Second lecture

Structure of Solid

Fourth Stage

Department of medical physics

Al-Mustaqbal University-College

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Structure of Solid

Introduction

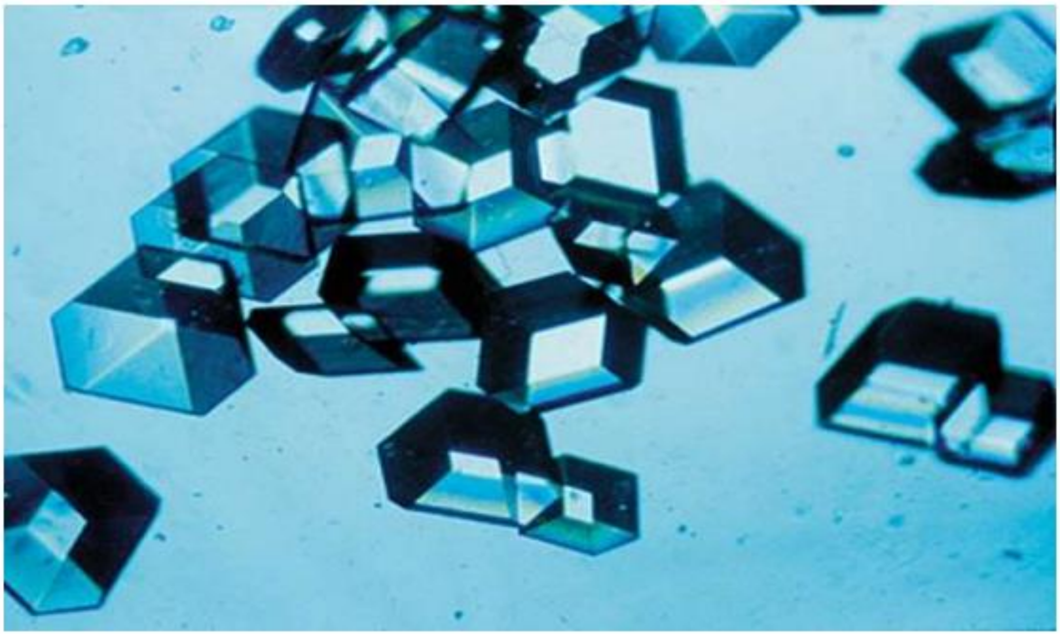
In a solid metals ,principally composed of atoms, molecules, and/or ions but their distribution in the matter depends upon the state it is representing, that is, either solid, liquid, or gaseous. Depending on the state, the molecular structures of solid, liquid, and gases are geometrically and structurally 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 categories 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 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 no uniform 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 chancellors 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.

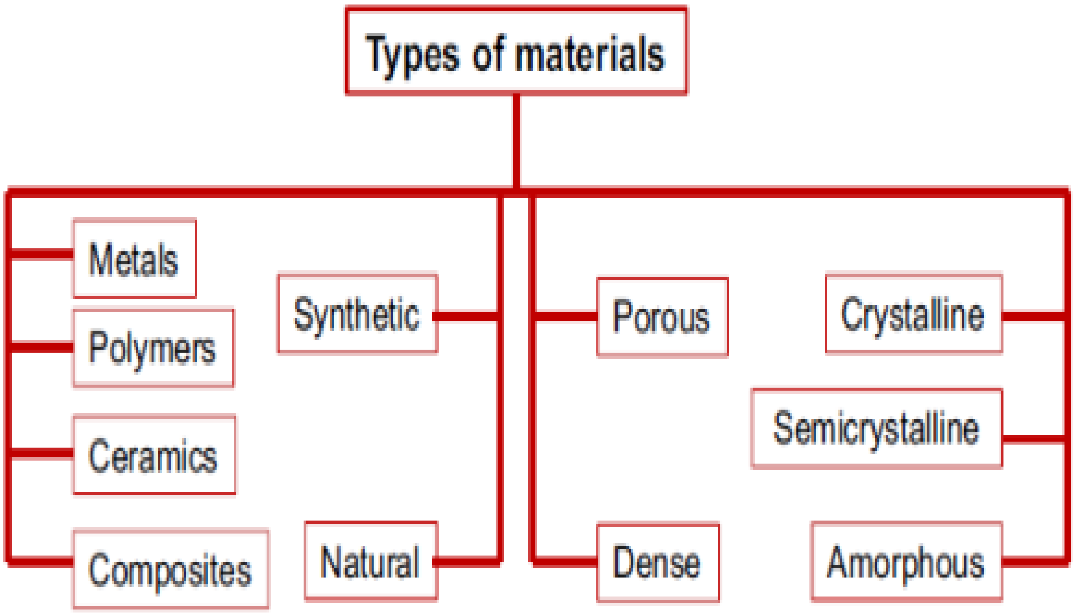


FIGURE 1.1 Different types of materials.

Materials for Use in the Body

Materials	Advantages	Disadvantages	Examples
Polymers (nylon, silicon Rubber, polyester, PTFE, etc)	**Resilient Easy to Fabricate**	**Not strong Deforms with time May degrade**	**Blood vessels, Sutures, ear, nose, Soft tissues**
Metals (Ti and its alloys Co-Cr alloys, stainless Steels)	**Strong Tough ductile**	**May corrode, dense, Difficult to make**	**Joint replacement, Bone plates and Screws, dental root Implant, pacer, and suture**
Ceramics (Aluminum Oxide, calcium phosphates, including hydroxyapatite carbon)	**Very biocompatible Inert strong in compression**	**Difficult to make Brittle Not resilient**	**Dental coating Orthopedic implants Femoral head of hip**
Composites (Carbon-carbon, wire Or fiber reinforced Bone cement)	**Compression strong**	**Difficult to make**	**Joint implants Heart valves**