

## SAMPLE QUESTION ANSWERS

### CC-2 PHYSICAL CHEMISTRY

#### GASEOUS STATE

##### A. Very short type answers ( each will carry 1 mark)

**1. Which factor is mainly responsible for real gases to show deviation from ideal gases?**

Ans: Intermolecular force of attraction between the molecules of real gas molecules is mainly responsible for the deviation from the ideal behaviour.

**2. How does the kinetic energy varies with temperature?**

Ans: Kinetic energy increases linearly with increase in temperature and this direct proportionality can be given by the following relation

$$\epsilon = 3/2 (kT)$$

where  $\epsilon$  is the kinetic energy,  $k$  is Boltzman constant,  $T$  is temperature of the gas.

**3. With increase in pressure temperatue of a gas will decrease - True or False?**

Ans : With increase in pressure temperatue of a gas will decrease -this statement is False.

**4. Give the c.g.s unit of viscosity of gas.**

Ans : the cgs unit of viscosity is Poise.

**5. The dimension formula of R is .....**

Ans : [  $ML^2 T^{-2} K^{-1}$  ]

##### B. Short type answer :

**1. Define viscosity of gas. Show how it varries with temperature.**

**1+2 =3**

Ans : *Viscosity of gas* : The viscosity of a gas can be thought of as a measure of its resistance to flow of the gas layers. In random motion there will be transfer of momentum by the gas molecules between the adjacent layers which decreases the flow of layers. In order to maintain the uniform velocity one has to apply a force along the direction of movement of the layers. This applied force is known as the viscosity of the gas.

*Variation of viscosity of gas with temperature* : With an increase in temperature, there is typically an increase in the molecular interchange between the adjacent layers as molecules move faster in higher temperatures. As a result the friction also increases and a greater force is needed to maintain uniform velocity. So, the gas viscosity will increase with temperature. ... With high temperatures, viscosity increases in gases.

**2. Gases cannot be liquefied unless their temperature be lowered to values equal to or below their critical temperature. Justify or correct.** **2.5**

Ans: This assertion is correct. A gas can be liquefied by applying more pressure alone at or below the critical temperature. We know the Van der Waals equation for one mole gas is given by

$$P = \frac{RT}{V-b} - \frac{a}{V^2}$$

At very high temperature, the second term may be neglected in comparison and  $V \gg b$  so that the equation becomes equal to ideal gas equation. Thus at those temperatures liquifaction will not take place. Below and at some certain temperature, both the terms will be important – the gas will behave non ideally and can be liquefied. The same is true for any other equation of state. This certain temperature is known as Critical temperature,  $T_c$

**3. Derive Barometric distribution formula. What is the effect of molar mass on the distribution?**

**3+2= 5**

Ans: *Barometric distribution formula* : For derivation see any Textbook for physical chemistry for B.Sc.

*Effect of molar mass on the distribution* : The relative decrease in pressure is directly proportional to the molar mass of the gas according to the following expression-

$$-dP/P = (Mg/RT) dh, \quad M = \text{molar mass}, P = \text{pressure}, T = \text{temperature}$$

Therefore, for a specific increase in height at a given T, the relative decrease in pressure will be larger for a gas with greater molar mass than that of lighter molecules. It follows that the partial pressures of the lighter gases such as hydrogen, helium etc decrease less rapidly with height than that of heavier gases like oxygen, nitrogen etc. Thus it is cleared that lighter gases exist at higher percentage in upper atmosphere than near the surface of Earth.

**C. NUMERICAL PROBLEMS :( Each question carries 2 marks)**

1. The density of oxygen at 273 °K and 1 atm is 1.4290 gm/l. Calculate the r.m.s. velocity of oxygen at 273 °K.

$$\text{Soln. : } \bar{c} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3P}{d}}$$

$$P = 1 \text{ atm} = 1.01325 \times 10^5 \text{ N.m}^{-2}$$

$$d = 1.4290 \text{ gm/l} = 1.4290 \text{ kg.m}^{-3}$$

$$\therefore \bar{c} = \sqrt{\frac{3 \times 1.01325 \times 10^5}{1.4290}} = 461.2143589 \text{ m.s}^{-1} = 461.21 \text{ m.s}^{-1}.$$

2. It was found that at 2800 K tungsten ( $M = 183.80$ ) loses a weight of  $2.15 \times 10^{-6}$  gm per second from a heated filament of 5 sq.cm area. Calculate the vapour pressure of tungsten at 2800 K.

**Soln. :** We know that mass leaking per area  $A$  in  $t$  sec is —

$$\mu = \sqrt{\frac{M}{2\pi RT}} P A t$$

By the problem

$$\mu = 2.15 \times 10^{-9} \text{ kg}$$

$$M = 0.1838 \text{ kg.mole}^{-1}$$

$$R = 8.314 \text{ J.K.mole}^{-1}$$

$$T = 2800 \text{ K}$$

$$A = 5 \times 10^{-4} \text{ sq. metre}$$

$$\therefore P = \frac{\mu \sqrt{2\pi RT}}{A\sqrt{M}} = \frac{2.15 \times 10^{-9} \sqrt{2 \times 3.142 \times 8.314 \times 2800}}{5 \times 10^{-4} \sqrt{0.1838}}$$

$$= \frac{8.223194714 \times 10^{-7}}{5 \times 10^{-4} \sqrt{0.1838}} = 3.84 \times 10^{-3} \text{ Pa} \approx 2.9 \times 10^{-5} \text{ mm of Hg (760 mm of$$

$$\text{Hg} = 1.01325 \times 10^5 \text{ Pa}).$$

3. Calculate  $\eta$  (viscosity coefficient) of nitrogen at 300 K ( $\sigma = 4 \times 10^{-8}$  cm).

Soln. :  $\eta = \frac{1}{3} d \bar{v} \lambda$      $d = \frac{MP}{RT}$      $\bar{v} = \sqrt{\frac{8RT}{\pi M}}$

$$\begin{aligned} \therefore \eta &= \frac{1}{3} \frac{MP}{RT} \sqrt{\frac{8 \times 8.314 \times 10^7 \times 300}{3.142 \times 28}} \cdot \frac{RT}{\sqrt{2} \pi P N_A \sigma^2} \\ &= \frac{1}{3} 28 \sqrt{\frac{8.314 \times 10^7 \times 2400}{3.142 \times 28}} \times \frac{1}{\sqrt{2} \times 3.142 \times (4 \times 10^{-8})^2 N_A} \\ &= 1.038205653 \times 10^{-4} \\ &= \mathbf{1.04 \times 10^{-4} \text{ poise.}} \end{aligned}$$

4. Molecular diameter of CO is  $3.19 \text{ \AA}$ . At  $27^\circ \text{C}$  and 100 mm of Hg pressure what could be (i) collision frequency and (ii) mean free path.

Hints :  $Z_{11} = \frac{\pi \sigma^2}{\sqrt{2}} \cdot \bar{v} \cdot \left( \frac{N_A P}{RT} \right)^2$

By the problem,

$$Z_{11} = \frac{3.142 \times (3.19 \times 10^{-8})^2}{\sqrt{2}} \times \sqrt{\frac{8 \times 8.314 \times 10^7 \times 300}{3.142 \times 28}} \times \left( \frac{6.022 \times 10^{23} \times 100}{760 \times 0.08206 \times 10^3 \times 300} \right)^2$$

$$\lambda = \frac{RT}{\sqrt{2} \pi P N_A \sigma^2} \quad [\text{Ans. } 11.12 \times 10^{21} \text{ per cc per sec, } 6.87 \times 10^{-5} \text{ cm}]$$

5. A gas contains  $10^{15}$  molecules/l. The mean free path of the molecules is  $\frac{1}{\sqrt{2} \pi}$  metre. Calculate  $\sigma$ .

Soln. : We know that  $\lambda = \frac{1}{\sqrt{2} \pi \sigma^2 N'}$ ,

where  $\sigma^2$  is the square of collision diameter and  $N'$  is the number of molecules per unit volume

By the problem,  $N' = 10^{18}$  molecules/ $\text{m}^3$

$$\frac{1}{\sigma^2 N'} = 1 \text{ metre}$$

$$\sigma^2 = \frac{1}{N'} \text{ m}^2$$

or,  $\sigma = \sqrt{\frac{1}{10^{18}}} = 10^{-9} \text{ m.}$

$\therefore \sigma = \mathbf{1.0 \text{ \AA.}}$

# Solid State

## Group-A

**Q.1. What is meant by Space lattice and Unit cell?** 1

**Ans.** *Space Lattice.* The regular arrangement of the constituents of a crystalline substance in three dimensions is called space lattice or crystal lattice.

*Unit Cell.* The smallest portion of the arrangement of particle which when repeated in 3d produces the complete space lattice, is called unit cell.

**Q.2. Find the Miller indices of the plane that intersect the crystallographic axes at the distance a, 2b, ∞c.** 1

**Ans.** Miller indices of the plane are :  $\frac{1}{1} \frac{1}{2} \frac{1}{\infty}$  or 210

**Q.3. Write two difference between crystalline and amorphous solids.** 1

**Ans.**

(a)**Arrangement of particles:** The constituent atoms or ions are arranged in a definite pattern in a crystalline solids whereas there is no regular pattern of arrangement of particles in the amorphous solids.

(b)**Melting Point:**Crystalline solids melt sharply at their melting points whereas amorphous solids melt gradually over a range of temperature.

## Group-B

**Q.1. Determine the interplanar spacing between the (221) planes of a cubic lattice of length 4.5Å(450pm).** 2

**Ans.** In a cubic lattice, the interplanar distance  $d_{221}$  is given by,

$$\begin{aligned}d_{221} &= \frac{a}{\sqrt{h^2+k^2+l^2}} \text{ \AA} \\ &= \frac{4.5}{\sqrt{4+4+1}} \text{ \AA} \\ &= 1.5 \text{ \AA} = 150 \text{ pm}\end{aligned}$$

**Q.2. The second order reflection of X-rays from (110) planes of NaCl occurs at 29.3° C. If the wavelength used is 1.54 Å, calculate the distance between two successive (100) planes in NaCl.** 2

**Ans.** The Bragg's equation relating the angle, wavelength of light and the distance between successive planes is,

$$2d\sin\theta = n\lambda, \text{ where } n \text{ is the order of reflection.}$$

$$2d\sin 29.3^\circ = 2 \times 1.54$$

$$d = \frac{1.54}{\sin 29.3} = 3.17 \text{ \AA}$$

**Q.3. Show with the help of diagrams various planes and axes of symmetry in a simple cube.** 2

**Ans.** A cubic crystal always possesses the following 23 different elements of symmetry.

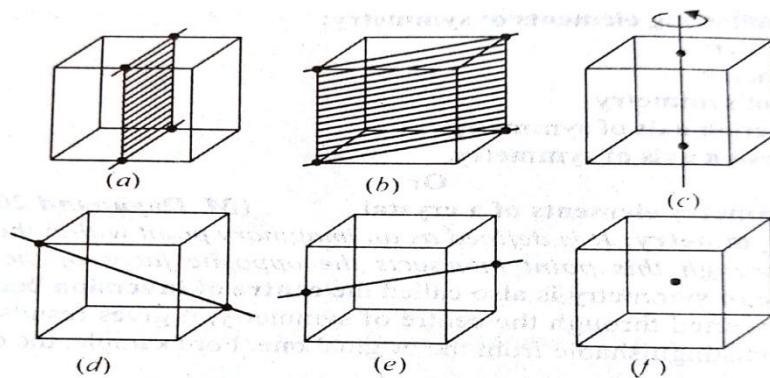


Fig. Elements of symmetry of a cube

(a) Rectangular planes of symmetry- 3

(b) Diagonal plane of symmetry-6

(c) Four – fold axes of symmetry-3

(d) Three – fold axes of symmetry-4

(e) Two –fold axes of symmetry-6

(f) Centre of symmetry-1

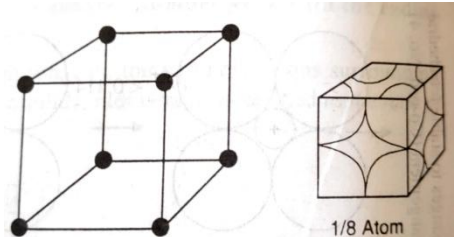
### Group-C

**Q.1. Calculate the number of atoms in a simple cubic, FCC and BCC structures?** 3

**Ans.**

(a) **No. of atoms in unit cell of simple cubic .**

In this type of structure the atoms are situated only at the corners of a cube. Each corner atom contributes 1/8 to a unit cell.



Contribution of 1 corner atom =  $1/8$

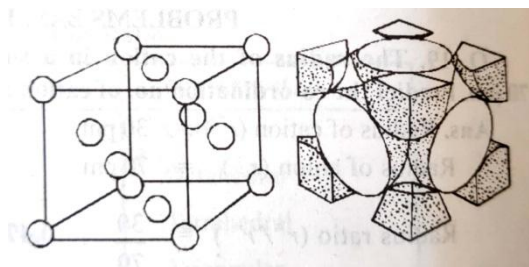
Contribution of 8 corner atoms =  $1/8 \times 8 = 1$

Hence, the no. of atoms per unit cell in a simple cubic structure is 1 .

**(b) No. of atoms in a unit cell of FCC .**

**3**

In a face-centred cubic, there are 8 atoms at the 8 corners of the cubic and 6 atoms at the centre of 6 faces of the cube.



Contribution of 1 corner atom =  $1/8$

Contribution of 8 corner atoms =  $1/8 \times 8 = 1$

Contribution of 1 face atom =  $1/2$

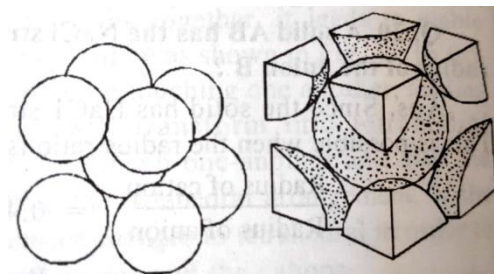
Contribution of 6 face atoms =  $6 \times 1/2 = 3$

Hence, the total no. of atoms in unit cell of FCC =  $1 + 3 = 4$

**(c) No. of atoms in a unit cell of BCC .**

**3**

In a body-centred cubic, there are 8 atoms at the 8 corners of the cubic and 1 atom at the centre of the body of the cube.



Contribution of 1 corner atom =  $1/8$

Contribution of 8 corner atoms =  $1/8 \times 8 = 1$

Contribution of 1 centre atom = 1

Hence, the total no. atoms in unit cell of BCC = 2

**Q.2. A compound formed by elements X and Y. Crystallizes in the cubic structures. X atoms situated at the corners and Y atoms are at the centre of faces. What is the formula of the compound?** **3**

**Ans.** There are 8 atoms of X at corners and 6 atoms of Y at the centre of 6 faces of the FCC lattice.

Contribution of 1 corner atom =  $1/8$

Contribution of 8 corner atoms =  $1/8 \times 8 = 1$

Contribution of 1 face atom =  $1/2$

Contribution of 6 face atoms =  $6 \times 1/2 = 3$

Thus there is one atom of X and 3 atoms of Y per unit cell. Hence the formula of the compound is  $XY_3$ .

### Properties Of Liquid

**1. Write down the unit of surface energy?** **1**

**Ans.** The unit of surface energy is dynes/cm.

**2. What is fluidity?** **1**

**Ans.** Reciprocal of viscosity is called fluidity.

**3. Write the expression describing capillary rise phenomenon.** **1**

**Ans.** The expression is as  $h = \frac{2\sigma \cos \theta}{\rho g r}$ , surface-tension =  $\sigma$ . Where symbols have their usual meaning.

**4. Why is the drop of a liquid spherical?** **2**

**Ans.** As a result of the inward pull on the molecules at the surface, the surface of the liquid tends to contract to the smallest possible area for a given volume of the liquid. It is for that the drops of a liquid are spherical because for a given volume, a sphere has minimum surface area.

**5. Explain interfacial tension.** **2**

**Ans.** If two immiscible or partially miscible liquids are taken in a vessel, then the surface tension acting along their surface of separation i.e., along the



interface is called the interfacial tension. Its value is generally intermediate between the two but sometimes it may be less than both.

**6. A liquid of density 0.9 gm/cc is kept in a beaker . A clean capillary tube of diameter 0.033cm is dipped into it. It rises to a height of 3.8 cm. Calculate the surface tension of the liquid. 3**

Ans. Given,  $d = 0.9 \text{ gm/cc}$

$$2r = 0.033$$

$$h = 3.8 \text{ cm}$$

surface tension =  $(hgrd)/2$

$$= \{3.8 \times 980.665 \times (0.033/2) \times 0.9\}$$

$$= 27.68 \text{ dynes/cm}$$

**7. Do electrolytes lead to increase in surface tension of water with increase in concentration always? 3**

Ans. Liquid molecules in the surface are attracted strongly to the interior. This is the reason of surface energy and surface tension. Electrolytes attract polar solvents very strongly and this increased attraction leads to increase in surface tension. In a solution ions are solvated. As suggested by M.Dole , a special orientation of hydrated ions of the interface may reduce the attractions of surface molecules to the bulk. This may lead to decrease in surface tension at low concentration with increase in concentration of electrolytes.