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Chapter1 Kinetic Particle Theory

properties	solid	liquid	gas
diagram			
Arrangement	Closely packed Orderly	Less closely packed Disorderly	Very far apart Disorderly
Motion (Movement)	Vibrate at fixed position	Slide over each other	Move randomly at fast speeds
Attraction forces between particles	Very strong	strong	Very weak

- **The lower the Mr, the higher the rate of diffusion** for example, ammonia gas ($M_r = 17$) diffuses faster than hydrogen chloride gas ($M_r = 36.5$)
- The higher the temperature, the higher the rate of diffusion

Chapter 2 Experimental Techniques (Purification and separation)

Filtration	To separate an insoluble solid from a liquid	NaCl & CaCO ₃	NaCl is soluble in water, but CaCO ₃ is insoluble in water
Separating funnel	To separate immiscible liquids	Petrol and water	
Simple distillation	To separate a solvent from a solution	Water from sea water	
Fractional distillation	To separate a mixture of miscible liquids	- Oxygen and nitrogen from liquid air - useful products (petrol and kerosene) from Crude oil - Ethanol & water	
Crystallisation	Suitable for salts that decompose if evaporated to dryness	Separate magnesium sulfate from magnesium sulfate solution	
Evaporation To dryness	To separate a solid from its solution (suitable only for salts that do NOT decompose on heating)	Sodium chloride from sea water	
sublimation	Separate 2 substances, one of which sublimes <i>Q: What substances can sublime?</i> <i>very few solids</i> - ammonium salts (NH ₄ Cl) - Anhydrous AlCl ₃ - Iodine (I ₂) - Dry ice (CO ₂)	To separate Ammonium chloride from a mixture of ammonium chloride and sodium chloride	
Paper chromatography	To separate compounds with similar properties in a solution	$R_f = \frac{\text{distance travelled by the substance}}{\text{distance travelled by the solvent}}$ - The starting line should be drawn with pencil line and NOT ink, because ink contains dyes that will dissolve in the solvent - if the spots are colorless, to spray with special locating agent on dried chromatography paper to show up the components as coloured spots	

- The greater the amount of impurities, the **lower the melting point** and the **higher the boiling point**.
- To check whether it's pure or impure, use melting point test or boiling point test (pure substances have fixed melting point and boiling point, but mixture with impurity doesn't have fix melting point and boiling point, they melt and boil over a range of temperature)

Chapter 3 Elements, Compounds and mixtures

Elements		Compounds	Mixtures
A pure substance that cannot be split up into two or more simpler substances by physical processes or by chemical processes.		A pure substance that contains two or more elements chemically combined in a fixed ratio	Are formed when two or more substances are added together without chemical bonds being formed.
H ₂ , O ₂ , Cu, Zn etc		H ₂ O, CO ₂ , CaCO ₃ etc	air, seawater, petrol, brass, etc
Fixed melting point & boiling point		Fixed melting point & boiling point	Melt & boil over a range of temperature
metals	Non-metals		
High m.p/b.p	Low m.p/b.p	Can ONLY be separated by chemical reactions or by using electricity(electrolysis)	Can be separated by physical means
Good conductors of heat and electricity	Poor conductors of heat and electricity	Fixed composition by mass	Variable composition by mass
Malleable(hammered into different shapes) ductile(stretched into wires w/o breaking)		Have own physical and chemical properties, different from its elements	Same as the chemical properties of the constituents in the mixture

Gas collection

Mr: relative molecular mass

gas	Factor1: Solubility in water	Factor2: Density compared to air (Mr of air = 28.8) Reason: In air, N ₂ is 78%, and O ₂ is 21%	Mr	Gas Collection system
Ammonia NH ₃	Extremely soluble	Less dense	17	Upwards delivery
Chlorine Cl ₂	Soluble	denser	71	Downwards delivery
Hydrogen chloride HCl	Very soluble	denser	36.5	Downwards delivery
Sulphur dioxide SO ₂	Very soluble	denser	64	Downwards delivery
Hydrogen H ₂	NOT soluble	Less dense	2	Displacement of water
Carbon dioxide CO ₂	Slightly soluble	denser	44	Displacement of water
Oxygen O ₂	Very Slightly soluble	denser	32	Displacement of water

Drying agents

Concentrated sulphuric acid H ₂ SO ₄	Can not be used to dry ammonia gas Why? Ammonia gas is alkali gas and it can react with sulfuric acid
Quick lime (CaO)	For drying alkaline gases, such as ammonia. Can not be used to dry acidic gas Why? CaO, as a base, will react with acidic gas.
Fused calcium chloride CaCl ₂	Can not be used to dry ammonia gas also, Why? because ammonia reacts with calcium chloride.

Chapter 5 Atomic structure

23 (nucleon number or mass number)

Na

11 (proton number or atomic number)

neutron number = mass number – proton number

	Inside the nucleus		Outside the nucleus
	Proton	Neutron	Electron
Relative mass	1	1	1/1840
Relative charge	+1	0	-1
symbol	p	n	e

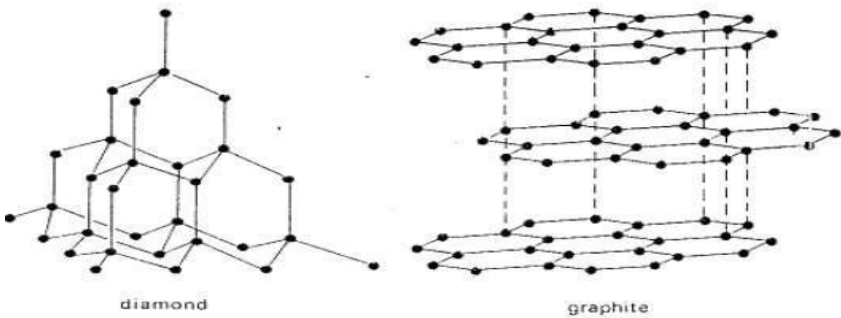
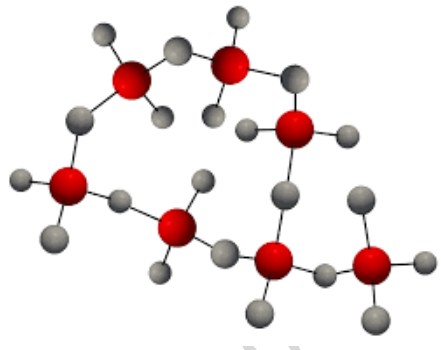
Isotopes are defined as: atoms of the same element that have the same number of protons but different number of neutrons.

Isotopes of the same element have the same chemical properties but slightly different physical properties.

Chapter 6 Ionic bonding

Chapter 7 Covalent bonding and metallic bonding

	Ionic bonding	Covalent bonding		Metallic bonding
	Formed between metal and non-metal	Formed between non-metal and non-metal		Only in metals
Examples	Sodium chloride NaCl, Magnesium oxide, MgO	Simple molecule <ul style="list-style-type: none"> Iodine I₂ Carbon dioxide CO₂ Water H₂O 	Giant molecule <ul style="list-style-type: none"> Diamond graphite silicon dioxide 	Cu, Zn, Fe, etc
Structure	giant ionic lattice structure	simple molecular structure	Giant molecular structure	giant lattice structure
volatility	Non-volatile	Very volatile	Non-volatile	
Property 1	High melting and boiling point	Lower melting and boiling point.	High m.p/b.p.	The metallic structure consists of positive ions surrounded by a "sea of mobile electrons". These mobile electrons (from the valence electrons of the atoms in the metal structure) allows metals to conduct heat and electricity.
Melting point and boiling point	Why? (bonding and structure) It is formed by ionic bonds which have strong electrostatic forces between the positive ions and negative ions in the giant lattice structure. A large amount of heat energy is needed to overcome these strong bonds. Hence it has High melting points and high boiling points.	Why? It is formed by covalent bonds which have weak intermolecular forces. Only little amount of heat energy is needed to overcome these weak forces of attraction. Hence it has low melting points and boiling points.	More details can be found in next page	
Electrical conductivity	- cannot conduct electricity in solid state because ions are not free to move about - Conducts electricity in molten state or in aqueous solution because there are free moving ions	Cannot conduct electricity at any state		
Solubility in water and organic solvents	Usually soluble in water but insoluble in organic solvents	Usually insoluble in water but soluble in organic solvent		

Allotropes: different forms of the same element		
		
		
Diamond	Graphite	Silicon dioxide
<ul style="list-style-type: none"> Each carbon atom has four valence electrons. Each carbon atoms is joined to four other carbon atoms by strong covalent bonds in a tetrahedral arrangement. 	<ul style="list-style-type: none"> Each carbon atoms is bonded to three other carbon atoms, three valence electrons in each carbon atom are used for covalent bonding and the fourth valence electron is not involved in chemical bonding. This gives hexagonal rings of six atoms that join together to form flat layers. These layers of carbon atoms, lie on top of each other and are held together by van der waal' forces. 	<ul style="list-style-type: none"> Each silicon atom has four valence electrons and forms four covalent bonds with four oxygen atoms in a tetrahedral structures. Each oxygen atom is bonded to two silicon atoms.
<p>Cannot conduct electricity Why?</p> <p>In the diamond structure, all the valence electrons of the carbon atoms are used for bonding. There are no free electrons that move through the structure. Hence, diamond cannot conduct electricity.</p>	<p>Graphite can conduct electricity. why?</p> <p>In graphite, each carbon atom has one outer shell electron that is not used to form covalent bonds. These electrons are delocalized, that is, they can move along the layers from one carbon atom to the next when graphite is connected to a battery. Hence, graphite is a good conductor of electricity.</p>	<p>Cannot conduct electricity</p>
<p>Hard Why?</p> <p>A crystal of diamond contains millions of carbon atoms joined by strong covalent bonds. A lot of energy is required to break these strong covalent bonds. This explains why diamond is so hard and difficult to melt.</p>	<p>Soft and slippery. why?</p> <p>The forces of attraction between the layers of carbon are very weak. The layers can slide over each other.</p>	
<p>High melting point and boiling points why?</p> <p>A crystal of diamond contains millions of carbon atoms joined by strong covalent bonds. A lot of energy is required to break these strong covalent bonds. This explains why diamond is so hard and difficult to melt.</p>	<p>High melting point and boiling points, why?</p> <p>In graphite, the bonds within each layer are strong and difficult to break. Large amount of heat energy are needed to break the bonds. Therefore it has high melting and boiling points.</p>	<p>High melting and boiling point</p>
<ul style="list-style-type: none"> As gemstones As tips of grinding, cutting and polishing tools 	<ul style="list-style-type: none"> In pencils As a dry lubricant Brushes for electric motors As inert electrodes 	<ul style="list-style-type: none"> Main components of concrete and glass production As an abrasive and in media filters for filtering water

Chapter 11 Acid/Base/Alkali

Chapter 12 Salts

	Acid	Alkali
	Acid: a substance that produce hydrogen ions, H^+ , when it is dissolved in water	a substance that produce hydroxide ions, OH^- , when it is dissolved in water
	- <i>Strong acid is an acid that completely dissociates(ionizes) in water to produce higher concentration of hydrogen ions (H^+)</i> - <i>Weak acid is an acid that partially dissociates in water to produce lower concentration of hydrogen ions (H^+)</i>	- <i>All alkalis are bases but only soluble bases are alkalis. Bases is a big family, alkali is a special class</i> - What are Bases? Included metal oxides and metal hydroxides
	Turn blue litmus paper red	Turn red litmus paper blue
	Turn universal indicator red or orange	Turn universal indicator violet or blue
reactions	Acid + fairly reactive metals $\rightarrow$ salt + H_2	Alkali + acid $\rightarrow$ salt + water
	Acid + Base or alkali $\rightarrow$ salt + H_2O	Alkali + ammonium salt $\rightarrow$ salt + H_2O + NH_3
	Acid + carbonates $\rightarrow$ salt + H_2O + CO_2	
	<ul style="list-style-type: none"> H_2SO_4 sulfuric acid is used in manufacturing of detergents and fertilisers, also used in car batteries Ethanoic acid(in vinegar) used as flavouring agent(sour taste) and as food preservative. 	

4. Types of oxides

Metal oxides		Non-metals oxides	
Basic oxides	Amphoteric oxides (only 3) React with both acids and bases to form salts and water	Neutral oxides (only 3) Show neither basic nor acidic properties	Acidic oxides Dissolve in water to form acidic solution with pH less than 7
CuO, Fe ₂ O ₃ , MgO, Na ₂ O, Etc - Most basic oxides are insoluble in water, but a few such as Na ₂ O, K ₂ O, CaO dissolve in water to form alkaline solutions	<ul style="list-style-type: none"> ZnO Al_2O_3 PbO 	<ul style="list-style-type: none"> NO H_2O CO 	SO ₂ , CO ₂ , NO ₂ , P ₂ O ₅ etc

Indicators

Indicator	Color in acidic solution	pH range at which indicator changes color	Color in alkaline solution
Methyl orange	red	3 - 5	yellow
phenolphthalein	colorless	8 - 10	pink
litmus	red	5 - 8	blue

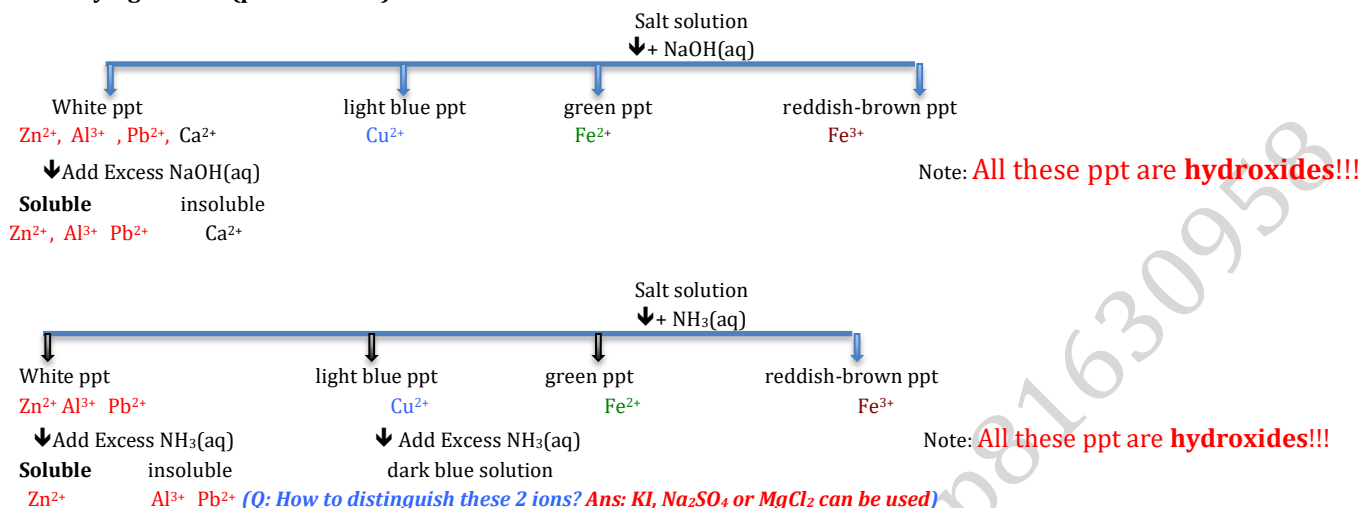
How to Control Acidity in soil for farmers for plants growth well?

- Add quicklime (calcium oxide) or slaked lime (calcium hydroxide) to reduce the acidity of the soil **by neutralize the acid in the soil**. This is known as liming the soil.
- Q? Why can NOT add calcium hydroxide together with fertilizer ammonium compounds(ammonium nitrate), Ans: because calcium hydroxide react with ammonium nitrate to form ammonia gas which escape into the atmosphere to cause the nitrogen loss.

- Litmus paper** will only show if a solution is an acid or a base. It cannot show the pH value of the solution.
- The pH value of a solution can be measured using **universal indicator**

Chapter 12 Salts

Identifying cations (positive ions)



identifying anions (negative ions)

Anions	test	Observation & inference
CO_3^{2-}	+ HCl Add dilute hydrochloric acid, pass the gas given off into limewater	Effervescence observed. Gas given off forms a white ppt with limewater. CO_2 is given off $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$
Cl^-	+ HNO_3 , + $AgNO_3$ (Q: why add dilute nitric acid 1 st ? A: to remove the carbonate ions)	White ppt AgCl formed
SO_4^{2-}	+ HNO_3 , + $Ba(NO_3)_2$	White ppt $BaSO_4$ formed
I^-	+ HNO_3 , + $AgNO_3$ or $Pb(NO_3)_2$	Yellow ppt AgI or Yellow ppt of PbI_2 formed
NO_3^-	+ Dilute NaOH + Al + warm or heat	Gas produced, Test the gas by using moist red litmus paper, it turns blue Why it is necessary to moisten?

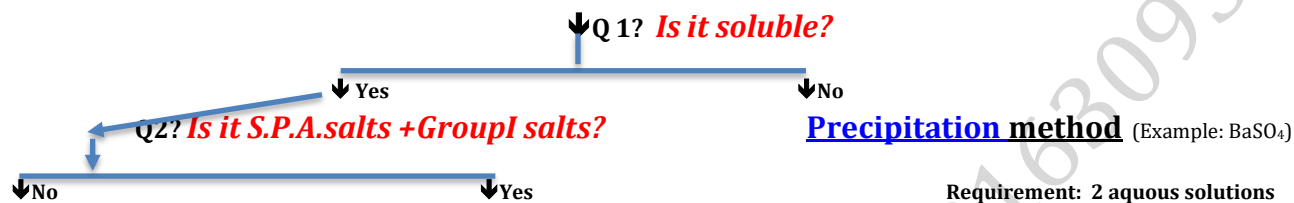
Identifying gases and water

Gas and water	Colour & smell	Test	Observation
Hydrogen H_2	Colourless and odourless	Insert a lighted splint at the mouth of the test tube	The lighted splint is extinguished with a "pop" sound.
Oxygen O_2	Colourless and odourless	Insert a glowing splint into the test tube	The glowing splint is rekindled (catch fire).
Carbon dioxide CO_2	Colourless and odourless	Bubble gas through limewater	A white precipitate is formed.
Ammonia NH_3	Colourless and pungent smell	Place a piece of moist red litmus paper at the mouth of the test tube	The moist red litmus paper turns blue. Why use moist?
Sulfur dioxide SO_2	Colourless and pungent smell	Place a piece of filter paper soaked with acidified potassium dichromate(VI) , $K_2Cr_2O_7$, at the mouth of the test tube.	The filter paper changes colour from orange to green.
Chlorine Cl_2	Greenish-yellow with pungent smell	Place a piece of moist blue litmus paper at the mouth of the test tube	The moist blue litmus paper turns red, then bleached (turn colourless).
Water H_2O	Anhydrous copper(II) sulfate	Water will change white anhydrous copper(II) sulfate to blue	

Solubility table

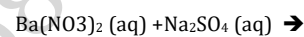
	Insoluble	soluble
Cl ⁻	AgCl, PbCl ₂	All others
SO ₄ ²⁻	BaSO ₄ , PbSO ₄ , CaSO ₄	All others
CO ₃ ²⁻	All others	Na ₂ CO ₃ , K ₂ CO ₃ , (NH ₄) ₂ CO ₃ (S.P.A.) + Group I
Na ⁺ , K ⁺ , NH ₄ ⁺ , (+ Group I)	×	All
NO ₃ ⁻	×	All

Salt Preparation (2 Questions, 3 Methods)



Filtration method (Example: CuSO₄)

Titration method (Example: K₂SO₄)



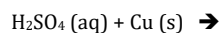
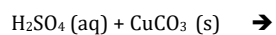
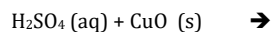
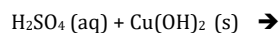
Note: Pipette and burette involved

Requirement (3 options)

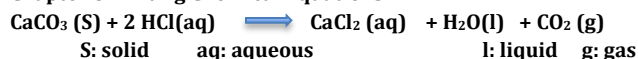
Requirement (2 options)

1. Acid + Excessive metals (excluding K, Na, Ca, Cu, Ag)
2. Acid + excessive insoluble carbonates
3. Acid + excessive insoluble bases

1. acid + alkali
 2. acid + soluble carbonates
- H₂SO₄ (aq) + KOH (aq) →
- H₂SO₄ (aq) + K₂CO₃ (aq) →



Chapter 8 Writing Chemical Equations



How to write ionic equation?

Step1 write the balanced chemical equation including the state of symbols.



Step2 Rewrite the equation in terms of ions for substances in the aqueous state. (for substances in solid/liquid/gas, just copy)



Step3 Cancel out the spectator ions



Step4 Rewrite the equation without the spectator ions.



Chapter 9 Mole

$$1. \text{ no. of mole} = \frac{\text{mass}}{\text{Mr}} \quad (\text{unit: g})$$

Mr: relative molecular mass

The most commonly-used formula, can be used for solid, liquid, and gas

$$2. \text{ no. of mole} = \frac{\text{volume}}{24 \text{ dm}^3}$$

Only for gas!!!

For gases, the mole ratio is the same as volume ratio

$$3. \text{ no. of mole} = \text{volume} \times \text{concentration} \quad (\text{for solution ONLY!})$$

Only for solution

$$4. \text{ no. of mole} = \frac{\text{no. of particle}}{6 \times 10^{23}}$$

For all particles including atoms, molecules, ions

$$5. \text{ Concentration convert: } \frac{\text{mol}}{\text{dm}^3} \times \text{Mr} = \frac{\text{g}}{\text{dm}^3}$$

$$\frac{\text{g}}{\text{dm}^3} \div \text{Mr} = \frac{\text{mol}}{\text{dm}^3}$$

$$6. \text{ Percentage yield} = \frac{\text{actual yield}}{\text{Theoretical yield}} \times 100\%$$

$$7. \text{ Percentage purity} = \frac{\text{mass of pure substance}}{\text{mass of impure sample}} \times 100\%$$

Chapter 13 Oxidation & Reduction

Oxidation	Reduction
Gain oxygen ↑	Lose oxygen ↓
Lose hydrogen ↓	Gain hydrogen ↑
Lose electrons ↓	Gain electrons ↑
Oxidation state increases ↑	Oxidation state decreases ↓



Why its redox? The oxidation state of Mg increases from 0 in Mg to +2 in MgCl₂, Mg is being oxidized, The oxidation state of H decreases from +1 in HCl to 0 in H₂, HCl is being reduced. Hence its redox reaction.

Both **neutralization** and **precipitation** reactions are NOT re-dox reactions !!!

Test for oxidising agent	Test for reducing agent
Aqueous potassium iodide KI KI > I ₂ colourless to brown	Potassium manganate (VII) KMnO ₄ MnO ₄ ⁻ > Mn ²⁺ Purple to colourless
Starch-iodide paper White to blue	Acidified potassium dichromate (VI) Cr ₂ O ₇ ²⁻ > Cr ³⁺



Mg is being oxidized, so Mg is reducing agent;
HCl is being reduced, so HCl is oxidizing agent.

	Orange	to green
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Chapter 14 Metals

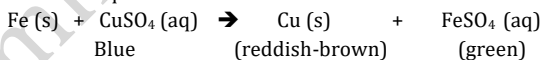
- Q: How metals conduct electricity?
A: The metallic structure consists of positive ions surrounded by a "sea of mobile electrons". These mobile electrons (from the valence electrons of the atoms in the metal structure) allows metals to conduct heat and electricity.
- Definition:
Alloy: a mixture of metal with one or a few other elements.
Benefits: Alloy can
 - improve the appearance,
 - more resistant to corrosion,
 - lower the melting point.
- Q: Why alloy is harder than pure metal?
A: for pure metal, the metal atoms are of the same size and packed regularly in layers. When a force is applied, the layers slide over each other easily. So it's soft (malleable, easily beaten into different shapes and ductile, easily pulled out into wires without breaking). However **the different sized atoms** in an alloy break up the **regular packing of atoms** in the pure metal. This makes it more difficult for the layers of atoms to slide over one another. As a result, alloy is harder and stronger than the pure metal.

Extracting metals	Metals	+ H ₂ O (l) react with cold water (form metal hydroxide and hydrogen gas)	+ H ₂ O (g) react with steam (form metal oxide and hydrogen gas)	+ HCl (aq) react with dilute hydrochloric acid
Highly reactive metals - Most difficult to extract - Extracted by electrolysis	K	Very Violently	Explosively	Explosively
	Na	Violently	Explosively	Explosively
	Ca	readily	violently	Very rapidly
	Mg	Very slowly	Violently	rapidly
	C			
Less reactive metals - Easier to extract - Extracted by reducing the metal oxides with carbon	Zn	No reaction	readily	Moderately fast
	Fe	No reaction	Very slowly	slowly
	Pb	No reaction	No reaction	No reaction
	H			
	Cu	No reaction	No reaction	No reaction
	Ag	No reaction	No reaction	No reaction
Least reactive, found naturally as free element	Au	No reaction	No reaction	No reaction

- For Oxides of metals, above **zinc**, CAN NOT be reduced by heating with **carbon**
- For Oxides of metals, above **iron**, CAN NOT be reduced by heating with **hydrogen**
- Metal carbonates (**K₂CO₃, Na₂CO₃ only**) are **NOT affected** by heat, they are thermal stable
- **Displacement reactions** of metals:
more reactive metal can displace a less reactive metal from its salt solution

Example: if a piece of iron is put into copper(II) sulfate solution,

Chemical equation



Observation:

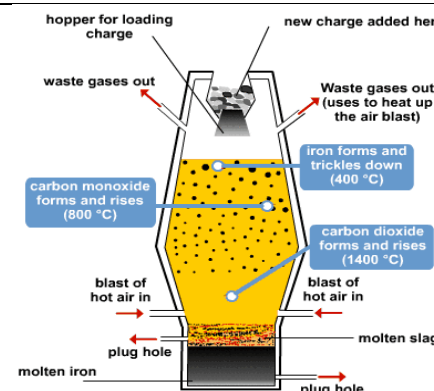
- Iron dissolves,
- metallic copper (reddish brown solid) is formed.
- The solution turns from blue (Cu²⁺ solution) to green (Fe²⁺ solution)

Exam tip !!!

In the exam, when you are asked to describe your observations, be sure to give your observations in terms of what you

- see (color change, color of gas/precipitate formed, solid/metal dissolving, flame/glow, effervescences/gas bubbles),
- hear ("pop" sound, "hiss" sound),
- feel (hot, cold, soapy feel for alkalis) or
- smell (pungent/fragrant smell) .

Extracting Iron from Haematite (**blast furnace**)

<ul style="list-style-type: none"> Haematite: Iron ore (Fe_2O_3) Coke (C) Limestone (CaCO_3), to remove the impurities 	<p>Chemical reactions:</p> <ul style="list-style-type: none"> $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ $\text{CO}_2 + \text{C} \rightarrow 2 \text{CO}$ $3 \text{CO} + \text{Fe}_2\text{O}_3 \rightarrow 2 \text{Fe} + 3 \text{CO}_2$ $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$ (molten slag) 	 <p>hot waste gases containing carbon monoxide, carbon dioxide and nitrogen escape through the top of the furnace.</p>
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Rusting

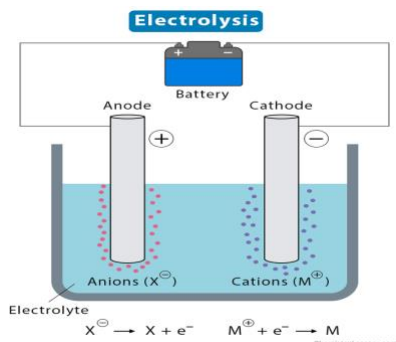
- Conditions: both **water** and **oxygen** are present at the same time
- Rust prevention (3 Types)
 - protective layer** (painting, oiling, greasing, tin-plating, chrome-plating, galvanizing(zinc plating)
 - Why?**
 - use a more reactive metal (**sacrificial protection**) attaching **magnesium** blocks or **zinc** blocks
 - why? Because Mg or Zn are more reactive than Fe, so Mg or Zn will corrode instead of Fe.
 - using alloys (stainless steel)

Why Recycling metals??? Advantages?

- To conserve the limited resources of metal ores (socially), as metal ores are a finite resources
- To save cost of extracting metals from their ores (economically)
- To reduce environmental issues by extracting metals from their ores (environmentally)

	Composition	property	uses
High carbon steel	Iron and 0.5-1.5% carbon	Strong but brittle	To make tools such as knives hammers and other cutting tools
Low carbon steel (also called mild steel)	Iron and 0.25% carbon	Softer and more easily shaped(malleable)	To make car bodies and machinery
Stainless steel	Iron and 20% chromium, 10% nickel, a little carbon	Does not rust	To make cutlery and surgical instruments, also used in chemical plants

Chapter 15. Electrolysis



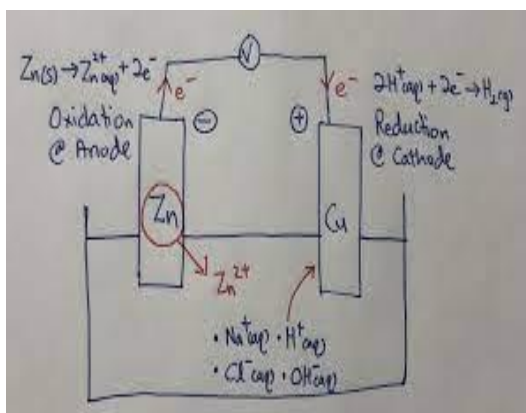
Electrolysis: is the process of using electricity to break down or decompose a compound (usually an ionic compound in the molten state or in aqueous solution).

- The anode is connected to positive terminal, cathode is connected to negative terminal.
- Anions (negative ions) move to the anode, so anode is also positive electrode, and cations (positive ions) move to the cathode, so cathode is also negative electrode.
- At anode, anions give up electrons and oxidation occurs, and at cathode, cations gain electrons and reduction occurs.

	Electrolyte	Ions present	Anode	Cathode	
1	Molten NaCl (graphite as electrodes)	Na^+ , Cl^-	$2 Cl^- (l) \rightarrow Cl_2 (g) + 2 e^-$	$Na^+ (l) + e^- \rightarrow Na (l)$	
2	Dilute NaCl solution (graphite as electrodes)	Na^+ , Cl^- , H^+ , OH^-	$4 OH^- (aq) \rightarrow 2 H_2O(l) + O_2 (g) + 4 e^-$ <ul style="list-style-type: none"> The overall reaction is $2 H_2O(l) \ggg 2 H_2 (g) + O_2 (g)$ The equation above shows that the electrolysis of dilute sodium chloride solution is equivalent to the electrolysis of water. As water is removed (by decomposition into hydrogen and oxygen), the concentration of sodium chloride solution gradually increases. 	$2 H^+ (aq) + 2 e^- \rightarrow H_2 (g)$	the concentration of sodium chloride solution gradually increases.
3	Concentrated NaCl solution (graphite as electrodes)	Na^+ , Cl^- , H^+ , OH^-	$2 Cl^- (aq) \rightarrow Cl_2 (g) + 2 e^-$ <ul style="list-style-type: none"> One volume of hydrogen gas is given off at the cathode and one volume of chlorine gas is produced at the anode. The remaining Na^+ and OH^- ions recombine to form sodium hydroxide. The resulting solution becomes alkaline. 	$2 H^+ (aq) + 2 e^- \rightarrow H_2 (g)$	The resulting solution becomes alkaline.
4	Copper(II) sulfate solution (graphite as electrodes)	Cu^{2+} , SO_4^{2-} , H^+ , OH^-	$4 OH^- (aq) \rightarrow 2 H_2O(l) + O_2 (g) + 4 e^-$ <ul style="list-style-type: none"> Reddish brown copper metal is deposited at the cathode and oxygen gas is given off at the anode. The blue colour of solution gradually fades as more copper is deposited. The remaining H^+ and SO_4^{2-} ions recombine to form sulfuric acid. The resulting electrolyte become increasingly acidic. 	$Cu^{2+} (aq) + 2 e^- \rightarrow Cu (s)$	The resulting electrolyte become increasingly acidic.
5	Copper(II) sulfate solution (Copper as electrodes)	Cu^{2+} , SO_4^{2-} , H^+ , OH^-	$Cu (s) \rightarrow Cu^{2+} (aq) + 2 e^-$ <ul style="list-style-type: none"> The Cu^{2+} ions that get discharged at the cathode come mainly from the copper anode. There is no net loss of Cu^{2+} ions from the copper(II) sulfate solution. The colour and concentration of the copper(II) sulfate solution remain unchanged. 	$Cu^{2+} (aq) + 2 e^- \rightarrow Cu (s)$	The colour and concentration of the copper(II) sulfate solution remain unchanged.

Simple cell

- In the simple cell, the more reactive metal lose electrons and become the negative electrode, the less reactive metal gain electrons and become the positive electrode.
- The further apart the two metals (electrodes) are in the reactivity series, the greater the voltage produced in the cell.



Chapter 16 The Periodic Table

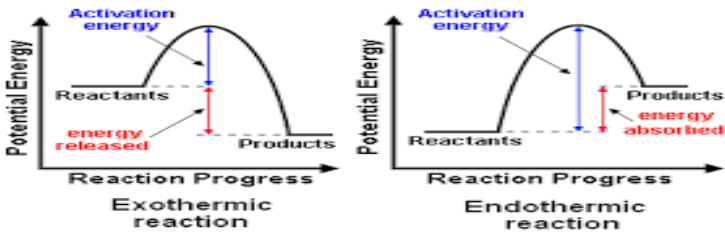
- The periodic table is arranged in order of their increasing proton (atomic) number.
- The **group number** of an element tells us the number of **valence electrons**.
- The **period** in which the element is placed tells us the **number of shells** of electrons in the electronic configuration.
- Elements on the left of the periodic table are metals, while those on the right are non-metals.
- A metalloid is an element with properties that are intermediate between metals and non-metals. Examples are silicon, Si (period 3), and germanium, Ge (period 4)
- From left to right across the period, there is decrease in metallic properties and an increase in non-metallic properties.

Group I	Group VII	Group 0 (group VIII)
Alkali metals Li Na K Rb Cs Fr	Halogens diatomic, F ₂ , gas, pale yellow, Cl ₂ , gas, greenish-yellow Br ₂ , liquid, reddish-brown I ₂ , solid, purplish-black At ₂ , solid, black	Noble gases monatomic He Ne Ar Kr Xe
Down the group reactivity increases ↑ (reducing power increases) Reasons: The larger the atomic size, the further the valence electron is from the nucleus, the weaker attraction forces between valence electrons and nucleus. the easier for the atom to lose the valence electron to form positive ions.	Down the group, reactivity decreases ↓ (oxidizing power decreases) More reactive halogen displaces less reactive halogen from its halide $\text{Cl}_2(\text{aq}) + 2\text{NaBr}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{Br}_2(\text{aq})$ $\text{Cl}_2(\text{aq}) + 2\text{Br}^{-}(\text{aq}) \rightarrow 2\text{Cl}^{-}(\text{aq}) + \text{Br}_2(\text{aq})$	Unreactive Because they have stable electronic configurations. Their outer shells are fully occupied, with two valence electrons for helium atom and eight valence electrons for the other noble gases.
Density increase ↑ Top 3 float on water, starting from Rb sink down in water	Density increase ↑	Do NOT form compounds with any other elements
Melting and boiling points decrease ↓	Melting and boiling points increase ↑	<ul style="list-style-type: none"> - Helium: balloons - Neon: neon lights - Argon: light bulbs, in welding and making steel
Below are the Special properties for group I only which means other typical metals don't have: <ul style="list-style-type: none"> • Soft, easily cut by knife • Low density • Low melting point/boiling point 	Color darker (color intensity increases) ↑ <ul style="list-style-type: none"> • F₂ pale yellow gas, • Cl₂ greenish-yellow gas, • Br₂ reddish-brown liquid, • I₂ purplish-black solid 	<ul style="list-style-type: none"> • Helium: filling weather balloons, advertisement and airships (low density, non-flammable) • Neon: neon lights (glow brightly) • Argon: in light bulbs, in welding and making steel (provide inert atmosphere)

Transition metals properties:

- high melting points and high density,
- variable oxidation states,
- form colored compounds,
- can be used as catalysts.

Chapter 17 Energy Changes

Exothermic	Endothermic
Give out heat energy to surroundings (surrounding temperature increases $\uparrow$)	Take in heat energy from surroundings (surrounding temperature decreases $\downarrow$)
 <p>The image contains two potential energy diagrams. The left diagram is for an exothermic reaction. The y-axis is labeled 'Potential Energy' and the x-axis is labeled 'Reaction Progress'. A curve starts at a level labeled 'Reactants', rises to a peak labeled 'Activation energy', and then falls to a lower level labeled 'Products'. A red arrow points from the reactant level down to the product level, labeled 'energy released'. Below the x-axis, it says 'Exothermic reaction'. The right diagram is for an endothermic reaction. The y-axis is labeled 'Potential Energy' and the x-axis is labeled 'Reaction Progress'. A curve starts at a level labeled 'Reactants', rises to a peak labeled 'Activation energy', and then falls to a higher level labeled 'Products'. A red arrow points from the reactant level up to the product level, labeled 'energy absorbed'. Below the x-axis, it says 'Endothermic reaction'.</p>	
Enthalpy change of reaction: $\Delta H = \text{products energy level} - \text{reactants energy level}$	
$\Delta H < 0$	$\Delta H > 0$
Bonds forming is Exothermic	Bonds breaking is Endothermic

<p>Examples</p> <p>Chemical changes</p> <ul style="list-style-type: none"> Combustion of fuels Neutralisation Reaction of sodium carbonate with dilute acids Respiration Rusting of iron Corrosion of metals <p>Physical changes</p> <ul style="list-style-type: none"> Freezing, condensation Dissolving anhydrous salts, Na_2CO_3 in water Dissolving NaOH or H_2SO_4 in water 	<p>Examples</p> <p>Chemical changes</p> <ul style="list-style-type: none"> Thermal decomposition Action of light on silver bromide in photographic film Photosynthesis <p>Physical changes</p> <ul style="list-style-type: none"> Melting, boiling, sublimation Dissolving ammonium salts or crystalline salts CuSO_4 in water
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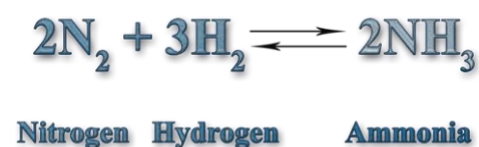
Chapter 18 Speed of Reaction

<i>5 factors</i> affecting speed of reaction	Explanation
Concentration of the reactants	The higher the concentration of the reactant, <ul style="list-style-type: none"> The greater is the number of particles per unit volume The higher is the frequency of effective collisions The greater is the speed of reaction
Temperature at which the reaction is occurring	At a higher temperature, <ul style="list-style-type: none"> The reactant particles absorb energy and move faster More reactant particles have the minimum activation energy to react The higher is the frequency of effective collisions The greater is the speed of reaction
Particle size of the reactants	The smaller the particles size, <ul style="list-style-type: none"> The larger is the total surface area exposed to collisions The higher is the frequency of effective collisions The greater is the speed of reaction
Pressure of the reactants (if gaseous)	The higher the pressure of gaseous reactants, <ul style="list-style-type: none"> The smaller is the volume The greater is the number of particles per unit volume The higher is the frequency of effective collisions The greater is the speed of reaction

<p>Catalyst</p>	<p>A catalyst provides an alternative route that requires a lower activation energy More reactant particles can overcome the lower activation energy This increases the frequency of effective collisions and hence the speed of reaction increases</p>
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Chapter 19 Ammonia

Reversible reaction can go both forward and backward at the same time.



Haber process

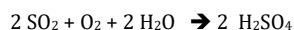
- The highest yield of ammonia is obtained at minimum cost under the following conditions:
 - Temperature **450 °C**
 - Pressure **250 atm**
 - Catalyst: **finely divided iron**
- **The higher the pressure**, the higher the yield of ammonia.
 - However, maintaining high pressure is costly because expensive equipment (like special pumps and stronger pipes) is required.
- **The lower the temperature**, the higher the yield of ammonia.
 - However, a lower temperature also results in a slower reaction.

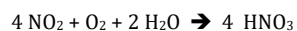
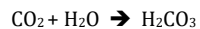
Chapter 20 The Atmosphere and Environment

Air pollutants	Sources	Harmful effects
CO	Incomplete combustion of carbon containing substances	React with haemoglobin in blood to form carboxyhaemoglobin, reduce its capability of transport oxygen to the rest of body. Cause headache, and even death
SO ₂	S is the impurities in fossil fuels <ul style="list-style-type: none"> • Volcanoes • Combustion of fossil fuels 	Acid rain (damage building, damage marine life)
Oxides of nitrogen (NO, NO ₂)	At high temperature, nitrogen and oxygen in the air react to form nitrogen oxides <ul style="list-style-type: none"> • Lightning • Internal combustion engines 	Acid rain (damage building, damage marine life)
CH ₄	Decay of plants and animals	Greenhouse gas cause global warming
Ozone O ₃	Reaction of unburn hydrocarbons with nitrogen dioxide in the presence of sunlight	Irritate eyes, nose and throat, damage trees and plants

Acid rain

Acid rain is formed when acidic air pollutants such as sulfur dioxide and nitrogen dioxide dissolve in water.

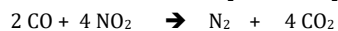




Catalytic Converters

Purpose: Harmful pollutants are converted to harmless substances

Catalyst: platinum and rhodium

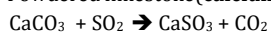


Unburned hydrocarbon are oxidized to carbon dioxide and water



Flue Gas Desulphurisation

- Powdered limestone(**calcium carbonate**) is used



. **calcium oxide** can also be used, $\text{CaO} + \text{SO}_2 \rightarrow \text{CaSO}_3$

- calcium sulfite is further oxidized by oxygen to form calcium sulfate, $\text{CaSO}_3 + \text{O}_2 \rightarrow \text{CaSO}_4$

Chapter21 Introduction to Organic Chemistry

Crude oil (petroleum)	Fractional distillation	Petroleum gas	Fuel for cooking and heating
		Petrol (gasoline)	Fuel for vehicles
		naphtha	Feedstock for making petrochemicals such as plastics and detergents
		Kerosene (paraffin)	Fuel for aircraft engines , cooking and heating
		Diesel oil	Fuel for diesel engines in buses, lorries and trains
		Lubricating oil	For lubricating machines, for making waxes and polishes
		bitumen	Making road surfaces and roofing

Chapter 22/23 Alkanes/Alkenes/Alcohols/Carboxylic Acids

Homologous series	Alkanes	Alkenes	Alcohols	Carboxylic acids
Same General formula	$C_n H_{2n+2}$	$C_n H_{2n}$	$C_n H_{2n+1} OH$	$C_n H_{2n+1} COOH$
Same Functional group	NIL	$C=C$	-OH	-COOH
	<p>CH₄ methane C₂H₆ ethane C₃H₈ propane C₄H₁₀ butane C₅H₁₂ pentane C₆H₁₄ hexane</p> <p>- Melting and boiling points increase ↑ Reason: As alkane molecules become larger, the forces of attraction between molecules become larger, more energy is needed to separate the molecules during melting and boiling - Viscosity increase ↑ - Density increase ↑ - Flammability decrease ↓</p>	<p>A homologous series is a family of organic compounds with</p> <ul style="list-style-type: none"> Same general formula Same functional group Similar chemical properties 	<p>Methanol CH₃OH Ethanol C₂H₅OH Propanol C₃H₇OH Butanol C₄H₉OH</p> <p>as the molecular size increases - Solubility decreases - Boiling points increase</p>	<p>The carbon in the COOH is considered one of the carbon when naming</p>
Similar Chemical properties	<p>Combustion Complete combustion(form carbon dioxide and water), incomplete combustion(form carbon monoxide, carbon, and water)</p>	Combustion	Combustion	<ul style="list-style-type: none"> - React with metals - React with bases - React with carbonates
	<p>Substitution (UV light) $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (mixture of 5 products)</p>	<p>Addition</p> <ul style="list-style-type: none"> Hydrogenation $C_2H_4 + H_2 \rightarrow C_2H_6$ (200 degree, Ni) Bromination $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ brown colorless 	<p>Oxidation $C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$ Uses as</p> <ul style="list-style-type: none"> Solvent Fuel alcoholic drinks <p>Q: How to produce ethanol? Fermentation</p>	

		<p>used to test for Alkenes and Alkanes</p> <ul style="list-style-type: none"> Hydration $C_2H_4 + H_2O \rightarrow C_2H_5OH$ (300 degree, 60 atm, phosphoric(V) acid) Polymerisation 	<p>Fermentation</p> $C_6H_{12}O_6 \rightarrow 2 C_2H_5OH + 2 CO_2$	- temperature 37 degree - No oxygen present - yeast(bio-catalyst)
	<p>Similarities: both are hydrocarbons, both are flammable, both exhibit isomerisms.</p> <p>Differences: molecular structure, reactivity, type of reaction, with aqueous bromine, combustion</p>			
	<p>Isomers Two or more organic molecules have the same molecular formula but <i>different structural formulae</i>.</p> <div style="text-align: center;"> <p>I II III</p> </div> <p>Isomers have different melting and boiling points.</p>			
	<p>Cracking</p> <p>The process in which large hydrocarbon molecules are broken down into a mixture of short chain alkanes, alkenes and hydrogen.</p> <p>Q. Why cracking is important?</p> <p>A: cracking can product petrol to meet the high demand for petrol, can produce alkenes which can be used to for making ethanol and plastics, can produce hydrogen (used to make ammonia in Haber process)</p> <p>- 600 degree - aluminium oxide or silicon oxide</p> <div style="text-align: center;"> <p>Long Hydrocarbon</p> <p>Ethene Alkane</p> </div>	<p>Esters: Reaction: Alcohols + Carboxylic acids Warm + a few drops of concentrated sulphuric acid(catalyst)</p> <div style="text-align: center;"> <p>Methanol Ethanoic acid Methyl ethanoate</p> </div> <p>when Naming : 1= part tells the alcohol, 2= part tells the Carboxylic acids</p> <p>use of Ester: perfumes, solvents and food flavourings</p>		

Chapter 24 Macromolecules

Addition polymerisation	Condensation polymerisation
A reaction in which monomers join together to form a large molecule(polymer) as the only product. Monomer units join together without losing any molecules or atoms	A reaction in which monomers join together to form a large molecule(polymer) with the elimination of small molecules. Monomer units combine to form a polymer, and small simple molecule such as water are eliminated
<p>Q : What are the differences?</p> <p>A: Additional polymers are formed from monomers with C=C bonds while condensation polymers are formed from monomers with two of the functional groups of -COOH, -OH or -NH₂.</p> <p>Condensation polymers are formed by an elimination of small molecules, such as water.</p> <p>Hence the mass of condensation polymers is less than the mass of the monomers. Mass of addition polymers equal mass of its monomers since only product is formed.</p>	
Poly(ethane) and poly(propene) are made from one type of monomer, i.e. ethane and	<p style="text-align: center;">Nylon</p> <p style="text-align: center;">Terylene</p>

<p>propene respectively, but addition polymers can also be made from two or more different type of monomers, as long as each monomer contains at least one C=C bond.</p> <p>Addition polymers can only be made from a single type of monomer.</p>	<p>Dicarboxylic acid & diamine</p> $\text{HO}-\text{C}(=\text{O})-\square-\text{C}(=\text{O})-\text{OH} + \text{H}_2\text{N}-\square-\text{NH}_2$ <p>a dicarboxylic acid a diamine</p> $\downarrow$ $\left[\text{C}(=\text{O})-\square-\text{C}(=\text{O})-\text{NH}-\square-\text{NH} \right]_n$ <p>a polyamide</p>	<p>Dicarboxylic acid & diol</p> <p>Monomers: Dicarboxylic acid Diol</p> $\text{O}=\text{C}-\square-\text{C}=\text{O} + \text{H}-\text{O}-\square-\text{O}-\text{H}$ <p>Polymer</p> $\dots -\text{C}(=\text{O})-\square-\text{O}-\text{C}(=\text{O})-\square-\text{O}-\dots$
	<p>Nylon and Terylene are synthetic fibres, they are used for making clothing materials, fishing lines, parachutes and sleeping bags</p>	
<p> </p> <p>Fig 1: The polymerisation of ethene into poly(ethene)</p> <p> </p> <p>Vinyl chloride monomer Poly(vinyl chloride) PVC Polymer Repeating unit</p> <p>Poly(ethane) is widely used as plastic bags, plastic bottles and cling films for wrapping food.</p> <p>PVC(polyvinyl chloride) plastic is used for making floor coverings, artificial leather, plastic pipes, raincoats and floor mats.</p>	<p>Amide linkage</p> $\text{O} \quad \text{H}$ $\parallel \quad $ $-\text{C}-\text{N}-$	<p>Ester linkage</p> O $\parallel$ $-\text{C}-\text{O}-$

Disposal of non-biodegradable plastics

- **Non-biodegradable** substances are substances that cannot be decomposed by bacteria in the soil.
- Currently most plastic waste is **buried in landfill sites**, but plastic are non-biodegradable. They do not decay when throw away. Thus they can cause serious **land pollution** and **waste-disposal problems**.
- Plastics are often disposed of by **burning**. But this is not a solution as most plastics burn to give off **toxic fumes**. Thus burning plastics causes **air pollution**.