Characteristics of the Solid State and Differences between Crystalline and Amorphous Solids

Anu
Assistant Professor, Department of Physics, Indus Degree college, Kinana

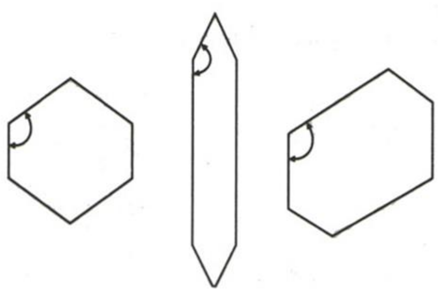
Abstract: "A crystal is a solid composed of atoms (ions or molecules) arranged in an orderly repetitive array." Most of the naturally occurring solids are found to have definite crystalline shapes which can be recognized easily. These are in large size because these are formed very slowly, thus particles get sufficient time to get proper position in the crystal structure. Some crystalline solids are so small that appear to be amorphous. But on examination under a powerful microscope they are also found to have a definite crystalline shape. Such solids are known as micro-crystalline solids.

Key Words: Crystal, Goniometer, Amorphous solids

I. INTRODUCTION

The smallest geometrical position of the crystal which can be used as repetitive unit to build up the whole crystal is called a unit cell."

The angle between two perpendiculars to the two intersecting faces is termed as the interfacial angle which may be same as the angle between the unit cell edges.



Interfacial Angle of a Crystal

Goniometer is used to measure the interfacial angle. It is important to note that interfacial angle of a substance remains the same although its shape may be different due to conditions of formation. This is known as law of constancy of interfacial angle or law of crystallography.

II. CHARACTERISTICS OF THE SOLID STATE

The solids are characterized by incompressibility, rigidity and mechanical strength. The molecules, atoms or ions in solids are closely packed i.e., they are held together by strong forces and cannot move about at random. Thus solids have definite volume, shape, slow diffusion, low vapour pressure and possess the unique property of being rigid. Such solids are known as true solids e.g., NaCl, KCl, Sugar, Ag, Cu etc.

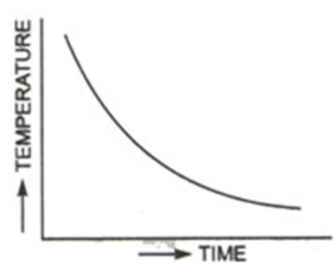
On the other hand the solid which loses shape on long standing, flows under its own weight and is easily distorted by even mild distortion force, is called pseudo solid e.g., glass, pith etc. Some solids such as NaCl, sugar, sulphur etc. have properties not only of rigidity and incompressibility but also of having typical geometrical forms. These solids are called crystalline solids. In such solids there is definite arrangement of particles (atoms, ions or molecules) throughout the entire three dimensional network of a crystal. This is named as long-range order. This three dimensional arrangement is called crystal lattice or space lattice. Other solids such as glass, rubber, plastics etc. which have rigidity and incompressibility to a certain extent but they do not have definite geometrical forms or do not have long-range order are known as amorphous solids.

Differences between Crystalline and Amorphous Solids

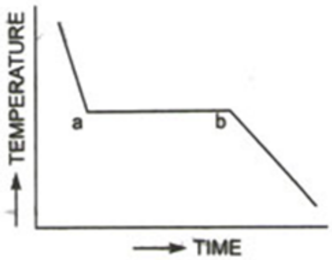
(i) Characteristic Geometry: In crystalline solids, the particles (atoms, ions or molecules) are definitely and orderly arranged. Thus these have characteristic geometry while amorphous solids do not have characteristic geometry.

(ii) Melting Point: A crystalline solid has a sharp melting point i.e., it changes into liquid state at a definite temperature. On the contrary, an amorphous solid does not have a sharp melting point. For example, when glass is heated, it softens and then starts flowing without undergoing any abrupt or sharp change from solid to liquid state. Therefore, amorphous solids are regarded as "liquids at all temperatures".

(iii) Cooling curve: Amorphous solids show smooth cooling curve while crystalline solids show two breaks in cooling curve. In the case of crystalline solids two break points 'a' and 'b' appear. These points indicate the beginning and the end of the process of crystallization.



Cooling curve of an amorphous solid

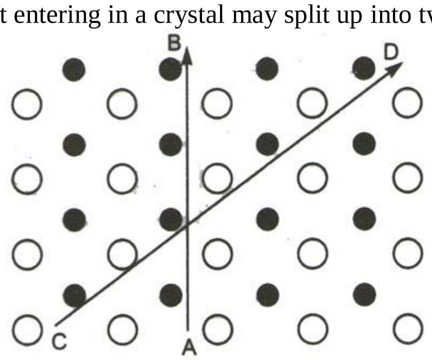


Cooling curve of a crystalline solid

In this time interval temperature remains constant. This is due to the fact that during crystallization process, energy is liberated which compensates for the loss of heat, thus the temperature remains constant.

(iv) Isotropy and Anisotropy: Amorphous solids differ from crystalline solids and resemble liquids in many respects. The properties of amorphous solids, such as electrical conductivity, thermal conductivity, mechanical strength, refractive index, coefficient of thermal expansion etc. are same in all directions. Such solids are known as isotropic. Gases and liquids are also isotropic.

On the other hand, crystalline solids show these physical properties different in different directions. Therefore crystalline solids are called anisotropic. The anisotropy itself is a strong evidence for the existence of orderly molecular arrangement in crystals. For example, the velocity of light passing through a crystal is different in different directions. A ray of light entering in a crystal may split up into two



Anisotropic behaviour of crystals

components, each following a different path and traveling with a different velocity. This phenomenon is called double refraction. In the figure, two different kinds of atoms are shown in two dimensional arrangement. If the properties are measured along the direction CD, they will be different from those measured along the direction AB. This is due to the fact that in the direction AB each row is made up of one type of atoms while in the direction CD each row is made up of two types of atoms. It is important to note that in the case of amorphous solids, liquids and gases, atoms or molecules are arranged disorderly. Therefore all directions are identical and all properties are same in all directions.

(v) Cutting: Crystalline solids give clean cleavage while amorphous solids give irregular cut, due to conchoidal fracture on cutting with a sharp edged tool.

III. CONCLUSION

Thus the crystallinity of a crystal may be defined as "A condition of matter resulting from an orderly, cohesive, three dimensional arrangement of its component particles (atoms, ions or molecules) in space". This three dimensional arrangement is called crystal lattice or space lattice. The positions occupied by the particles in the crystal lattice are called lattice sites or lattice points. The lattices are bound by surfaces that are usually planar and are known as faces of the crystal.

IV. REFERENCES

[1]. Introduction to Solid State Physics (7th edition) by Charles Kittel
[2]. Solid State Physics by Neil W. Ashcroft and N. David Mermin
[3]. Applied Solid State Physics by Rajnikant
[4]. http://www.xtal.iqfr.csic.es/Cristalografia/parte_01_3-en.html