

The Particulate Nature of Matter

1. Kinetic particle theory

- States of matter
 - Solid
 - Particles have a regular arrangement
 - ❖ Fixed shape
 - Particles are closely packed and cannot come closer to each other
 - ❖ Cannot be compressed
 - Particles have very strong attractive forces between them
 - ❖ Fixed volume
 - Particles vibrate and rotate about fixed positions
 - ❖ Does not take shape of container
 - Liquid
 - Particles have an irregular arrangement
 - ❖ No fixed shape
 - Particles are loosely packed, but still cannot come close to each other
 - ❖ Cannot be compressed
 - Particles have some attractive forces between them, but not as strong as in solids
 - ❖ Fixed volume
 - Particles vibrate, rotate and move freely within the liquid, keeping in contact with each other
 - ❖ Takes the shape of the container
 - Gas
 - Particles have an irregular arrangement
 - ❖ No fixed shape
 - Particles are spread far apart, and have space to come closer to each other
 - ❖ May be compressed
 - Particles have negligible forces of attraction between them
 - ❖ No fixed volume
 - Particles vibrate, rotate and move with no restrictions at high speeds
 - ❖ Takes the shape and volume of container
- Changes in state
 - Melting
 - Solid → Liquid
 - The particles gain energy and vibrate and rotate about their fixed positions more vigorously

- Eventually they gain enough energy to weaken the attractive forces between particles and break from their fixed positions.
 - They can now move freely within the liquid
- Boiling
 - Liquid → Gas
 - The particles gain energy and move about more quickly, while keeping in contact with each other
 - Eventually they gain enough energy to overcome almost all the attractive forces
 - They can now leave the liquid and move freely without constraints
- Freezing
 - Liquid → Solid
 - The particles lose energy and move about less quickly, while keeping in contact with each other
 - Eventually they lack the energy to continue to move freely with the liquid
 - They then vibrate and rotate about their fixed positions, as stronger forces of attraction is formed between particles
- Condensing
 - Gas → Liquid
 - The particles lose energy and move about less quickly
 - Eventually they lack the energy to continue to move freely without constraints
 - They then move closer to each other, moving freely while keeping in contact with each other, as stronger forces of attraction is formed between particles
- Sublimation
 - Solid → Gas
 - Particles at the surface possess so much energy they vibrate and rotate about their fixed positions extremely vigorously
 - They have enough energy to overcome most of the attractive forces, and break away from their fixed positions
 - They then can move freely with no constraints at high speeds
- Evidence for movement of particles
 - Liquid
 - Potassium permanganate dissolves at the base in a beaker, forming a dark purple solution at the bottom
 - Over time, the colour spreads until the whole beaker is uniform in colour
 - Gas

- Two gas jars are connected to each other, one contains brown bromine, other contains colourless air
 - After some time, both gas jars would be of the same brown colour
- Diffusion
 - It is the movement of liquid/ gaseous particles from a region of higher concentration to a region of lower concentration
 - When both regions are the same, they have a homogenous mixture
 - Factors
 - Molecular mass
 - ❖ The smaller the mass, the lighter the particle is, hence the faster it diffuses
 - Temperature
 - ❖ The higher the temperature, the faster the particles move about, hence the faster they diffuse

2. Atomic structure

- Sub-atomic particles
 - Proton
 - Positive charge, +1
 - Relative mass = 1
 - Neutron
 - No charge
 - Relative mass = 1
 - Electron
 - Negative charge, -1
 - Relative mass = $1/1840$ (negligible)
- Proton/ atomic number
 - It is the number of protons in an atom
 - Can be used to find number of electrons
- Nucleon/ mass number
 - It is the total number of protons and neutrons in an atom
- Isotopes
 - They are two or more atoms with the same number of protons, but different number of neutrons
 - Hence they have similar chemical properties, but different physical

3. Structure and properties of material

- Elements
 - It is a pure substance that cannot be split up into two or more simpler substances by chemical means or electricity
- Compounds

- It is pure substance that contain two or more different elements that are chemically combined and cannot be separated by physical means
- Mixtures
 - It is two or more substance added together without any chemical bonds being formed, allowing the to be separated by physical methods
- Differences

	Mixture	Compound
Separation	Can be separated by physical means	Only by chemical means
Properties	Chemical properties are same as the components	Physical and chemical properties differ from the components
Energy change	Little or no energy change	Has energy change
Composition	No fixed composition	Components are in fixed proportions

4. Ionic bonding

- What
 - It is the transfer of electrons from a metal to a non-metal, in order to achieve noble gas configuration
- Structure
 - Ionic compounds are a lattice of positive and negative ion when are held together by electrostatic forces of attraction
- Properties
 - Have high melting and boiling points
 - Generally soluble in water, not in organic solvents
 - Can conduct electricity in aqueous or molten state

5. Covalent bonding

- What
 - It is the sharing of electrons between two or more non-metals, in order to achieve noble gas configuration
- Simple
 - The atoms in a molecule are held together by strong covalent bonds
 - But between molecules there are weak intermolecular forces of attraction
 - Properties
 - Low melting and boiling points
 - Generally insoluble in water, but soluble in organic solvents
 - Cannot conduct electricity
- Giant
 - All the atoms are covalently bonded together to form one giant molecule (macromolecule)
 - Diamond

- An allotrope of carbon
 - ❖ Each carbon atom is bonded to four others, forming tetrahedral arrangement
- Properties
 - ❖ High melting and boiling points
 - ❖ Hard
 - ❖ Does not conduct electricity
- Graphite
 - An allotrope of carbon
 - ❖ Made up of layers of carbon atoms
 - ❖ Each carbon atom is bonded to three others, forming a hexagonal arrangement
 - ❖ Each layer is held together by weak intermolecular forces
 - Properties
 - ❖ High melting and boiling point
 - ❖ Soft and slippery
 - ❖ Can conduct electricity along plane

6. Metallic bonding

- What
 - A lattice of positive ions in a 'sea' of delocalized electrons
- Properties
 - Good conductors of electricity
 - Malleable and ductile