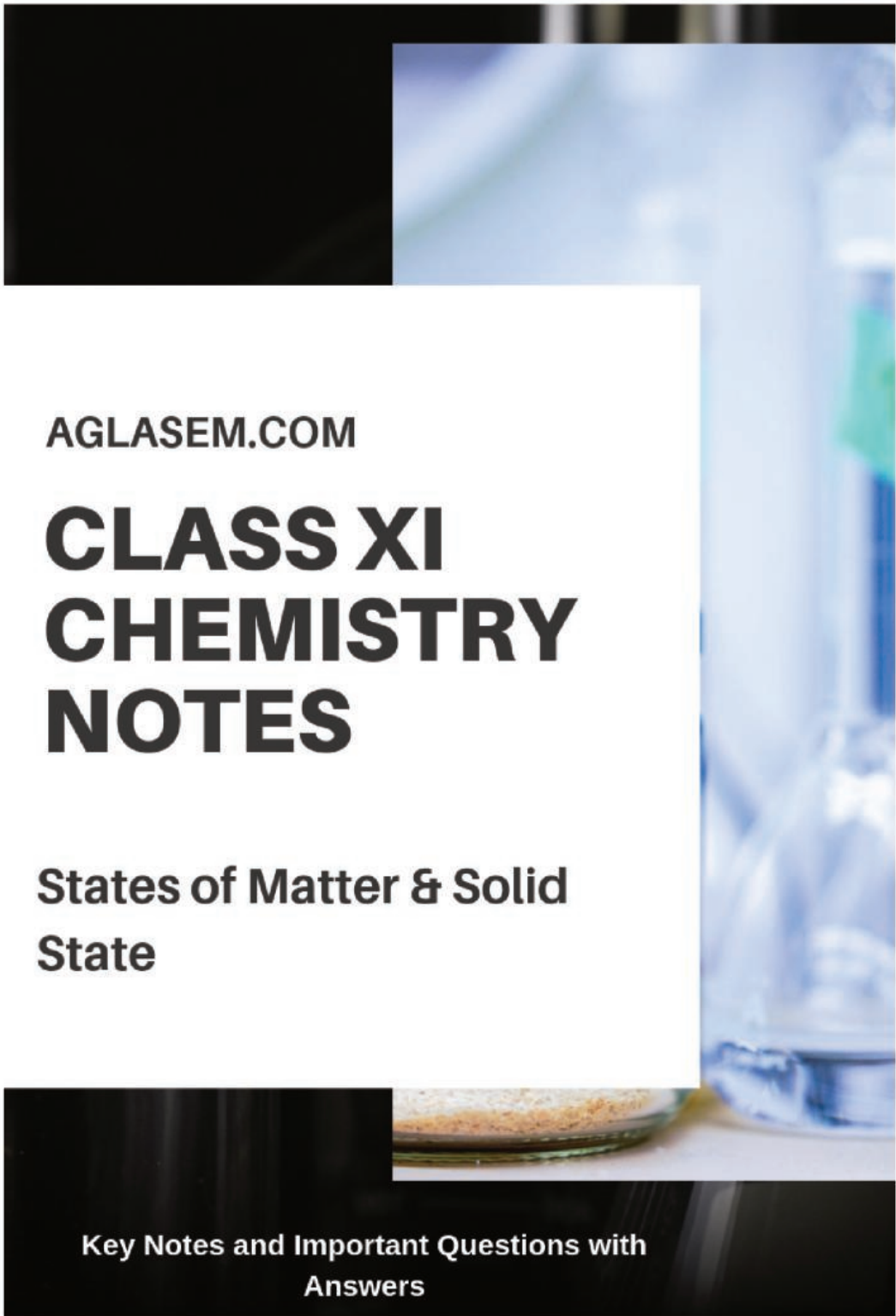


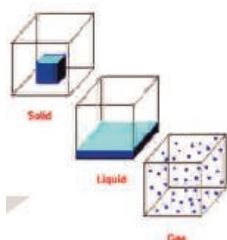
The background of the cover features a blurred image of laboratory glassware, including a large Erlenmeyer flask and a beaker, both containing liquids. The scene is set in a laboratory environment with a white surface.

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CLASS XI CHEMISTRY NOTES

**States of Matter & Solid
State**

**Key Notes and Important Questions with
Answers**



Chapter - 5

States of Matter: Gases, Liquids and Solids

- On the basis of nature of intermolecular forces/molecular interactions, matter exists in three physical states : **solid, liquid and gas**.
- Intermolecular forces are the forces of attraction or repulsion between interacting particles (atoms and molecules). Attractive/repulsive intermolecular forces are known as **van der Waal's forces**.

Different types of van der Waal's forces are :

- Dispersion forces or London forces** : The interaction which is present between two non polar molecules for example force between : noble gases.
 - Dipole-dipole forces** : The interaction which is present between molecules having permanent dipoles *i.e.*, between polar molecules, for example NH_3 , HCl etc.
 - Dipole-induced dipole forces** : The interaction which is present between a polar and non polar molecule.
- Boyle's law** : At constant temperature, the pressure of a fixed amount of gas, varies inversely with volume.

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

$$P_1 V_1 = P_2 V_2 \text{ [At constant temperature]}$$

- Charle's law** : At constant pressure, the volume of a fixed mass of gas is directly proportional to its absolute temperature.

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ [At constant pressure (p) and n]}$$

- **Gay Lussac's law** : At constant volume, pressure of a fixed amount of gas varies directly with the absolute temperature.

$$P \propto T, \frac{P_1}{T_1} = \frac{P_2}{T_2} \text{ [At constant volume (V) and } n\text{].}$$

- **STP (Standard Temperature and Pressure)** : STP means 273.15 K (0°C) temperature and 1 bar (*i.e.*, exactly 10^5 Pascal.) Volume occupied by 1 mole gas at STP = 22.7 L.

If pressure is taken in atm (atmosphere), then the standard molar volume is 22.4 L.

- **Ideal gas equation** : $PV = nRT$

R is universal gas constant.

$$R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1} = 0.083 \text{ L bar mol}^{-1} \text{ K}^{-1}$$

- **Combined gas law** : $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

- **Density and molar mass of a gaseous substance** :

$$M = \frac{dRT}{P}$$

- **Dalton's law of partial pressure** : Dalton states that the total pressure exerted by the mixture of non reacting gases is equal to the sum of the partial pressures of individual gases.

$$P_{\text{total}} = P_1 + P_2 + P_3 + \dots \text{ [at constant T, V]}$$

$$P_1 = x_1 \times P_{\text{Total}} = \text{Here } x_1 \text{ is called mole fraction of the first gas.}$$

$$P_{\text{dry gas}} = P_{\text{Total}} - \text{Aqueous tension.}$$

Here aqueous tension is the pressure exerted by water vapours.

- **Compressibility factor** : The extent of deviation of a real gas from an ideal behaviour is expressed in terms of compressibility factor, $Z = \frac{PV}{nRT}$

For ideal gas, $Z = 1$ at all temperatures and pressures. For real gases, greater is the deviation in the value of Z from 1, more is the deviation from ideal behaviour. When $Z < 1$, the gas is said to show negative deviation. This implies that gas is more compressible than expected from ideal behaviour. When $Z > 1$, the gas is said to show positive deviation and the gas is less compressible than expected from ideal behaviour.

At ordinary temperatures ($T \geq 273 \text{ K}$), only H_2 and He show positive deviations. However at low temperatures, even these gases show negative deviation *i.e.*, < 1 . For example, in case of these gases, if $T \ll 273 \text{ K}$, $Z < 1$.

- **Boyle temperature :** The temperature at which a real gas behaves like an ideal gas over an appreciable pressure range is called Boyle temperature or Boyle point.
- **Causes of deviation from ideal behaviour :** The following two assumptions of the kinetic theory of gases are faulty :
 - (a) The volume occupied by the gas molecules is negligible as compared to the total volume of the gas.
 - (b) The forces of attraction or repulsion between the gas molecules are negligible.

The above assumptions are correct only if the temperature is high and pressure is low.

van der Waal's equation :

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad \text{for 1 mole of the gas}$$

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT \quad \text{for } n \text{ moles of the gas}$$

Here a and b are constants called van der Waal's constants.

- **Significance and units of van der Waal's constants :** ' a ' gives the idea of the magnitude of attractive forces among the gas molecules. As correction in pressure is $P = \frac{an^2}{V^2}$, therefore $a = (P \times V^2)/n^2 = \text{atm L}^2 \text{ mol}^{-2}$. As correction in volume $V = nb$, therefore ' b ' has the unit of L mol^{-1} . The near constancy in the volume of b shows that the gas molecules are incompressible.
- **Vapour pressure :** The pressure exerted by the vapours of a liquid, when it is in equilibrium with the liquid surface, at constant temperature.
- **Boiling temperature :** The temperature at which vapour pressure of a liquid is equal to the external pressure.
- At 1 atm, boiling temperature is called normal boiling point.
- At 1 bar boiling temperature is called standard boiling point.

- Vapour pressure of a pure liquid depends upon (i) intermolecular forces, (ii) Temperature.
- Surface tension is defined as force acting per unit length perpendicular to the line drawn on the surface. Its units is Nm^{-1} .
- **Effect of temperature on surface tension :** Surface tension decreases with increase in temperature with the increase in temperature, kinetic energy of molecules increases. As a result, intermolecular forces decreases and hence force acting per unit length decreases.
- **Viscosity :** It is defined as resistance offered to the flow of liquid due to internal friction between layers of fluids as they pass over each other.

$$F = \eta A. \frac{du}{dx}$$

η is called **coefficient of viscosity**.

Effect of temperature on viscosity : Viscosity decrease with increase in temperature because with the increase in temperature the average kinetic energy increases and the intermolecular forces can be easily overcome.

The Solid State

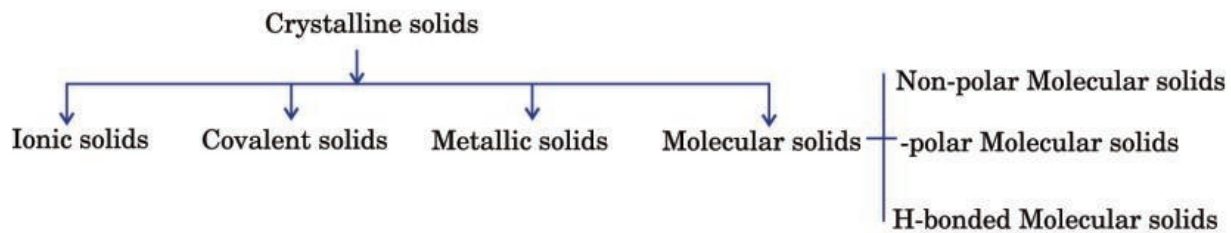
Crystalline and Amorphous solids

Crystalline solids	Amorphous solids
1. They have regular geometry	They have irregular geometry
2. They have long range order	They have short range order.
3. They have sharp melting point.	They have no sharp melting point.
4. They are anisotropic	They are isotropic
5. They give clean and smooth surface on cleavage.	They give irregular cut on cleavage
6. They have definite heat of fusion.	They do not have definite heat of fusion.
7. They are true solids.	They are pseudo solids or super cooled liquids.

Anisotropic : Solids which have different values of their physical properties such as refractive index, conductivity etc. in different directions.

Isotropic : Solids which have same values of their physical properties such as refractive index, conductivity etc. in different directions.

Classification of crystalline solids:



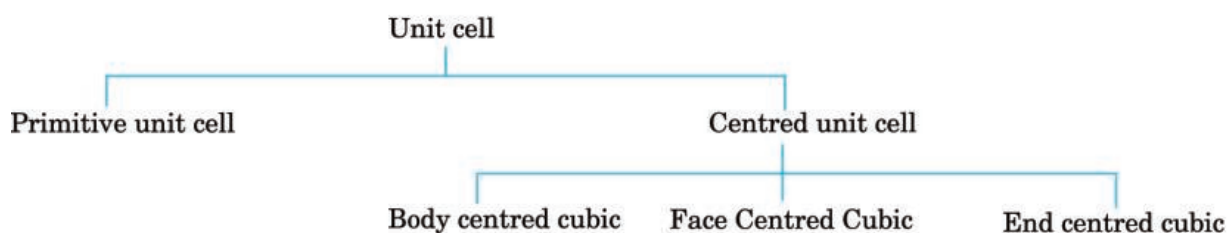
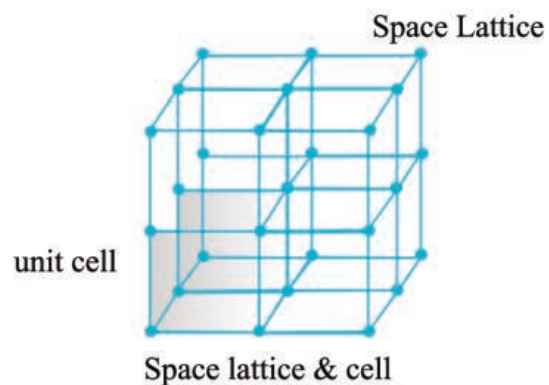
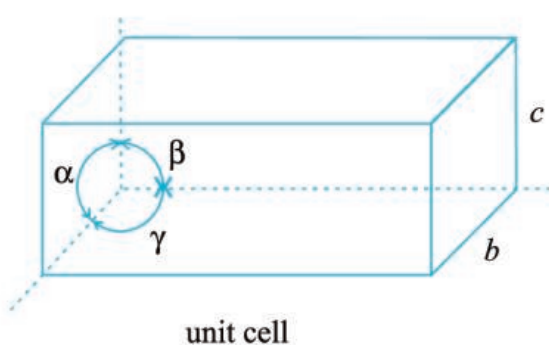
Space lattice (Crystal lattice)

A regular arrangement of the constituents particles (atoms, molecules or ions) in the three dimensional space which represent the geometry of a crystal is called space lattice.

There are only **14** possible three dimensional lattices. These are called **Bravias lattices**

Unit cell

The smallest repeating unit of the space lattice is called unit cell.



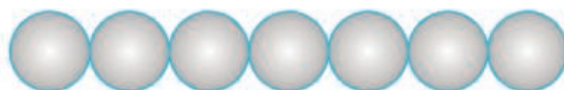
Total number of atoms (Particle) per unit cell (Z)

Unit cell	Contributions	Number of particles (Z)
Simple cubic	$(1/8 \times 8) = 1$ atom (corner)	1
Body centred cubic	$(1/8 \times 8) = 1$ atom (corner) $(1 \times 1) = 1$ atom (Body centre)	2
Face centred cubic	$(1/8 \times 8) = 1$ atom (corner) $(1/2 \times 6) = 3$ atom (face centre)	4

Close packing

Close packing in one dimensions

In this arrangement, each sphere is in contact with two of its neighbours.



Close packing of spheres in one dimensional

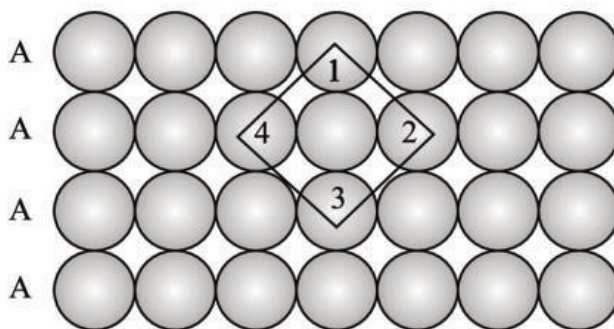
Close packing in two dimension

Square close packing

In this arrangement each sphere is in contact with four of its neighbours, thus packing is called square close packing.

Coordination number is **four**.

52.4% of the available space is occupied by the spheres (AAA type arrangement).



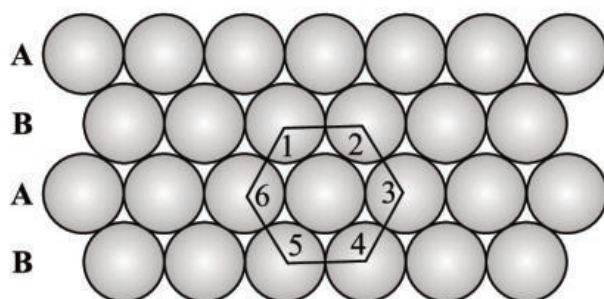
Square close packed layer

Hexagonal close packing

In this arrangement each sphere is in contact with six of its neighbours, thus packing is called Hexagonal close packing.

Coordination number is **six**.

60.4% of the available space is occupied by the spheres (**ABAB** type arrangement).



Close packing in three dimensional

HCP and CCP have equal efficiency i.e 74% of the space is occupied and coordination number is 12. CCP arrangement has FCC lattice.

Unoccupied spaces in solids are called **interstitial voids** or **interstitial sites**.

Two types of interstitial voids are:

- (i) Tetrahedral void (ii) Octahedral void

Number of tetrahedral voids = 2 N

(where N is number of close packed particles)

Number of octahedral voids = N

Type of unit cell	Relation between r , a , & d	Packing fraction
Simple cubic	$r = a/2$	52.4%
Body centred cubic	$d = \frac{\sqrt{3}a}{2}$ $r = \frac{a}{2\sqrt{2}}$	68%
Face centred cubic	$d = \frac{a}{\sqrt{2}}$ $r = \frac{a}{2\sqrt{2}}$	74%

r = radius of the atom, d = nearest neighbour distance between two atoms
& a = edge length of unit cell.

Packing Efficiency (Packing fraction)

The percentage of the total space which is occupied by the particles in a certain packing is known as packing efficiency or the total space filled is called **packing fraction**.

$$\text{Packing efficiency} = \frac{\text{Number of atoms in unit cell} \times \text{Volume of one atom}}{\text{Volume of the cubic unit cell}}$$

Density of the unit cell

$$\text{Density of the unit cell} = \frac{Z \times M(g)}{a^3 \times N_A}$$

where Z is the number of atoms per unit cell, M is molar mass / atomic mass, a is the edge length of the cubic unit cell and N_A is the Avogadro constant

Imperfection or Defects in solids

Any deviation from perfectly ordered arrangement of atoms in crystal is called imperfection or defect. There are two types of the defects : (i) Line defects (ii) point defects.

(i) Line defects

The defects which arise due to irregularity or deviation from ideal arrangement in entire row of lattice points.

(ii) Point defects

The defects which arise due to irregularity in the arrangement of atoms or ions are called atomic imperfection or point defect.

Point defects can be classified in to three types

- (a) stoichiometric defect
- (b) Non stoichiometric defect
- (c) Impurity defect

(a) stoichiometric defect (i) vacancy defect : When some of the lattice sites are vacant in a crystal, the crystal is said to have vacancy defect.

(ii) Interstitial defect : When some constituent particles occupy an interstitial site the crystal is said to have interstitial defect.

(iii) Schottky defect: It is basically a vacancy defect in ionic solids

In this defect equal number of cations and anions are missing from their lattice site so that the electrical neutrality is maintained.

Conditions causing Schottky defects :

- (i) *high coordination number, and*
- (ii) *small difference in the size of cations and anions*

For example, NaCl, KCl, KBr

(iv) Frenkel defect

In this defect, the smaller ion (usually cation) is dislocated from its normal site to an interstitial site.

It creates a vacancy defect at its original site and an interstitial defect at its new location. Frenkel defect is also called dislocation defect.

Conditions causing Frenkel defects :

This type of defect is generally occurs in compounds which have

- (i) low coordination number, and
- (ii) large difference in the size of cations and anions.

Frenkel defects are found in silver halides (AgCl, AgBr and AgI)

(b) Non stoichiometric defects

Theses defect are of the two types:-

(a) Metal excess defect :

(i) Metal excess defect due to anion vacancies:

In this case, negative ions may be missing from their lattices leaving holes in which the electron remain entrapped to maintain the electrical neutrality. The anionic sites occupied by unpaired electrons are called F-centres.

(ii) Metal excess due to the presence of extra cations at interstitial sites:

In this case, there are extra positive ions occupying interstitial sites and electrons in another interstitial sites to maintain electrical neutrality.

(b) Metal deficiency defect

In this defect, the positive ions may be missing from their lattice sites. The extra negative charge may be balanced by some nearby metal ion acquiring extra positive charges.

(c) Impurity defect (Due to ions)

The process of adding impurities to a crystalline substance so as to change its properties is called doping

p -type semiconductors

Group-14 group elements doped with group-13 are called **p-type semiconductors** because group 13 elements like **B, Al** or **Ga** contains three valence electrons.

n-type semiconductors :

When group 14 elements (**Si** or **Ge**) are doped with group 15 elements like **P** or **As**,

Magnetic properties:

Diamagnetic substances (Diamagnetism.)

The substances which are weakly repelled by the external magnetic field are called diamagnetic substances, e.g. TiO, H₂O, NaCl, benzene, etc.

Paramagnetic substances

The substances which are weakly attracted by external magnetic field are called paramagnetic substances.

Ferromagnetic substances (Ferromagnetism):-

The substances which are strongly attracted by a magnetic field are called ferromagnetic substances. For ex :- Fe, Ni, Co, CrO₂

Antiferromagnetic substances (Antiferromagnetism):

The substances which have net magnetic moments zero due to equal and opposite alignment of domains.

Examples are MnO, FeO, CoO, NiO and many other oxides.

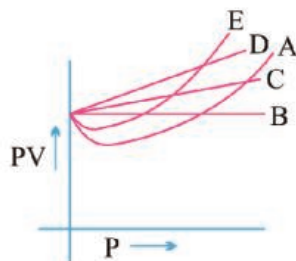
Ferrimagnetic substances (Ferrimagnetism):

Ferrimagnetism is observed when the magnetic moments of the domains in the substance are aligned in parallel and anti-parallel directions in unequal numbers.

Ferromagnetism	(a)	
Antiferromagnetism	(b)	
Ferrimagnetism	(c)	

1 - Mark Questions

1. Name the intermolecular forces, which include the term. van der Waal's forces. [Ans. LONDON forces, Dipole-Dipole, Dipole-induced dipole]
2. Define Boyle's law.
3. Write the condition in terms of temperature and pressure, under which all gases obey Charle's law. [Ans. High temperature, low pressure]
4. Mention the volume occupied by one mole of an ideal gas at STP.
[Ans. 22.7 L]
5. Define the term absolute zero. [Ans. 0K]
6. Define aqueous tension.
7. Mention the S.I. unit for the quantity $\frac{PV^2T^2}{n^2}$. [Ans. Nm⁴ K² mol⁻¹]
8. Define the term critical temperature.
9. Write any two postulates of kinetic molecular theory of gases.
10. Which curve in the figure represents the curve for ideal gas ? [Ans. B]



11. Define the term normal boiling point of a liquid.
12. Mention the factors on, which the vapour pressure of a pure liquid depends?
13. Define surface tension.
14. What do you understand by the term viscosity?

15. Out of Ethyl alcohol or Dimethyl ether, which one have higher vapour pressure at same temperature ? [Ans. Dimethylether]

16. Why glass is called supercooled liquid?

[Hint: Its molecules move under gravity.]

17. Why glass panes fixed to windows or doors of old buildings are found be thicker at the bottom ?

18. Some of the glass objects from ancient civilizations are found to be milky in appearance. Explain.

[Hint: Realignment of molecules takes place due to movement because of constant heating and cooling]

19. "Crystalline solids are anisotropic in nature" what does this statement mean ?

20. What makes a glass different from a solid such as quartz? Under what conditions could quartz be converted into glass?

[Hint: On melting quartz and then rapidly cooling it.]

21. Write a feature which will distinguish a metallic solid from ionic solid.

22. Name the crystal system for which all four types of unit cells are possible. [Hint: Orthorhombic]

23. What is the total number of atoms per unit cell in a FCC crystal structure?

24. What difference in behaviour between the glass and sodium chloride would you expect to observe, if you break off a piece of either cube?

25. Give the significance of a lattice point.

26. What type of stoichiometric defect is shown by (i) ZnS and (ii) CsCl?

27. If the formula of a compound is A_2B , which sites would be occupied by A ions?

[Hint: A ions occupy tetrahedral voids]

28. How many octahedral voids are there in 1 mole of a compound having cubic closed packed structure?

29. Calculate the number of atoms in a cubic unit cell having one atom on each corner and two atoms on each body diagonal.
30. In NaCl crystal, Cl^- ions form the cubic close packing. What sites are occupied by Na^+ ions?
31. In Corundum, O^{2-} ions form hcp and Al^{3+} occupy two third of octahedral voids. Determine the formula of corundum.
32. Why is Frenkel defect not found in pure alkali metal halides?
33. What is the formula of a compound in which element Y forms ccp lattice and atoms X occupy $1/3$ rd of tetrahedral voids ?
34. Although pure silicon is an insulator then how does it behave as a semiconductor on heating?
35. Name the crystal defect which lowers the density of an ionic crystal.
36. What makes the crystal of KCl sometimes appear violet?
37. Which point defect in ionic crystal does not alter the density of the relevant solid?
38. Name one solid in which both Frenkel and Schottky defects occur.
39. Fe_3O_4 is ferrimagnetic at room temperature but becomes paramagnetic at 850 K. Why?
40. Why common salt is some time yellow instead of being pure white ?
41. Why conductivity of the metal decrease with increase in temperature ?
42. What type of substances would make better permanent magnets, ferromagnetic or ferrimagnetic ?
43. What type of magnetism is shown by a substance if magnetic moments of domains are arranged in the same direction ?

2 - Marks Questions

1. What will be the minimum pressure required to compress 500 dm^3 of air at 1 bar to 200 dm^3 at 30°C ?
[Ans. 2.5 bar]
2. Name the intermolecular force present in :
(i) H_2O (ii) HCl
[Ans. H-bonding, Dipole-Dipole]

3. Explain Avogadro's law.
4. Find the molar mass of a gas if 300 mL of this has mass of 0.368 g at STP.
[Ans. 27.84 g/mol]
5. Why do real gases show deviation from ideal behaviour ? Write van der Waal's equation for n moles of a gas.
6. Calculate the temperature of 4 mole of a gas occupying in 5 dm^3 at 3.32 bar. ($R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$) [Ans. 50K]
7. Calculate the volume occupied by 8.8 g of CO_2 at 31.1°C and 1 bar pressure. [$R = 0.83 \text{ bar LK}^{-1} \text{ mol}^{-1}$] [Ans. 5.05 L]
8. Explain the physical significance of van der Waal's parameter.
9. Compressibility factor 'Z' of a gas is given as $Z = \frac{PV}{nRT}$.
 (i) What is the value of Z for an ideal gas ?
 (ii) For real gas, what will be the effect on value of Z above Boyle temperature? [Ans. $Z = 1$, $Z > 1$]
10. At 25°C and 760 mm Hg pressure a gas occupies 600 mL volume. What will be its pressure at a height where temperature is 10°C and volume of the gas is 640 mL. [Ans. 676.6 mm Hg]
11. Define the terms :
 (i) Standard boiling point.
 (ii) Vapour pressure of a liquid.
12. Drops of liquid are spherical in nature. Explain. Mention the effect of temperature on surface tension.
13. Write the S.I. units of :
 (i) Surface tension.
 (ii) Coefficient of viscosity.
14. Define viscosity. Mention the effect of temperature and pressure on viscosity of a liquid.

15. Explain :

- (i) Liquid drops are spherical in shape, why?
- (ii) Liquid tends to rise in a capillary.

16. List four distinctions between crystalline and amorphous solids with one example of each.

17. Give suitable reason for, the following-

- (a) Ionic solids are hard and brittle (b) Copper is malleable and ductile

18. Explain:

- (a) List two differences between metallic and ionic crystals.
- (b) Sodium chloride is hard but sodium metal is soft.

19. What do you understand by the following types of stacking sequences:

- (a) ABAB..... (b) ABCABC.....

20. What kind of lattices do these sequences lead to?

21. Calculate the number of atoms in a cubic based unit cell having one atom on each corner and two atoms on each body diagonal.

22. A unit cell consists of a cube in which there are A atoms are at the corners and B atoms at the face centres. Two A atoms are missing from the two corners of the unit cell. What is the formula of this compound ?

23. Pure silicon is an insulator. Silicon doped with phosphorus is a semiconductor. Silicon doped with gallium is also a semiconductor. What is the difference between the two types?

24. Explain how vacancies are introduced in a solid NaCl crystal when a compound containing cation of higher valence is added to it?

25. What is meant by non-stoichiometric defect? Ionic solids which have anionic vacancies due to metal excess defect develop colour. Explain with the help of suitable example.

26. Define the term 'point defects'. Mention the main difference between stoichiometric and non-stoichiometric point defects.

27. In a crystalline solid, anions B are arranged in a cubic close packing. Cations A are equally distributed between octahedral and tetrahedral voids. If all the octahedral voids are occupied, What is the formula of the solid?

28. In a solid, oxide ions are arranged in ccp. one sixth of the tetrahedral voids are occupied by the cations A while one - third of the octahedral voids are occupied by the cation B. What is the formula of the compound ?
29. In the mineral, spinel having the formula MgAl_2O_4 oxide ions are arranged in the cubic close packing, Mg^{2+} ions occupy tetrahedral voids and Al^{3+} ions occupy the octahedral voids.
- What percentage of tetrahedral voids is occupied by Mg^{2+} ions ?
 - What percentage of octahedral voids is occupied by Al^{3+} ions?
30. The electrical conductivity of a metal decrease with rise in temperature while that of a semiconductor increase. Explain
31. CdCl_2 , will introduce impurity defect if added to AgCl crystal. Explain.
32. In a crystalline solid, the atoms A and B are arranged as follows:
- Atoms A are arranged in ccp array.
 - Atoms B occupy all the octahedral voids and half of tetrahedral voids.
- What is the formula of the compound ?
33. Nickel oxide has formula $\text{Ni}_{0.94}\text{O}_{1.00}$. What fractions of the nickel exist as Ni^{2+} and Ni^{3+} ions?
34. The composition of a sample of wustite is $\text{Fe}_{0.93}\text{O}_{1.00}$. What percent of iron is present in the form of Fe(III) ?
35. Tungsten crystallizes in body centred cubic unit cell. If the edge length of the unit cell is 316.5 pm, what is the radius of tungsten atom ?

[Ans: 137 Pm]

3 - Mark Questions

- Define and explain Dalton's Law of partial pressure.
- A balloon is filled with hydrogen at room temperature. It will burst if pressure exceeds 0.2 bar. If at 1 bar pressure the gas occupies 2.27 L volume, upto what volume can the balloon be expanded?
- Calculate the total pressure in a mixture of 8g of dioxygen and 4g of dihydrogen confined in a vessel of 1dm^3 at 27°C .

[$R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$]

[Ans. 56.025 bar]

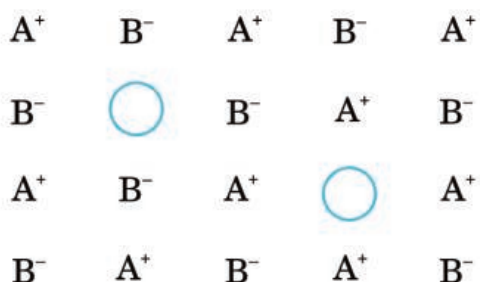
4. 300 mL of oxygen gas at -10°C are heated to 10°C . Find the volume of gas at 10°C if pressure remains constant. [Ans. 322.8 mL]
5. A gas at a pressure of 5 atm is heated from 0° to 546°C and is simultaneously compressed to one third of its original volume. Find the final pressure of the gas. [Ans. 45 atm]
6. Pressure of one gram of an ideal gas A at 27°C is found to be 2 bar. When 2g of another gas (ideal) B is introduced in the same flask at the same temperature the pressure becomes 3 bar. Find a relationship between their molecular masses. [Ans. $M_B = 4M_A$]
7. What will be the pressure exerted by a mixture of 3.2g of methane and 4.4 g of carbon dioxide contained in a 9 dm^3 flask at 27°C . [Ans. 0.82 atm]
8. A neon-dioxygen mixture contains 70.6 dioxygen and 167.5 neon. If the pressure of the mixture of gases in cylinder is 25 bar. What is the partial pressure of dioxygen and neon in the mixture. [Ans. 5.25 bar, 17.75 bar]
9. With the help of a gas laws, deduce an expression for the ideal gas equation. What is the utility of the gas equation ?
10. A vessel of 120 mL capacity contains a certain mass of a gas at 20°C and 750 mm Hg pressure the gas was transferred to a vessel whose volume is 180 mL. Calculate the pressure of the gas at 20°C . [Ans. 500 mm Hg]
11. Explain :
 - (i) Liquid at higher altitudes boil at low temperature.
 - (ii) In hospital surgical instruments are sterilised in auto caves.
 - (iii) Out of, alcohols and ethers of comparable mass which one have higher boiling points ?
12. (i) Define surface energy in relation to surface tension.
 (ii) Name the temperature at which the density of water is maximum.
 (iii) Moist soil grains are pulled together. Explain.
13. (i) Define the term coefficient of viscosity. Name the unit of viscosity coefficient in cgs system.
 (ii) Give the difference between boiling and evaporation.
14. Explain with suitable reason :
 - (i) Tea or coffee is sipped from the saucer, when it is quite hot.
 - (ii) Liquids possesses fluidity.

15. Which among the following will have ?
- HCl or H_2O (Higher boiling point)
 - Ether or water (Higher viscosity)
 - $\text{Br}_2(l)$ or water (Lower surface tension)
16. Write the relationship between atomic radius (r) and edge length (a) of cubic unit cell for
- Simple cubic unit cell
 - Body centred cubic unit cell
 - Face centred cubic unit cell
17. Write and explain three differences between Schottky and Frenkel defects under the heads :
- Effect on density
 - Effect on electrical conductivity
 - Effect on stability of the crystal
18. What is a semiconductor? Describe the two main types of semiconductors on the basis of their conductance mechanism.
19. Explain the following with one examples each :
- Ferromagnetism
 - Antiferromagnetism
 - 13-15 compounds
20. Explain the following terms with suitable examples :
- Ferrimagnetism
 - n -type semiconductor
 - Forbidden zone
21. How would you account for the following :
- Frenkel defects are not found in alkali metals.
 - Schottky defects lower the density of the related solid.
 - Impurity doped silicon is a semiconductor.
22. (a) What type of semiconductor is obtained when silicon is doped with boron?
- (b) What type of magnetism is shown in the following alignment of magnetic moments ?



(c) What type of defect is produced when AgCl is doped with CdCl₂ ?
Answer the following questions:

22. (i) What type of stoichiometric defect shown by the crystal ?
(ii) How is the density of the crystal affected by this defect ?
(iii) What type of ionic substances show such defect ?



24. (a) A compound forms hexagonal close-packed structure. What is the total number of voids in 0.5 mol of it? How many of these are tetrahedral voids?

(b) Atoms of element B form *hcp* lattice and those of the element A occupy 2/3rd of tetrahedral voids. What is the formula of the compound formed by the elements A and B?

25. An element crystallises in a cubic close packed structure having a fcc unit cell of an edge 200 pm. Calculate the density if 200 g of this element contain 24×10^{23} atoms. [Ans. : 41.6 g cm⁻³]

26. A fcc unit cell containing atoms of element (molar mass 60.4 g mol⁻¹) has cell edge 4×10^{-8} cm. Calculate the density of unit cell.

[Ans. : 6.23 g/cm³]

27. KF has NaCl structure. It's density is 2.48 g/cm³. Calculate edge length of crystal lattice. (Given At. mass of K = 39 g mol⁻¹, F = 19 g mol⁻¹ and $N_A = 6.002 \times 10^{23}$ mol⁻¹) [Ans. : 538 pm]

28. Molybdenum has atomic mass 96 g mol⁻¹ with density 10.3 g/cm³. The edge length of unit cell is 314 pm. Determine lattice structure whether simple cubic, fcc or bcc. (Given $N_A = 6.022 \times 10^{23}$ mol⁻¹)

[Ans. : Z = 2, bcc type]

29. Iron has a bcc unit cell with a cell edge of 286.65 pm. The density of iron is 7.87 g cm⁻³. Use this information to calculate Avogadro's number (At. Mass of Fe = 56 g mol⁻¹)

[Ans. : 6.022×10^{23} mol⁻¹]

30. The density of copper metal is 8.95 g cm^{-3} . If the radius of copper atom is 127 pm, is the copper unit cell a simple cubic, a body-centred cubic or a face centred cubic structure?

(Given at. mass of Cu = 63.54 g mol^{-1} and $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$)

[Ans. : Z = 4, fcc type]

31. The well known mineral fluorite is chemically calcium fluoride. It is known that in one unit cell of this mineral there are 4 Ca^{2+} ions and 8F^- ions and that Ca^{2+} ions are arranged in a fcc lattice. The F^- ions fill all the tetrahedral holes in the fcc lattice of Ca^{2+} ions. The edge of the unit cell is $5.46 \times 10^{-8} \text{ cm}$ in length.

The density of the solid is 3.18 g cm^{-3} . Use this information to calculate Avogadro's number (Molar mass of $\text{CaF}_2 = 78.08 \text{ g mol}^{-1}$).

[Ans. : $6.02 \times 10^{23} \text{ mol}^{-1}$]

32. Silver crystallizes in face centred cubic unit cell. Each side of this unit cell has a length of 400 pm. Calculate the radius of the silver atom. (Assume the atoms just touch each other on the diagonal across the face of the unit cell. That is each face atom is touching the four corner atoms.)

[Ans: 141.5 pm]

33. The density of the lead is 11.35 g cm^{-3} and the metal crystallizes with fcc unit cell. Estimate the radius of the lead atom.

[Ans: 175 pm]

34. An element with density 11.2 g cm^{-3} forms a f.c.c lattice with edge length of $4 \times 10^{-8} \text{ cm}$. Calculate the atomic mass of the element.

[Ans: 107.9 g mol^{-1}]

35. An element with molar mass 27 g mol^{-1} forms a cubic unit cell with edge length $4.05 \times 10^{-8} \text{ cm}$. If its density is 2.7 g cm^{-3} , what is the nature of the cubic unit cell?

[Ans : FCC]

36. An element crystallizes in a fcc lattice with cell edge of 250 pm. Calculate the density if 300 g of this element contain 2×10^{24} atoms. [38.4 g/cm^3]

37. An element 'X' (At. mass = 40 g mol^{-1}) having FCC structure, has unit cell edge length of 400 pm. Calculate the density of 'X' and the number of unit cell in 4g of 'X'

[d = 4.15 g/cm^3 , No. of unit cell = 1.5×10^{22}]

5 - Mark Questions

1. (a) An element has atomic mass 93 g mol^{-1} . If the edge length of its unit cell is 300 pm, identify the type of unit cell. [Ans.: BCC, $Z = 2$]
 (b) Write any two differences between amorphous solids and crystalline solids.
2. (a) Calculate the number of unit cells in 8.1 g of aluminium, if it crystallizes in a f.c.c. structure. (Given: Atomic mass of Al = 27 g mol^{-1}) [Ans: No. of unit cell 4.5×10^{22}]
 (b) Give reasons:
 (i) In stoichiometric defects, NaCl exhibits schotky defect and not Frenkel defect.
 (ii) Silicon on doping with Phosphorus forms n-type semiconductor.
 (iii) Ferrimagnetic substances show better magnetism than antiferromagnetic substance.
3. (a) An element crystallises in b.c.c. lattice with cell edge of 400 pm. Calculate its density if 500 g of this element contains 2.5×10^{24} atoms. [Ans: 6.25 g/cm^3]
 (b) A metallic element crystallises into a lattice having a pattern of ABAB..... and packing of spheres leaves out voids in the lattice. What type of structure is formed by this arrangement? [Ans: HCP]
4. Mention the intermolecular forces present between :
 (a) H_2O and alcohol (b) Cl_2 and CCl_4 (c) He and He atoms (d) Na^+ ion and H_2O (e) HBr and HBr.
5. (a) Find the pressure of 4g of O_2 and 2g of H_2 confined in a bulb of 1 litre at 0°C .
 (b) What is the molar volume of a gas at SATP conditions ?
 (c) Define and explain Gay Lussac's law.
6. (a) For Dalton's law of pressure derive the expression $P_{\text{gas}} = X_{\text{gas}} P_{\text{total}}$.
 (b) A 2-L flask contains 1.6 g of methane and 0.5 g of hydrogen at 27°C . Calculate the partial pressure of each gas in the mixture and also, calculate the total pressure.

[Ans. $p_{\text{CH}_4} = 1.23 \text{ atm}$, $p_{\text{H}_2} = 3.079 \text{ atm}$, $P_{\text{total}} = 4.31 \text{ atm}$.]

7. (a) Using van der waal's equation calculate the constant ' a ' when two moles of a gas confined in a four litre flask exerts a pressure of 11.0 atm. at a temperature of 300 K. The value of ' b ' is $0.05 \text{ litre mol}^{-1}$.

[Ans. $6.49 \text{ atm L}^2 \text{ mol}^{-2}$]

8. (a) Mention the factors on which vapour pressure of a pure liquid depends.
(b) Define boiling point of a liquid.
(c) Which will have higher viscosity Glycerol or Ethylene glycol?

[Ans. Glycerol]

- (d) Surface tension of a liquid with increase in the magnitude of intermolecular forces.

[Ans. Increases]

