Biomaterials

المحاضرة الثانية

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Structure of Solid

Introduction

In a solid metals ,principally composed of atoms, molecules, and/or ions but their distribution in the matter depends upon the state it is representing, that is, either solid, liquid, or gaseous. Depending on the state, the molecular structures of solid, liquid, and gases are geometrically and structurally different. This difference in structure is primarily due to the variation of the arrangement of molecules in liquid, solid, and gases

The particles in the gases are far away from each other and thus are well separated and do not have a definite shape. Because of the large distance between the molecules of gases, they move quite easily and very fast causing vibration, therefore, possessing high kinetic energy.

On the other hand, liquid molecules are close together but are not tightly packed; they do not show any definite molecular arrangements and have no definite shape of their own. The liquid vibrates and slides across each other with lesser speed as compared to gases and therefore shows less kinetic energy.

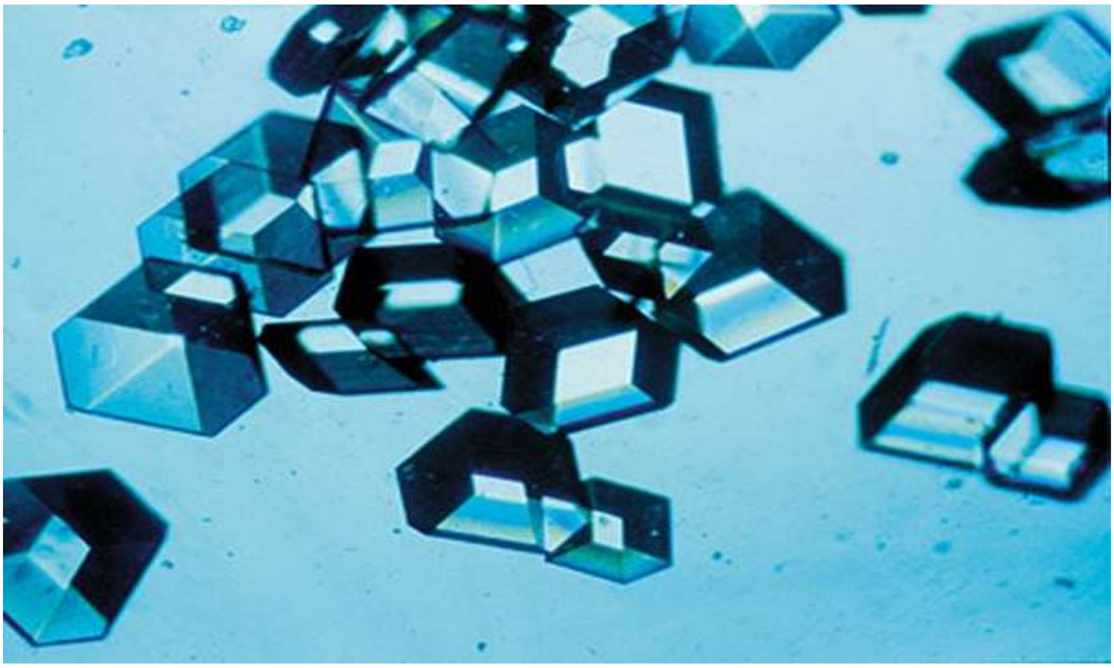
In solid matters, the molecules are tightly packed with each other in a definite arrangement and thus have a defined structure, shape, and size. Solid vibrates but its molecules do not move from place to place. The molecular structure of solid, liquid, and gas .

Properties of Solids

In the solid state, the particles do not have enough energy to overcome the strong intermolecular forces, which means they are tightly held against each other. As a result, solids have a definite shape and volume.

The particles vibrate back and forth within their fixed positions and do not move freely. Solids are incompressible and have high density, compared to liquids and gases. They can be crystalline, like table salt, or amorphous, like glass, rubber or plastic.

Many elements exist as solid-state at room temperatures, such as sodium, vanadium and magnesium.



Properties of Liquids

In the liquid state, the intermolecular forces between the particles are strong enough to have a definite volume. However, they are not strong enough to have a definite shape. Consequently, the particles move freely, but they are still attracted to each other. Liquids are incompressible but conform to the shape of the container. They are slightly less dense than the solid state, 10% less dense on average. They usually exhibit surface tension, capillary action, and viscosity.

Mercury is an example of a liquid metal with a very high cohesion and surface tension, which makes it easily bead up when spilled.

Water is a liquid with many unusual properties, such as expanding when it freezes. This is due to its hydrogen bonding.

Properties of Gases

In the gaseous state, the particles have enough kinetic energy to overcome the weak intermolecular forces between each other. Therefore, they move in random motion without being attracted to each other. As a result, gases have neither a definite shape nor volume. They consist of widely separated molecules.

Gases are compressible and have low density – often 1,000 times less dense than the liquid or solid phase. Gases can diffuse, and they exert pressure on surfaces with which they collide..

At room temperature, some elements exist as gas. Examples of these elements is fluorine, hydrogen and helium.

TYPES OF MATERIALS

Materials can be classified into different groups based on their crystal structure, bonding, and macrostructures. Each subgroup of materials shows somewhat similar properties and then those materials can be clubbed together to study their performance for different applications. If we look at types of bonding, materials can be classified into three broad categoriesd metals, ceramics and polymers. Materials that are bonded via metallic bonds are called metals. Due to abundance of free electrons in metallic bonds, metals are both thermally and electrically conductive, and show malleability in terms of their mechanical properties. Materials that are primarily ionic and/or covalently bonded are called ceramics. Since ionic and covalent bonds do not offer any free electrons, ceramics are generally no conducting materials both thermally and electrically. However, due to the movements of defects, some ceramics show conductivity at higher temperature. Materials that are based on long carbon chain and covalently bonded with some secondary bonding are polymers, where “mers” or units are connected in the long range. Due to covalent bonding, most polymers are no conducting. When any three of these main materials are mixed together without losing its inherent characteristics, then we form a new class of materials, called composites. Some examples of natural composites are wood and bone.

the unit cell, the basic building block of any material, we can classify materials into three groups crystalline, semi crystalline and amorphous. If the unit cell is repeated in all three directions and maintains a long-range order, then those materials are called a crystalline material such as iron, titanium, chromium or polycrystalline ceramics. The basic unit cell, defined by the three-dimensional shape and atom positions, can be for example body centered cubic or face centered cubic or hexagonal close packed (hcp), where “cubic” or “hexagonal” are crystal systems defined by the shape of the unit cell and “body centered” or “face centered” Materials can also be classified as natural or synthetic. Natural materials are those which are available in nature such as wood, rocks, corals and bones. Most natural materials are ceramics, polymers and their composites. Synthetic materials are man-made materials designed for specific functionality. These materials include metallic materials such as steels for fracture management devices, to titanium and its alloys for implant, to polymers for ocular lenses and to ceramics for bone-tissue engineering.

Materials can also be classified based on their macrostructures such as

dense or porous. Most natural materials such as rocks, tissues, wood are porous materials. Porosity in these materials can serve various purposes. Most ceramic materials have residual porosity. Porosity can be nonuniform and vary in size and distribution. Porosity in materials can vary from 1% to 10% such as in cortical bone to as high as >70% in some cancellous bones

Figure 1.1 schematically shows different types of materials. Any one material can also fall into many of these categories. For example, bone is a natural material, that is porous, and a ceramic–polymer composite

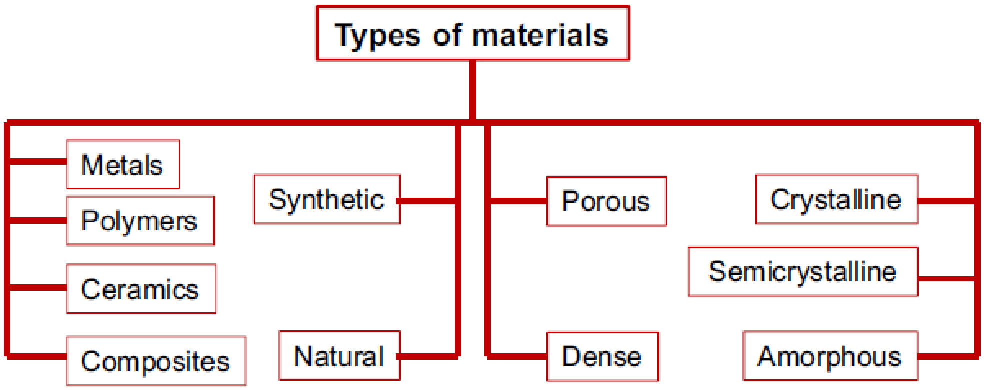


FIGURE 1.1 Different types of materials.