SOLID STATE

Why do the solids have fixed shape?

Ans: In solids, the molecules are tightly packed with no or very less intermolecular space that gives the certain shape so the solids have fixed shape.

1. Which of the following is not a feature is not a feature of solids?
   a. Fixed shape and volume
   b. Rigidity
   c. Frequent fluidity
   d. Definite mass

7.3.1 Types of solids

Solids can be classified on the basis of dominant type of bonds they involve. Viz

a. Ionic solids
b. Molecular solids
c. Covalent solids
d. Metallic solids

(as studied in detail in Chemical bonding and shape of molecules)

2. Which of the following statement is incorrect
   a. NaCl is a bad conductor in the solid state.
   b. NaCl consists of Na^+ and Cl^- ions.
   c. NaCl is a covalent solid.
   d. NaCl is a good conductor in solution and molten state.

1. *What are ionic crystals? Give examples.*

Ans: The crystal in which ions are arranged in a specific pattern to give certain structure is called ionic crystal. E.g. NaCl, KNO_3, KCl etc.

2. How does a covalent crystal differ from ionic crystal?

Covalent crystal	Ionic crystal
The crystal in which atoms are held	The crystal in which ions are arranged

together by covalent bonds are called covalent crystal .e.g.: diamond, graphite, silica etc.	in a specific pattern to give certain structure is called ionic crystal. E.g. NaCl, KNO_3 ,KCl etc.

3. What are molecular crystals? Give examples.

Ans: The crystal in which the molecules are constituent particles and are held together by weak Van der Waals force are molecular crystal. E.g., phosphorus, iodine etc.

4. Metallic crystals are good conductor of heat and electricity. Justify the statement.

Ans: The constituent of metallic crystals are metallic ions in the pool of valence electrons where kernels are embedded. Due to the presence of these free electrons, metallic crystals are good conductor of heat and electricity.

5. NaCl is bad conductor in solid state but good conductor in molten state. Explain.

Ans: In solid state, Na+ and Cl- ions are held strongly by ionic interaction so they are immobile but in molten state those ions are in mobile nature. So NaCl is bad conductor in solid state but good conductor in molten state.

6. Why the molecular crystals are soft and volatile?

Ans: Due to weak Van der Waals interaction among constituent molecules, molecular crystal are volatile and soft in nature.

7.3.2 Amorphous and crystalline solids

Amorphous solid	Crystalline solid
Amorphous solid do not possess certain geometrical shape and are super cooled liquids.	Crystalline solid possess certain geometrical shape and molecules are arranged in definite pattern in it.
They generally melt at a range of temperature.	They have sharp melting points.
They do not have sharp edges and plane surfaces.	They have sharp edges and plane surfaces.

They are isotropic.	They are anisotropic.

An isotropic solid is a solid material in which physical properties do not depend on the orientation. E.g. Glass

When the properties of a solid vary with different crystallographic orientations, the material is said to be anisotropic solid. E.g. NaCl crystal

3. Among the following which one is the crystalline solid?
   a. Sucrose c. Sand
   b. Glass d. Wood
4. Amorphous solid among the following is
   a. Table salt b. diamond c. plastic d. graphite
5. Which is pseudo solid?
   a. Glass c. Diamond
   b. Sodium Chloride d. $CaCO_3$
6. Amorphous solids do not have
   b. Sharp melting point
   c. Characteristic geometic shapes
   d. Regularity of the structure
   e. All of these
7. A crystalline solid has
   a. Definite geometric shape
   b. Flat faces
   c. Sharp edges
   d. All of these
8. A crystalline solid does not have which one of the following properties?
   a. It is anisotropic.
   b. It is isotropic.
   c. It has a sharp melting point.
   d. It has regular and definite geometry.
9. Amorphous solids are isotropic because
   e. They have the same value of any physical properties in different directions.

f. They have different values of physical properties in different directions
g. They have definite geometric shapes
h. None of the above.

1. *Distinguish between crystalline and amorphous solid. Give example of each.* 2
2. *Give any two important characteristic and two examples of crystalline solid.*2
3. *Give any two important characteristic and two examples of amorphous solid.*2
4. *What is meant by the term isotropy and anisotropic substance?* 2
5. *Distinguish between isotropic and anisotropic substance giving an example of each.* 2

7.3.3 Efflorescent, Deliquescent and Hygroscopic solids

Efflorescence

The spontaneous phenomenon of losing one or more water molecules (water of crystallization) by hydrated crystals when exposed to the atmosphere is called efflorescence and the substance is said to be efflorescent.

This occurs due to greater vapour pressure of the substance than the vapour pressure of the atmosphere. E.g. decahydrated sodium carbonate ($Na_2CO_3.10\ H_2O$) lose 9 water molecules of water of crystallization on exposure to form monohydrated salt. Other examples are $FeSO_4.7\ H_2O$, $CuSO_4.7H_2O$ etc.

Hygroscopy

Certain solids absorb water molecule from air and get hydrated. This is known as hygroscopy. Such solids are called hygroscopic solid. This is due to lower vapour pressure of such substance than the vapour pressure of the atmosphere.

For example anhydrous copper sulphate (II) exposed to air becomes pent hydrated salt.

Deliquescence

Some solids absorb moisture from the atmosphere to an extent that they become wet and even change into their solution in some instances. Such solids are said to be deliquescent solids and the phenomenon is called deliquescence.

This is also due to the lower vapour pressure of substance than the vapour pressure of atmosphere, E.g. anhydrous $CaCl_2$, NaOH, KOH etc.

10. Sodium carbonate is
    a. Efflorescent
    b. Hygroscopic
    c. Deliquescent
    d. oxidant

1. *Define: a. Efflorescence b. hygroscopy c. Deliquescence* *3*
2. *Give any two important characteristic and two example of efflorescent substance.* *2*
3. *Give reason- Efflorescent substances loose water of crystallization when exposed to atmospheric air.* *1*
4. *Mention any two important characteristic and two examples of deliquescent substance.* *2*
5. *Give reason- Deliquescent substances turn into liquid when exposed to atmospheric air.* *1*
6. *What is meant by the term hygroscopy?* *1*
7. *Distinguish between deliquescent and hygroscopic substance giving an example of each.* *2*
8. *Distinguish between efflorescent and deliquescent substance giving an example of each.* *2*
9. *Give an example of hygroscopic substance.* *1*

7.3.4 Crystallization and crystal growth

Crystallization is the slow precipitation (Precipitation is the formation of a solid in a solution during a chemical reaction or by diffusion in a solid) of crystals from a solution of a substance.

Crystallization may be defined as the process of obtaining crystals by cooling the saturated solution of the substance heated upto crystallization point.

Crystallization point is the temperature at which when saturated solution is heated is cooled to obtain crystals.

Crystals have their constituent particles arranged regularly in short and long range in fixed spots in the crystal lattice. But the constituent particles of liquid or solutions are irregularly arranged and moving continuously throughout the body of the liquid. So crystallization process involves arrangement of the particles in a regular pattern from the solution to crystals in a stepwise manner. This process is called crystal growth.

1. *Define crystallization and crystal growth.* 2

7.3.5 Water of crystallization

Most of the crystals consists of certain number of water molecules. The number of water molecules associated with one molecule of anhydrous solid to form hydrated crystal is called number of water of crystallization.

Crystals having water of crystallization are called hydrated salts and without water of crystallization are called anhydrous salts.

Water of crystallization serves as integral part of crystal and determines the geometry of the crystals even other properties in some cases.

Eg.

Molecular formula	Name	Common name
$CuSO_4.5H_2O$	Copper sulphate pentahydrate	Blue vitriol
$ZnSO_4.7H_2O$	Zinc sulphate heptahydrate	White vitriol
$FeSO_4.7H_2O$	Ferrous sulphate heptahydrate	Green viriol
$FeSO_4.(NH_4)_2SO_4.6H_2O$	Ferrous ammonium sulphate hexahydrate	Mohr's salt

There can be some crystals without water of crystallization e.g. NaCl crystals.

7. *Write differences between hydrated and anhydrous crystalline solid?*

Ans:

Hydrated crystalline solid	**Anhydrous** crystalline solid
The crystals which contain certain water molecule as its bonded part is hydrated crystalline solid.	The crystals which do not posses water of crystallization are anhydrated crystalline solid.
For example : pentahydrated copper sulphate ; $CuSO_4.5H_2O$	For example: sodium nitrate; $NaNO_3$

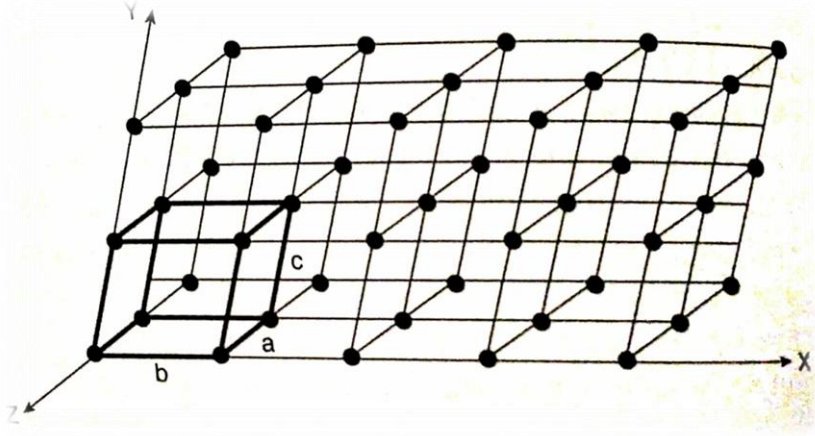
1. *What is meant by the term water of crystallization? Give two examples of water of crystallization.* 2

7.3.6 Introduction to crystal lattice and unit cell

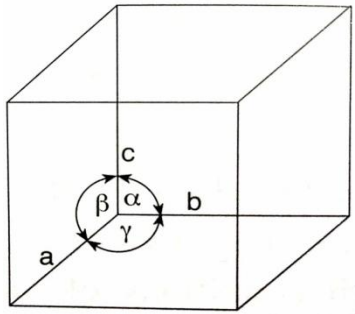
The constituent particles of a crystal are arranged in regular repeating manner in a 3D space.

The regular arrangement of the constituting units of a crystal in three dimensional spaces is called crystal lattice.

The points occupied by the constituent particles in a crystal are called crystal points or lattice points. Arrangement of these crystal points or lattice points in the crystals is called crystal lattice.



A three-dimensional smallest group of lattice points is called as unit cell.



11. In a crystal of NaCl, sodium ion is surrounded by :
    a. 6 Cl atom c. 6 Cl^- b. 12 Cl atom d. 12 Cl^-

1. *Distinguish between crystal lattice and unit cell.* 2
2. *Draw the structure of unit cell of NaCl.* 2

3. *Why sodium chloride doesn't conduct electricity in solid state but good conductor in molten state.*
4. *Define ionic crystal with its properties.*

Material for further study:

8. *Explain the process of determination of water of crystallization.*

Ans: the number of water molecules associated with one molecule of solid can be determinedby knowing the weight of anhydrous solid and associated with it and that is water of crystallization. This method of determination of water of crystallization is gravimetric method. In this method, certain amount of hydrated solid is taken in a clea, dried preweighed crucible followed by gradual heating to remove all the water of crystallization from it. The the weight of anhydrous solid is determined after xooling the crucible in dessicator. The process of heating, cooling and weighing is repeated until a consistent weight ofanhydrous solid is obtained. After knowing the weight of anhydrous solid , associated water and molecular weight of the compound, we can determine the the water of crystallization of the crystalline compound.

Let, weight of empty crucible= w1

Weight of crucible+ hydrated salt =w2

Weight of crucible +anhydrous solid= w3

Weight of hydrated solid = w2-w1

Weight of anhydrated solid= w3-w1

Weight of water = w2-w3

Now, (w3-w1)gm of anhydrous solidis associated with (w2-w3)gm of water molecules. Let the molecular weight of the salt be M then m gh of anhydrous salt is associated with (w2-w3)*M /(w3-w1)

So, the number of water associated with one molecule of the salt is = number of water of crystallization = (w2-w3)*M/(w3-w1)(M) .

9. How could the crystal of copper sulphate be prepared?

Ans: To prepare crystal of copper sulphate, here is the method:

Take China dish

Glass rod

Wash bottle

Copper sulphate

Burner

250 ml beaker

Wire gauze

Tripod stand

25 ml water

then follow the step as follows:

Method

1. Take a clean beaker (250 ml) and put the powdered impure sample of copper sulphate in it.

2. Add distilled water and stir the contents gently with the help of a glass rod.

3. In order to make the solution more clear add two or three drops of concentrated sulphuric acid in it.

4. Heat the solution in the beaker to 60-70^{0}C on a wire gauze.

5. Stir it continuously and add more impure copper sulphate until no more of it dissolves.

6. Filter the solution and collect the filtrate in a china dish.

7. Place the china dish over wire gauze kept over a tripod stand and heat it gently (do not boil).

8. As the solution gets heated, stir it with a glass rod. This helps in uniform evaporation and prevents the formation of a solid crust.

9. When the volume of the solution is reduced to one-half, take out a drop of the concentrated solution on one end of the glass rod and cool it by blowing air. Formation of thin crust indicates that crystallization point is reached.

10. Turn off the burner, cover the dish with a watch glass, and keep it undisturbed. As the solution cools down, crystals separate out. Slow cooling ensures better crystallization.

11. Decant the mother liquor and wash the crystals with a thin stream of cold water with the help of a wash bottle.

12. Dry the crystals by pressing them gently between sheets of filter paper.

After this we will observe Blue colored crystals of copper sulphate (CuSO4.5H2O) are formed.

By this, one can make crystal of copper sulphate.

*****This is not a complete note. It is just to guide you. It is recommended to study prescribed textbooks along with this material. *****