2RT}{M}}$

(ii) Average velocity $\bar{v} = \sqrt{\dfrac{2RT}{M}}$

(iii) Root mean square velocity in all three cases $v = \sqrt{\dfrac{3RT}{M}}$

In all the above cases
Velocity $\times \sqrt{T}$

11. **(c)** $\left(P + \dfrac{a}{V^2}\right)(V - b) = RT$ at high pressure $\dfrac{a}{V^2}$ can be neglected

$PV - Pb = RT$ and $PV = RT + Pb$

$$\dfrac{PV}{RT} = 1 + \dfrac{Pb}{RT}$$

$Z = 1 + \dfrac{Pb}{RT}$; $Z > 1$ at high pressure

12. **(c)** Most probable speed $(C^*) = \sqrt{\dfrac{2RT}{M}}$

Average Speed $(\overline{C}) = \sqrt{\dfrac{8RT}{\pi M}}$

Root mean square velocity $(C) = \sqrt{\dfrac{3RT}{M}}$

$$C^* : \overline{C} : C = \sqrt{\dfrac{2RT}{M}} : \sqrt{\dfrac{8RT}{\pi M}} : \sqrt{\dfrac{3RT}{M}}$$

$$= 1 : \sqrt{\dfrac{4}{\pi}} : \sqrt{\dfrac{3}{2}} = 1 : 1.128 : 1.225$$

13. **(b)** Compressibility factor $(Z) = \dfrac{PV}{RT}$
(For one mole of real gas)
van der Waals equation

$$(P + \dfrac{a}{V^2})(V - b) = RT$$

At low pressure, volume is very large and hence correction term b can be neglected in comparison to very large volume of V.
i.e. $V - b \approx V$

$$\left(P + \dfrac{a}{V^2}\right)V = RT$$

$$PV + \dfrac{a}{V} = RT$$

$$PV = RT - \dfrac{a}{V}$$

$$\dfrac{PV}{RT} = 1 - \dfrac{a}{VRT}$$

Hence, $\boxed{Z = 1 - \dfrac{a}{VRT}}$

14. **(b)** Number of moles of $O_2 = \dfrac{w}{32}$

Number of moles of $N_2 = \dfrac{4w}{28} = \dfrac{w}{7}$

$\therefore$ Ratio $= \dfrac{w}{32} : \dfrac{w}{7} = 7 : 32$

15. **(b)** Hydrogen bond is a type of strong electrostatic dipole-dipole interaction and dependent on the inverse cube of distance between the molecular ion-dipole interaction.

16. **(a)** For a given mass of an ideal gas, the volume and amount (moles) of the gas are directly proportional if the temperature and pressure are constant. i.e
Hence in the given case.
Initial moles and final moles are equal
$(n_T)_i = (n_T)_f$