Solid State

Introduction

Abeer Alshammari

What is solid state physics?

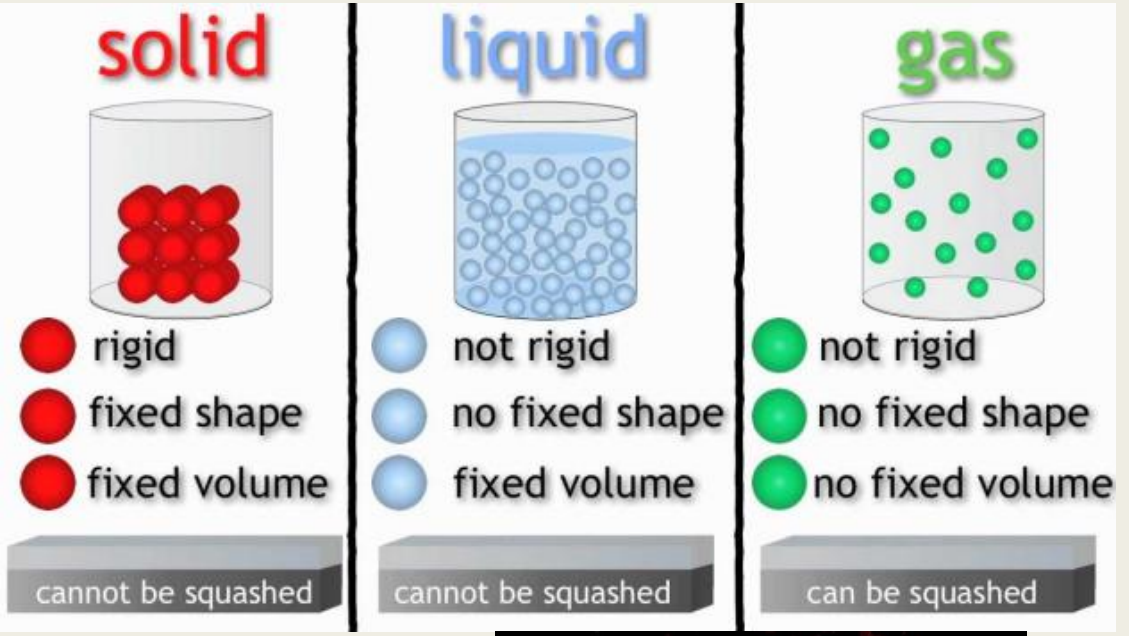
- Explains the properties of solid materials.
- Explains the properties of a collection of atomic nuclei and electrons interacting with electrostatic forces.
- Formulates fundamental laws that govern the behaviour of solids.

Outline

-Types of solids
-Types of crystalline
-classification of solids according to conductivity
-study of properties of solids

The States of Matter

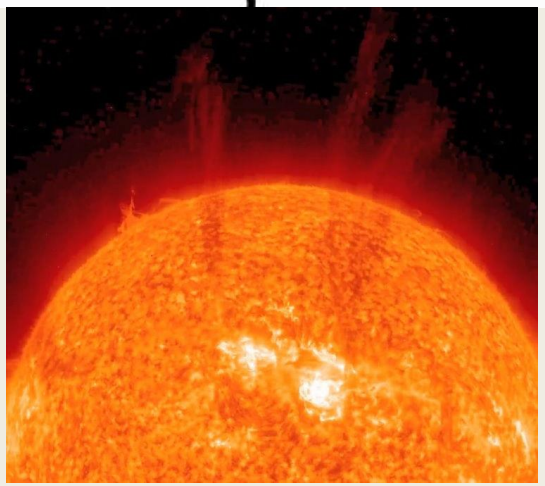
Building blocks – if you closely enough, everything is made of atoms and molecules!



fourth state of matter (Plasma)

A **plasma** is a hot ionized gas consisting of approximately equal numbers of positively charged ions and negatively charged electrons

Plasma makes up the sun and stars, and flames



Bose-Einstein condensates

A Bose-Einstein condensate is a group of atoms cooled to within a hair of absolute zero. When they reach that temperature the atoms are hardly moving relative to each other; they have almost no free energy to do so. At that point, the atoms begin to clump together, and enter the same energy states. Then they behave as a single atom.

Solids: The particles in a solid are packed close together and are fixed in position.

though they may vibrate

The close packing of the particles results in solids being incompressible.

The inability of the particles to move around results in solids retaining their shape and volume when placed in a new container, and prevents the solid from flowing.

Types of solids according to the arrangement of atoms:

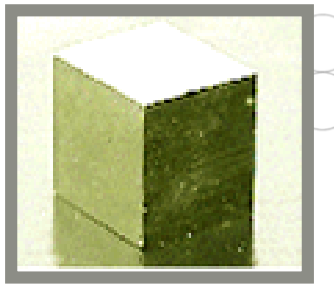
-Crystalline Solids

-Glassy (Amorphous) solids

- Para-crystalline solids

CLASSIFICATION OF SOLIDS

- SOLID MATERIALS
  - CRYSTALLINE
    - Single Crystal
  - POLYCRYSTALLINE
  - AMORPHOUS (Non-crystalline)



Crystalline

- **atoms pack in periodic, 3D arrays**
- **long rang order**
- **Melt at sharp temperature**
- **Can be cleaved along definite planes**
- **In general, are anisotrophic**
- **More rigid**

  Like: salt , diamonds, sugar

Noncrystalline (amorphous)

- **atoms have no periodic packing**
- **random order**
- **Do not have a sharp melting point**
- **Isotrophic**
- **Less rigid**
- **Undergo irregular breakage**

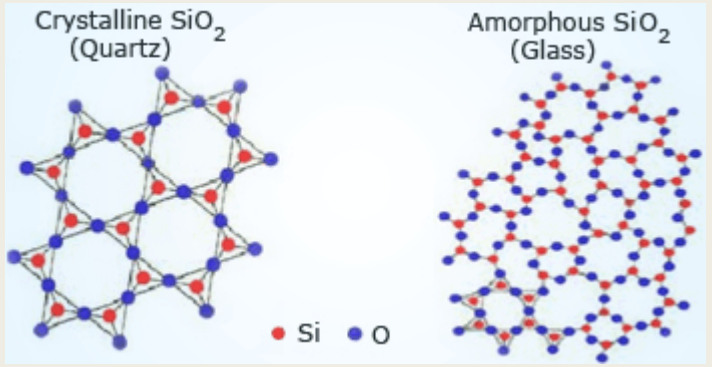
  e.g :plastic , glass, charcoal

Para-Crystalline

- **atoms pack in periodic, 3D arrays, short- range order**

Nacl

bismuth



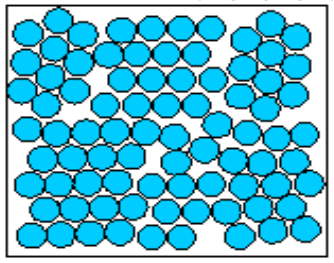
Is Glass a (Supercooled) Liquid?

Crystalline Solids

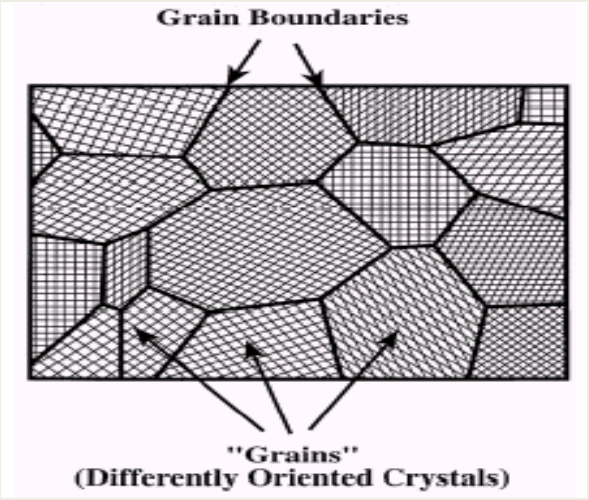
- Crystalline materials are solids with an atomic structure based on a regular repeated pattern.
- The majority of all solids are crystalline.
- More progress has been made in understanding the behavior of crystalline solids than that of non-crystalline materials since the calculation are easier in crystalline materials.
- Understanding the electrical properties of solids is right at the heart of modern society and technology.

POLYCRYSTALLINE SOLIDS

- **Polycrystalline materials** are made up of an aggregate of ***many small single crystals*** (also called crystallites or grains).
- **Polycrystalline materials** have a high degree of order over many atomic or molecular dimensions.
- ***Grains (domains)*** are separated by ***grain boundaries.*** *The atomic order can vary from one domain to the next.*
- The grains are usually ***100 nm - 100 microns in diameter***.
- Polycrystals with grains less than 10 nm in diameter are **nanocrystalline**



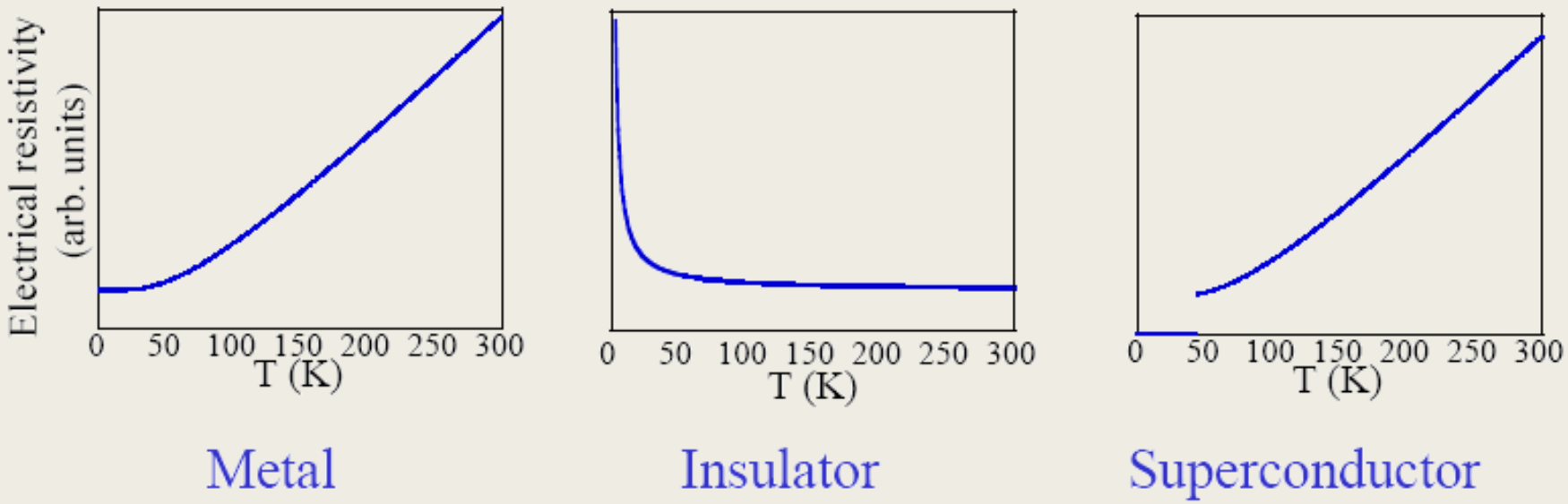
Polycrystalline Pyrite form (Grain)

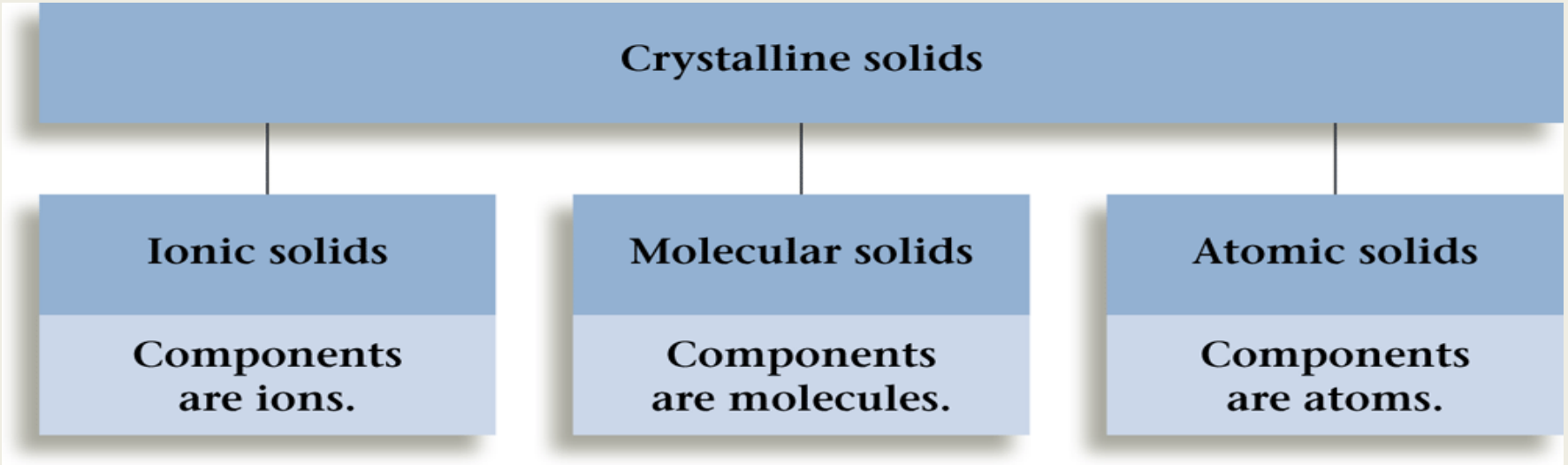


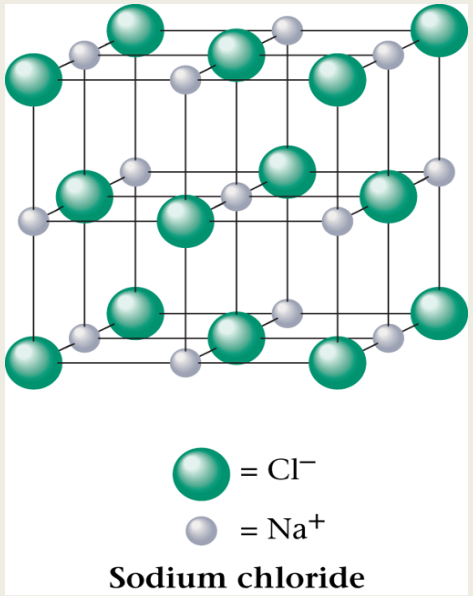
Electrical resistivity of three solid Carbon states

- How can this be? After all, they each contain a system of atoms and especially electrons of similar density. And the plot thickens: graphite is a conductor, diamond is an insulator and buckminster-fullerene is a superconductor.

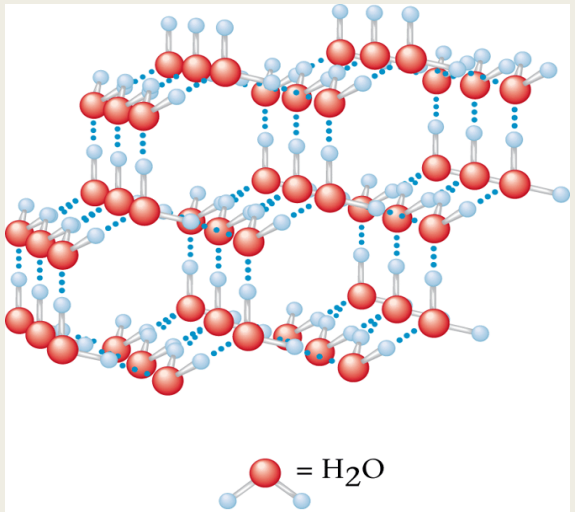
They are all just carbon!



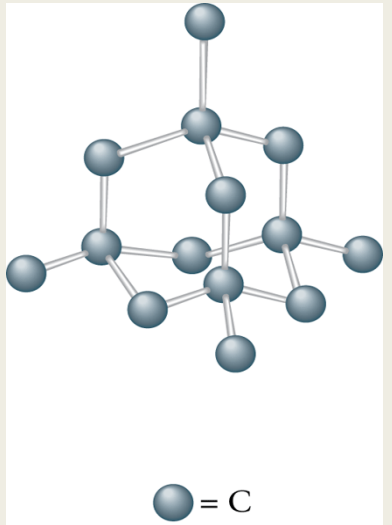




Sodium chloride



Ice



Diamond

Classification Of Materials On The Basis Of Conductivity

Conductors:- These are those materials whose electrical conductivity is very high. Conductors conduct charges very easily . For super-conductor , the value of electrical conductivity is infinite.
Examples. Copper,Silver.Aluminum,Tungsten etc.

Semiconductors:- They are those materials whose electrical conductivity lies in between insulators and conductors . Semiconductors can conduct charges but not so easily as in case of conductivity.
Examples. Germanium.Silicon etc.

Insulators:- These are those materials whose electrical conductivity is either very very small or nil. Insulators do not conduct charges.
Examples. Glass,Rubber,Wood etc.

semi-metals, are elements with properties intermediate between metals and non-metals
Examples. Graphene, boron nitride

Super Conductor: **A substance is said to be superconducting when it offers no resistance to the flow of electricity. Electrical resistance decreases with decreases in temperature and becomes almost zero near the absolute zero.**

Study of properties of solids

Electrical properties of solids may arise through the motion of electrons and positive holes (electronic conductivity) or through the motions of ions (ionic conductivity).

- Electrical conductivity of metal is due to motion of electrons and it increases with the number of electrons available to participate in the conduction process.
- Pure ionic solids where conduction can take place only through motion of ions are insulators. However, the presence of defects in the crystal structure increases their conductivity.

The magnetic properties of different materials are studies in terms of their magnetic moments which arise due to the orbital motion and spinning motion of the electron.

- As electron is charged particle, the circular motion of the electric charge causes the electron to act as a tiny electro magnet.
- The electron also possesses magnetic moment due to the spin which is directed along the spin axis.

Questions

1-Why the gases are compressible?
2- Is it possible to transfer glassy solids to crystalline?
3- what do you know about the graphite?