Solids, Liquids & Gases

Describe the structures of ***Solids, Liquids*** and ***Gases.***
Give 4 properties of each.

What are the 4 ***State Symbols***?

Define the following processes:
Melting
Boiling
Freezing
Condensation
Sublimation

Sketch a typical ***Heating Curve*** and describe what is happening at each stage and temperature.

0620/0971/03

Structure and Properties:

	Structure	Properties
Solids	Particles arranged in fixed lattice; particles can only vibrate	• Fixed shape • Fixed volume • Do not flow • Higher density than liquids & gases
Liquids	Particles close together; particles can move about	• Shape can change • Fixed volume • Can flow • Higher density than gases, lower than solids
Gases	Particles far apart; particles move quickly	• Shape can change • Volume can change *(expand to fill container)* • Can flow • Lower density than liquids & gases

State Symbols:

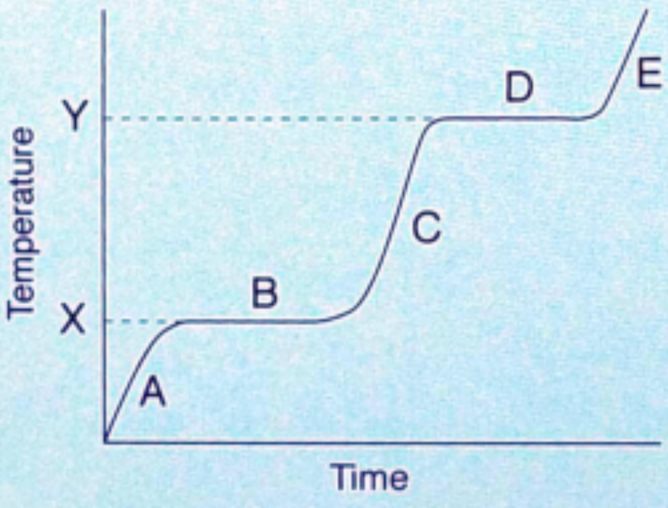
Aqueous: *(aq)* Solid: *(s)* Liquid: *(l)* Gas: *(g)*

Aqueous means "dissolved in water"

Changing State:

Melting: **Solid** changes into **liquid** *(at the **melting point**)*
Boiling: **Liquid** changes into **gas** *(at the **boiling point**)*
Freezing: **Liquid** changes into **solid** *(at the **melting point**)*
Condensation: **Gas** changes into **liquid** *(at the **boiling point**)*
Sublimation: **Solid** changes into **gas** *(without going through a liquid state)*

Heating Curve:



A: Solid heating up
B: Solid melts (turns into liquid)
C: Liquid heating up
D: Liquid boils (turns into gas)
E: Gas heating up

X = Melting point
Y = Boiling point

Diffusion & Brownian Motion

Define *Diffusion*.
What factors affect the rate of diffusion?
Describe an experiment that demonstrates one of these factors.

What is ***Brownian Motion?*** What causes it?
State two observations which are evidence for Brownian Motion.

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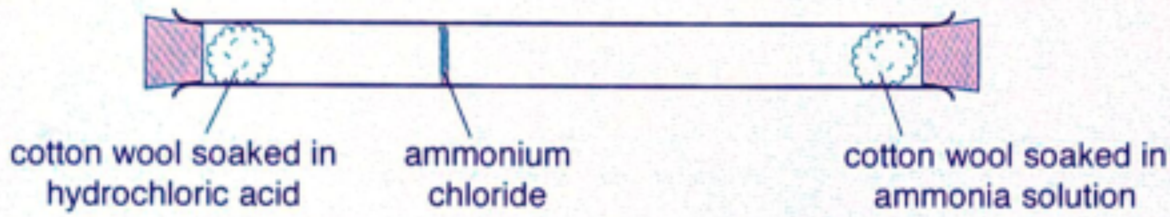
Diffusion:

- The process by which particles in liquids and gases mix together or spread out by colliding with each other
- Particles move down a concentration gradient from a high concentration to a low concentration

Factors Affecting Diffusion:

- Temperature (higher temperature = faster diffusion)
- Molecular Mass, M_r (higher molecular mass = slower diffusion)

Experiment to Demonstrate Diffusion:



*Gases evaporate from the two solutions and diffuse down the tube at different rates. **Ammonia** has a **lower molecular mass** so it diffuses **faster** than hydrochloric acid. Therefore the gases meet closer to the hydrochloric acid end, where they react to form a white ring of ammonium chloride.*

Brownian Motion:

The random motion of large particles in a gas or suspended in a liquid

This is caused by collision of the molecules in the surrounding gas or liquid with the large particles (i.e. particles which are visible with the naked eye or a microscope)

Evidence for Brownian Motion:

- Pollen grains move randomly in water when observed under a microscope
- Dust particles move randomly in the air (only visible when illuminated by bright sunlight)

Atomic Structure

Name the particles atoms are made of.
State the relative mass and charge of each particle and say where in the atom it is found.

Define ***Nucleon Number*** and ***Proton Number***.
What notation is used to represent a nucleus?

How many electrons can each of the first 3 shells hold?

What are ***Valency Electrons***?

How is the stability of atoms related to their electronic structure?

Atomic Structure:

Particle	Mass	Charge	Location
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	$\frac{1}{2000}$	−1	Shells orbiting the nucleus

Notation:

$$^{A}_{Z}X$$

A = ***Nucleon Number** (Mass Number) = total number of protons and neutrons

Z = ***Proton Number** (Atomic Number) = number of protons

Number of Electrons in Shells:

1st Shell – up to 2 electrons

2nd Shell – up to 8 electrons

3rd Shell – up to 8 electrons

Valency Electrons:

The electrons in the **outermost** shell

Stability:

Atoms with a **full outer shell** are stable

Atoms achieve full outer shells by gaining, losing or sharing electrons through bonding

Structure & Bonding Definitions

Define the following terms:

Atom
Element
Isotope
Compound
Mixture
Ion
Cation
Anion
Allotrope
Radioisotope

Give 3 uses of radioisotopes.

Atom:

The smallest particle of a chemical element, which cannot be broken down further (by chemical means)

Element:

A group of atoms which all have the same number of protons

***Isotopes:**

Atoms with the same number of protons but different numbers of neutrons

They are the same element because they have the same number of protons
They have the same chemical properties because they have the same number of electrons

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Compound:

A substance in which two or more elements are chemically combined

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Mixture:

A combination of two or more substances that are not chemically combined

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Ion:

An atom where the number of electrons is different from the number of protons, so it has an overall charge

Cation: A positively charged ion (i.e. fewer electrons than protons)

Anion: A negatively charged ion (i.e. more electrons than protons)

Allotropes:

Different forms of the same element, e.g. diamond and graphite

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Radioisotopes:

Unstable isotopes which give out radiation when they decay. They can be used for:

Tracers: Checking oil/gas pipes for leaks by adding radioisotopes to the oil/gas, then checking for radiation outside the pipe

Radiotherapy: Treating cancer (because gamma rays kill cancer cells)

Sterilisation: Gamma rays can kill bacteria on food (so that it does not go off as quickly) and on medical instruments

Ionic & Covalent Bonding

Explain *Ionic Bonding*.
How are ions formed?
Describe and draw the structure.

Explain *Covalent Bonding*.
Name the 2 types of covalent structure.
What is a *Molecule*?
What are *Intermolecular Forces*?

Compare the properties of *Ionic* compounds with those of *Simple Molecular Covalent* compounds.

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Ionic Bonding:

Occurrence: Between a metal and a non-metal

Ionic Bond: Attraction between positive metal ions and negative non-metal ions

Forming Ions:

- Metals **lose electrons** to form **positive ions**
- Non-metals **gain electrons** to form **negative ions**

Structure:

Giant ionic lattice (a regular arrangement of alternating positive ions and negative ions)

Covalent Bonding:

Occurrence: Between non-metals

Covalent Bond: A shared pair of electrons

Structures:

- Simple Molecular
- Giant Covalent Lattice (Covalent Macromolecules)

Molecule: A group of atoms held together by covalent bonds

Intermolecular Forces: Weak forces between covalently-bonded **molecules**

Comparing Properties – Ionic vs Simple Molecular Covalent:

Property	Ionic	Covalent (Simple Molecular)
State at room temperature	Solid	Solid, liquid or gas *(depending on structure)*
Melting & Boiling Points	High *strong attraction between ions requires a lot of energy to overcome*	Low *due to weak intermolecular forces*
Volatility	Not volatile *(do not evaporate)*	Volatile *(evaporate easily)*
Solubility	Usually soluble in water	Most are insoluble in water, but many dissolve in organic solvents
Electrical Conductivity	Only conduct electricity when aqueous (i.e. dissolved) or molten (i.e. liquid)	Do not conduct electricity

Covalent Macromolecules

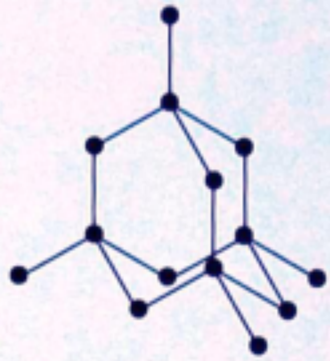
Name 3 *Covalent Macromolecules*.

Describe their structures and list their properties.

Give uses of each.

Diamond:

A giant lattice where each carbon atom forms strong covalent bonds with 4 other carbon atoms



Properties:

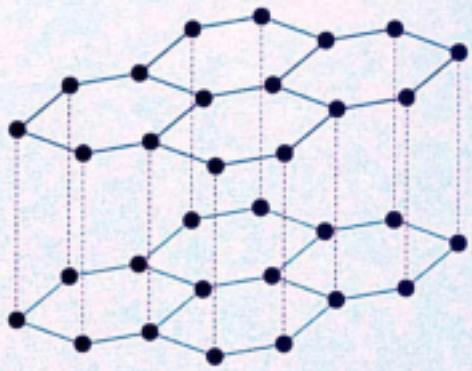
- Hardest known substance
- Does not conduct electricity
- Very high melting point (3550 °C)
- Cut diamonds sparkle

Uses: Jewellery, making tools for drilling and cutting

Graphite:

- A giant lattice where each carbon atom forms strong covalent bonds with 3 other carbon atoms, forming layers of hexagons
- Many layers are stacked on top of one another, held together by weak forces
- The 4th valence electron moves freely between the layers

Properties:



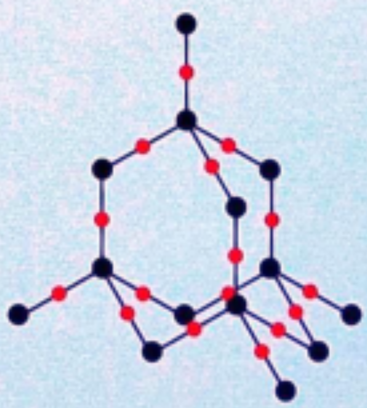
- Soft and slippery – the layers can slide over one another *(because the forces holding the layers together are weak)*
- Conducts electricity *(due to electrons which are free to move between layers)*
- Dark in colour

Uses: Pencil leads, making electrodes, as lubricants

Silicon(IV) Oxide, SiO_2:

Giant lattice where each silicon atom *(black)* forms covalent bonds with 4 oxygen atoms *(red)* and each oxygen atom forms covalent bonds with 2 silicon atoms

Properties:



- Hard, can scratch things
- Does not conduct electricity
- Light passes through it
- High melting point (1710 °C)

Uses: Sandpaper, making glass and lenses, bricks for lining furnaces

Metallic Bonding

Explain ***Metallic Bonding.***
Draw and describe the structure.

Describe the properties of metals.

Alloys

What is an ***Alloy***?
Draw and describe the structure.

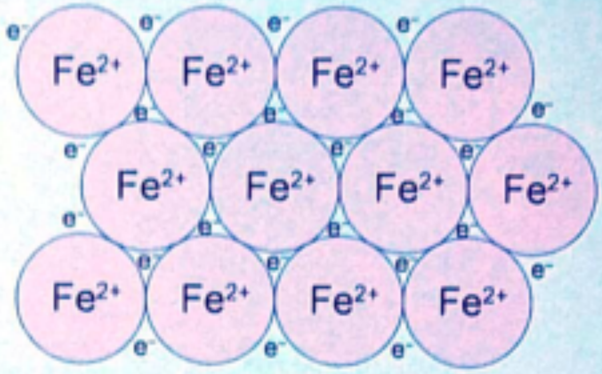
Why are alloys more useful than pure metals?

Metallic Bonding:

Occurrence: Metallic elements

Metallic Bonding: The attraction between positive metal ions and negative electrons

Structure: Giant metallic lattice of metal ions in a "sea" of delocalised electrons



Metal Properties:

Melting & Boiling Points: High

Physical Properties: Malleable and ductile

***Malleable:** can be hammered into shape.* ***Ductile:** can be drawn into wires.*

Electrical Conductivity: Good conductors of electricity

Thermal Conductivity: Good conductors of heat

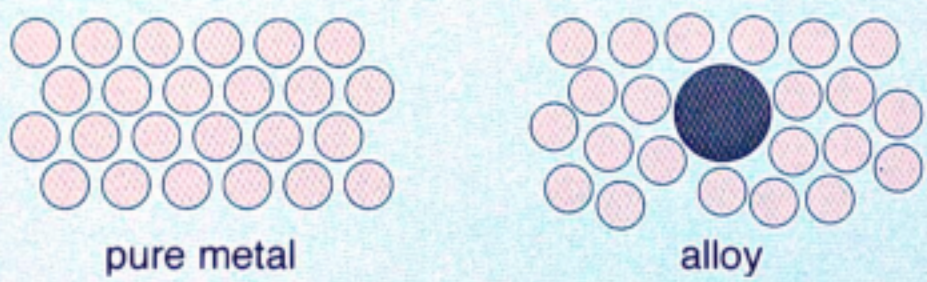
Solubility: Insoluble in water

Alloys:

Definition: A mixture of a metal with other elements

Structure: Atoms of the added elements are dispersed throughout the original metal

This disrupts the regular lattice, so the layers of atoms cannot slide over one another



Alloy Properties:

- Alloys are **harder** and **stronger** than pure metals, making them more useful
- Some alloys are more **resistant to corrosion** than the pure metal

The Periodic Table

Define ***Group*** and ***Period***.
Where are the ***Metals*** and ***Non-Metals*** found?
What patterns are found within a group?

How do you know how many
Valency Electrons an atom has?

Alkali Metals

Where are the ***Alkali Metals*** found on the periodic table?

Describe their ***Physical Properties*** and ***Trend In Reactivity***.

How do they react with water?

0620/0971/03

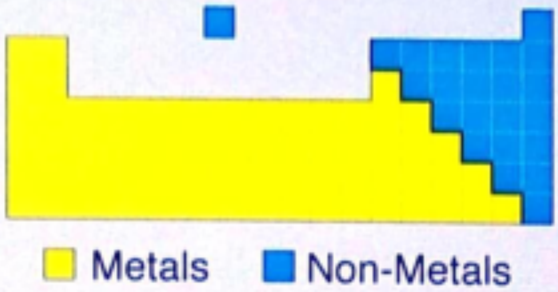
The Periodic Table:

Group: A column of the periodic table

Period: A row of the periodic table

Metals and Non-Metals:

- Metals are found to the left of the zig-zag line
- Non-Metals are found to the right of the zig-zag line



Patterns within a group:

Elements within a group have similar properties, which gradually change down the group

Valency Electrons:

The group number indicates the number of valency (outer shell) electrons (for neutral atoms)

Alkali Metals:

Location on Periodic Table: Group 1

Physical Properties:

- Relatively soft metals (they can be cut with a knife)
- Low melting points compared to most metals
  Melting points decrease down the group
- Low densities – Li, Na and K float on water
  Density increases down the group

Reactivity: Increases down the group (i.e. Lithium is the least reactive)

Reaction with water:

Vigorous reaction with water, e.g.

Sodium + Water ⟶ Sodium Hydroxide + Hydrogen

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2\,(g)}$$

The resulting solution is alkaline (because it contains a hydroxide)

Halogens

Where are the *Halogens* found on the periodic table?

Describe their:
Molecular Structure
Melting Point
Trend in Reactivity
Colour & Physical State

What are *Halides*?
Explain their *Displacement Reactions*, giving equations.

Location on Periodic Table:

Group 7

Molecular Structure:

Diatomic non-metals, e.g. Cl_2, Br_2, I_2

i.e. they contain 2 atoms per molecule

Melting Points:

Low melting points

Melting points increase down the group

Trend in Reactivity:

Decreases down the group (i.e. fluorine is the most reactive)

Colour & Physical State:

The halogens get darker in colour as you go down the group:

- Fluorine – yellow gas
- Chlorine – green gas
- Bromine – red liquid (forms orange vapour)
- Iodine – dark grey solid (forms purple vapour)

Halides:

Halides are compounds which contain halide ions (F^-, Cl^-, Br^-, I^-)
e.g. potassium chloride (KCl)

As opposed to halogens, which are halogen molecules, e.g. Cl_2

Displacement reactions:

A **more reactive halogen** will **displace** a **less reactive halogen** from a solution of its halide

More Reactive Halogen + Halide ⟶ Halide + Less Reactive Halogen

$$\text{e.g. } Cl_{2\,(g)} + 2KBr_{(aq)} \longrightarrow 2KCl_{(aq)} + Br_{2\,(aq)}$$

Transition Metals

Where are the *Transition Metals* found on the periodic table?

Describe their properties.

Give an important use for transition metals and their compounds.

Noble Gases

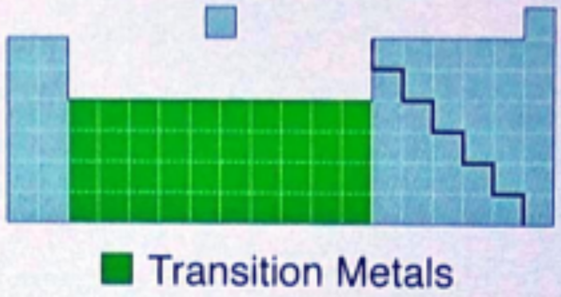
Where are the *Noble Gases* found on the periodic table?

Describe their structure and reactivity.

Give uses for each of the Noble Gases.

Transition Metals:

Location on Periodic Table: The block in the middle of the periodic table



Properties:

- High density
- High melting points (mostly above 1000°C)
- Good conductors of heat and electricity
- Pure metals look metallic (i.e. shiny)
- Compounds are coloured
- Variable oxidation numbers

Uses:

Transition metals and their compounds often act as catalysts

Noble Gases:

Location on Periodic Table: Group 0

Structure: Monatomic non-metal gases, e.g. He, Ne, Ar
i.e. they exist as single atoms

Reactivity: Extremely unreactive due to full outer shell of electrons

Uses:

Helium	• Filling balloons and airships (it is lighter than air and does not catch fire)
Neon	• Advertising signs – it makes them glow red
Argon	• Providing an inert atmosphere, e.g. in tungsten filament light bulbs • Welding
Krypton	• In lasers for eye surgery • In car headlamps
Xenon	• In lights (e.g. lighthouse lamps, lights in hospital operating rooms, car headlamps)