# Rebekah's Chemistry Notes

**CONTENT PAGE:**

**IMPORTANT SKILLS:CHEMICAL FORMULAE AND EQUATIONS**

Skill A:DEDUCING CHEMICAL FORMULAE

*1.Determining valency of elements*

Valency from Group numbers:

-to write the chemical formula of a compound,we must know the valency of the elements or polyatomic ions involved

-valency from group number in the periodic table

| Group number in the periodic table | Example of element | Valency |
|---|---|---|
| 1 | Li,Na | 1 |
| 2 | Be,Mg | 2 |
| 13 | B,Al | 3 |
| 14 | C,Si | 4 |
| 15 | N,P | 5 |
| 16 | O,S | 6 |
| 17 | F,Cl,Br,I | 7 |

Valency from Roman Numerals

-transition metallic elements have variable valencies.

-therefore,their valencies are indicated by a Roman numeral in the bracket

| Roman numeral | valency |
|---|---|
| copper(**II**) | 2 |
| Iron(**III**) | 3 |
| lead(**IV**) | 4 |
| Manganese(**VI**) | 6 |

## *Valency of Polyatomic Ions*

-there are radicals which consist of a group of atoms as polyatomic ions

| Common polyatomic ions | | | |
|---|---|---|---|
| Positive | Valency | Negative | Valency |
| Ammonium ion ,$NH_4^+$ | 1 | Nitrate ion,$NO_3^-$ | 1 |
| | | Hydroxide ion,$OH^-$ | 1 |
| | | Carbonate ion,$CO_3^{2-}$ | 2 |
| | | Sulfate ion,$SO_4^{2-}$ | 2 |
| | | Phosphate ion,$PO_4^{3-}$ | 3 |

<u>Methods to deduce chemical formulas</u>

1.write the respective valency and criss-cross

2.if the valency is equal,no need to criss-cross,just write out the formula

3.if a number us required for polyatomic ions,a bracket must be used

4.reduce the ratio by a common factor if possible

| Elements | Chemical formula | Elements | Chemical formula |
|---|---|---|---|
| K , N | $K^1X^3_N$ $K_3N$ | Ag , OH | $Ag^1X^1_{OH}$ $AgOH$ |
| Cu, S | $Cu^2X^2_S$ $CuS$ | lead(II), iodine | $Pb^2X^1_I$ $PbI_2$ |
| $NH_4$ , $NO_3$ | $NH_4^1$ $NO_3^1$ $NH_4NO_3$ | Mg , $NO_3$ | $Mg^2X^1_{NO_3}$ $Mg(NO_3)_2$ |
| Li , O | $Li^1X^2_O$ $Li_2O$ | copper(I), O | $Cu^1X^2_O$ $Cu_2O$ |
| Iron (III), O | $Fe^3X^2_O$ $Fe_2O_3$ | Ba, OH | $Ba^2X^1_{OH}$ $Ba(OH)_2$ |
| Mg, F | $Mg^2X^1_F$ $MgF_2$ | Na , $CO_3$ | $Na^1X^2_{CO_3}$ $Na_2CO_3$ |
| Li , $SO_4$ | $Li^1X^2_{SO_4}$ $Li_2SO_4$ | lead(IV), S | $Pb^4X^2_S$ $PbS_2$ |

*2.Naming chemical substances*

Naming Ionic Compound

-when naming an ionic compound containing two elements:

—metallic element comes before non-metallic element

—non-metallic elements end with ‘ide’

| Elements in an ionic compound | Chemical name |
|---|---|
| Calcium,chlorine | Calcium chlor**ide**<br>(metal) (non-metal) |
| Iodine,lithium | Lithium iod**ide**<br>(metal) (non-metal) |
| Magnesium,oxygen | Magnesium ox**ide**<br>(metal) (non-metal) |
| Sulfur,potassium | Potassium sulf**ide**<br>(metal) (non-metal) |

-in an ionic compound which contains a transition metal,a Roman numeral in a bracket is generally assigned to indicate its valency

-Eg:

—iron(II) oxide and iron(III) oxide

—copper(I) oxide and copper(II) oxide

—lead(II) oxide and lead (IV) oxide

-polyatomic ion will not change its name after combining with other elements

-Eg:

—sodium carbonate

—potassium sulfate

Naming covalent compound

When naming a covalent compound:

-the first element name remains unchanged

-the second element name ends with ‘ide’

-if necessary a prefix is used for the second element which depends on the number of atoms involved

| Number of atoms | Prefix | examples |
|---|---|---|
| 1 | mono | Carbon **mono**xide ($CO$) |
| 2 | di | Carbon **di**oxide ($CO_2$) |
| 3 | tri | Sulfur **tri**oxide ($SO_3$) |
| 4 | tetra | Carbon **tetra**chlor**ide** ($CCl_4$) |

-certain covalent compound have ‘special’ names
-Eg:
—Ammonia:$NH_3$
—Water:$H_2O$

## *SKILL B.Balancing chemical equations*

*Conservation of atoms in a chemical reaction*

-atoms can neither be destroyed nor created
-in a chemical reaction

$$\textit{the sum of atoms before reaction} = \textit{the sum of atoms after reaction}$$

Unbalanced equation:

$Mg + O_2 \xrightarrow{\text{after chemical reaction}} MgO$

Balanced equation:

$2Mg + O_2 \xrightarrow{\text{after chemical reaction}} 2MgO$ (2×1, 2×1)

(1) $Fe + O_2 \longrightarrow Fe_2O_3$

$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

(2) $K + O_2 \longrightarrow K_2O$

$4K + O_2 \longrightarrow 2K_2O$

(3) $Na + H_2O \longrightarrow NaOH + H_2$

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$

Balancing an equation containing polyatomic ions

unbalanced equation:

$Ca + HNO_3 \longrightarrow H_2 + Ca(NO_3)_2$ (2×1, 3×2)

Balanced equation

$Ca + 2HNO_3 \longrightarrow H_2 + Ca(NO_3)_2$

(1) $Zn(NO_3)_2 + Na \longrightarrow NaNO_3 + Zn$

$Zn(NO_3)_2 + 2Na \longrightarrow 2NaNO_3 + Zn$

(2) $(NH_4)_2SO_4 + NaOH \longrightarrow Na_2SO_4 + NH_3 + H_2O$

$(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2NH_3 + 2H_2O$

(3) $2AgNO_3 + CaCl_2 \longrightarrow 2AgCl + Ca(NO_3)_2$

$2AgNO_3 + CaCl_2 \longrightarrow 2AgCl + Ca(NO_3)_2$

(4) $KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

$2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

*Skill C:WRITING A BALANCED EQUATION*

-state symbols are sometimes required if question demands for it

-Eg:

—solid state(s)

—liquid state(l)

—gaseous state(g)

—aqueous solution(aq)

*Anatomy of a chemical equation:*

-reactants are on the left and products are on the right

Eg: $2HCl + Mg \rightarrow MgCl_2 + H_2$

*Conversion of word equation to chemical equation*

Eg:

| |
|---|
| In a precipitation reaction,sodium hydroxide solution is mixed with iron(II) chloride solution.sodium chloride solution and insoluble iron(II) hydroxide are produced.write a chemical balanced chemical equation including the state symbols |

**Step 1:**identify reactants and products and place them in a word equation.

Sodium hydroxide + iron(II) chloride → sodium chloride + iron(II) hydroxide

**Step 2:**apply skill A,convert the chemical names into chemical formulas.place them based on the anatomy of a chemical equation and write the state symbols if necessary.

$NaOH(aq) + FeCl_2(aq) \rightarrow NaCl(aq) + Fe(OH)_2(s)$

**Step 3:**using skill B,balance the chemical equation

$2NaOh(aq) + FeCl_2(aq) \rightarrow 2NaCl(aq) + Fe(OH)_2(s)$

Writing a balanced ionic equation

-to write an ionic equation,state symbols of the substances must be clearly indicated

Types of ionic equation:

(a)solubility of substances in water

Step 1:SPLITTING OF IONS

-only ionic compounds which are soluble in water(forming aqueous solution) will dissociate into ions in water.insoluble substance cannot dissociate into ions in water

Eg: $NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$

Step 2:CANCELLING OUT SPECTATOR IONS

-spectator ions are ions that remain the same in their original states before and after a chemical reaction

Eg: $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

$= Na^+(aq) + Cl^-(aq) + Ag^+(aq) + NO_3^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq)$

Step 3:WRITING A BALANCED IONIC EQUATION

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

(b)change in oxidation states

-in redox reaction such as electrolysis,elements gain or lose electrons

-Eg:

—copper atoms lose 2 electrons to form copper (II) ions

—ionic half equation:

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

IMPORTANT CHEMICAL FORMULAS TO MEMORISE

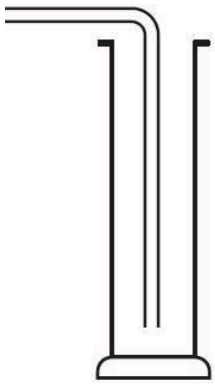
| S.N. | Name chemical compound | Chemical Formulas |
|---|---|---|
| 1 | sulphuric acid | $H_2SO_4$ |
| 2 | zinc sulphate | $ZnSO_4$ |
| 3 | magnesium oxide | $MgO$ |
| 4 | ferric oxide | $Fe_3O_4$ |
| 5 | ethyl alcohol | $C_2H_5OH$ |
| 6 | glucose | $C_6H_{12}O_6$ |
| 7 | calcium hydroxide | $Ca(OH)_2$ |
| 8 | calcium oxide | $CaO$ |
| 9 | carbon dioxide | $CO_2$ |
| 10 | ferrous sulphate | $FeSO_4$ |
| 11 | sulphur dioxide | $SO_2$ |
| 12 | sulphur tri-oxide | $SO_3$ |
| 13 | lead nitrate | $Pb(NO_3)_2$ |
| 14 | lead oxide | $PbO$ |
| 15 | nitrogen dioxide | $NO_2$ |
| 16 | silver chloride | $AgCl$ |
| 17 | Silver bromide | $AgBr$ |
| 18 | barium hydroxide | $Ba(OH)_2$ |
| 19 | ammonium chloride | $NH_4Cl$ |
| 20 | barium chloride | $BaCl_2$ |
| 21 | ammonium hydroxide | $NH_4OH$ |
| 22 | copper(II) sulphate | $CuSO_4$ |
| 23 | copper chloride | $CuCl_2$ |
| 24 | lead chloride | $PbCl_2$ |
| 25 | sodium sulphate | $Na_2SO_4$ |

## CHAPTER 1: EXPERIMENTAL CHEMISTRY

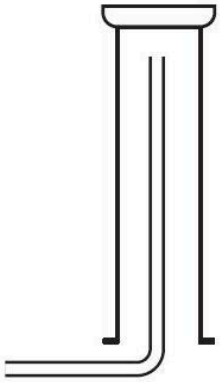
| Quantity measured | SI unit | Units commonly used by instruments | instruments /apparatus | Accuracy |
|---|---|---|---|---|
| mass | kilogram(kg) | kilogram (kg)<br>gram(g) | Electronic balance, Beam balance | Depending on instrument (accuracy to 2 or 3 dp) |
| Volume | Cubic metre($m^3$) | Cubic metre($m^3$):<br>Cubic cm($cm^3$)<br>Cubic dm($dm^3$) | For liquids | |
| | | | Measuring cylinder | Measures the cylinder to the nearest $cm^3$ |
| | | | Pipette | Measures the volume every accurately (eg.20.0$cm^3$,25.0$cm^3$) |
| | | | burette | Measures the volume very accurately to nearest 0.1$cm^3$(eg 26.70$cm^3$,26.75$cm^3$) |
| | | | For gases | |
| | | | Gas syringe | Depending on instrument (accuracy to 2 or 3 dp) |
| Temperature | Kelvin(K) | kelvin (K)<br>Degree Celsius(°C) | Thermometer<br>Temperature sensor attached to data logger | Accuracy to nearest 0.5°C |
| Time | second (s) | second(s):<br>minute(min)<br>hour(h) | Electronic stopwatch | Depending on instrument(accuracy to 2 or 3 dp) |

Collection of gas:
physical properties of a gas that will determine its method of collection is:

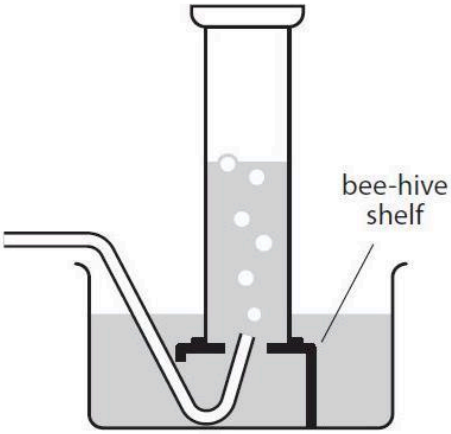
1.solubility of gas in water
2.density of the gas
Methods of collection:
-displacement of AIR
-displacement of WATER
-gas syringes



downward delivery
(upward displacement
of air)



upward delivery
(downward displacement
of air)




over water

| Upward displacement of AIR | Downward displacement of AIR | Displacement of water |
|---|---|---|
| Used when gas is denser than air | Used when gas is less dense than air | Used when gas is insoluble or SLIGHTLY soluble in water |
| EG:chlorine,hydrogen chloride and sulfur dioxide | EG:ammonia | EG:hydrogen,oxygen and carbon dioxide |

-if the gas is soluble in water,it will dissolve in water and thus,cannot be collected.hence,displacement of water cannot be used for collecting gas.

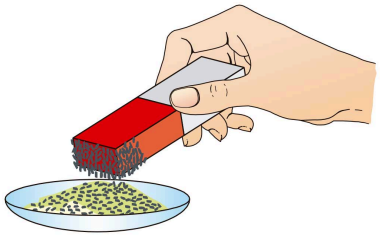
-for the gas to displace air by downward delivery,gas has to be denser than air so that it will sink and take over the place of air.
-for the gas to displace air by upward delivery,gas has to be less dense than the air so that it will rise and take over the place of the dense air

PHYSICAL METHODS OF SEPARATION:

-when two or more substances are present which are not chemically joined together,it is called a mixture
-a mixture is not a pure substance,there are physical methods which can be used to separate a mixture to obtain the respective pure substances again
-a physical method is a way of separating one substance from the other without changing the chemical composition of these substances
-the choice for selecting a suitable physical method is determined by the physical properties of substances in a mixture

| Nature of mixture | Physical methods | Physical properties of substances | Example of mixture |
|---|---|---|---|
| solid-solid | -magnetic attraction<br>-sieving<br>-using suitable solvents | -particle size<br>-magnetic properties | -iron fillings and sulfur powder<br>-fine salt and sand |
| solid-liquid | -filtration<br>-evaporation to dryness<br>-crystallisation<br>-simple distillation | -particle size<br>-solubility<br>-melting point and boiling point | -salt solution and chalk powder<br>-salt solution<br>-sugar solution<br>-seawater |
| Liquid-liquid | -chromatography<br>-fractional distillation | -solubility<br>-boiling point | -food dyes<br>-alcoholic solution<br>-crude oil |

*Separating Solid-Solid mixtures*

| Method | How it separates a solid-solid mixture | Examples |
|---|---|---|
| Magnetic attraction | -magnets attract magnetic substances,separating them from non-magnetic substances in a mixture<br>-common magnetic substances include iron,nickel,cobalt and certain alloys such as steel | -a magnet is used to separate iron filings from sulfur powder<br>  |
| Sieving | -a sieve separates substances in a mixture based on their particle size<br>-only the size of particles that is smaller than the pore size of the sieve can pass through the pores | -flour(fine particles) can pass through the sieve,leaving behind sand(coarse particles)on the sieve<br>  |
| Using suitable solvents | -when a mixture contains only one soluble solid,a suitable solvent is used to dissolve the soluble solid,separating it from insoluble solids<br>-a solute is a substance that dissolves in a solvent<br>-a solvent is a | -water(solvent) can be used to separate sugar crystals(soluble solid) from the sand by dissolving the sugar crystals,leaving behind the sane(insoluble solid) |

| | | |
|---|---|---|
| | substance that dissolves a solute<br>-solubility refers to the ability of a solute to dissolve in a solvent<br>-a very soluble solute means that most of it can dissolve in the solvent at a certain temperature | |

*Separating Solid-Liquid Mixtures*

1.filtration

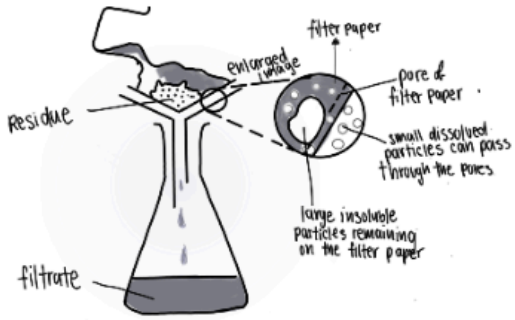
-it is suitable to separate a solid-liquid mixture

-EG:a mixture of sand and salt

-a filter paper is used to separate the mixture because it has very tiny pores

-the substance collected in the flask which passes through the filter paper is called the filtrate

-only the dissolved substances with particle size smaller than the pore size of the filter paper can pass through the pores.the insoluble solids are too large to pass through them.therefore,the large insoluble substances remain on the filter paper



2.evaporation to dryness and crystallisation

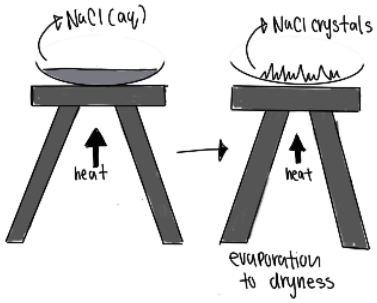
-these methods are used to recover pure soluble solid from a solution

-to obtain a soluble solid from a solution via a heat-stable method (evaporation to dryness) or a not heat-stable method(crystallisation)

2.1 evaporation to dryness

-if the solid is heat-stable,evaporation can be used by heating the solution to dryness.the solid remains as crystalline residue after the solvent has evaporated

-for example,sodium chloride is a heat-stable salt.a sodium chloride solution can be evaporated to dryness to obtain sodium chloride crystals




2.2 crystallisation

-if a compound is not heat-stable,strong heating to dryness would decompose it

-for example,sugar is not heat-stable.sugar crystals can be obtained by crystallisation from sugar solution.strong heating will decompose the sugar crystals to carbon

-when the soluble solid is not heat-stable,the solution is heated until it becomes saturated

-a saturated solution is a type of solution in which no more solute can dissolve in it

-the saturated solution is then allowed to cool.the size of the crystals formed depends on how the cooling is carried out

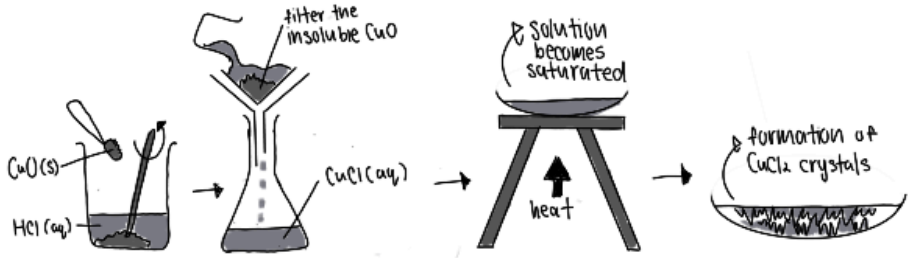
-if the cooling takes place quickly,the size of crystals is smaller or powdery

-if the cooling takes place slowly,the size of crystals is bigger

EXPERIMENT TO DEMONSTRATE CRYSTALLISATION TO RECOVER A SOLUBLE SOLID

-when copper(II) oxide(CuO) reacts with hydrochloric acid(HCl),copper(II) chloride ($CuCl_2$) solution is produced

-the crystals of copper(II) chloride can be obtained from the solution using crystallisation.




| Procedure | Reason for the underlined action |
|---|---|
| 1.copper(II) oxide powder is added in excess to a fixed volume of dilute hydrochloric acid | To make sure that all acid is used up |
| 2.filter the copper(II) chloride solution | To remove excess copper(II) oxide |
| 3.evaporate the filtrate until it becomes saturated | To allow the crystals to form easily |
| 4.let the solution cool slowly so that copper(II) chloride crystals can be formed | To obtain bigger size crystals |
| 5.filter the mixture once copper(II) chloride crystals have formed | To obtain copper(II) chloride crystals as residue on filter paper |
| 6.wash the copper(II) chloride crystals with cold distilled water | To remove impurities |
| 7.place the crystals in between th4e filter paper | To obtain dry crystals |

3.simple distillation

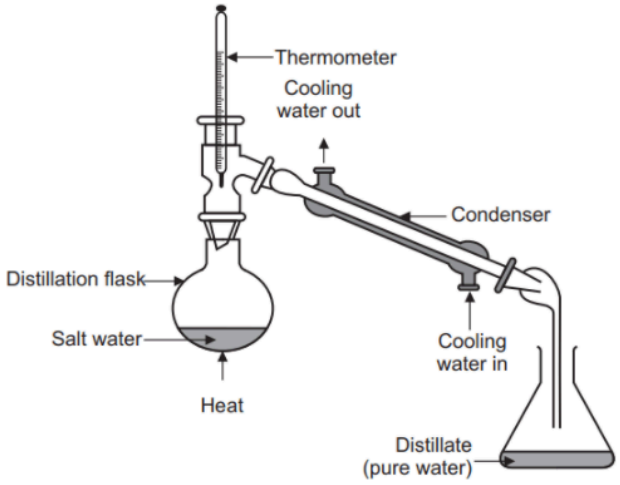
-it is used to separate a solid-liquid mixture

-the liquid is heated to reach its boiling point so that it changes into a vapour

-the process involves two physical state changes

-boiling takes place in the distillation flask

-condensation takes place in the condenser




-the vapour is then cooled by a condenser and changes back into a liquid.it is collected in the receiver as a distillate

-the impurities which have much higher boiling points remain in the flask

-the bulb of the thermometer must be placed near the opening of the condenser so that it can measure the boiling point of the substance accurately

-during the boiling of a substance,the temperature remains constant

-the boiling chips are added to ensure smooth boiling(or to prevent bumping during boiling)

-a conical flask is used as the receiving flask instead of a beaker because its narrow neck can reduce the loss of distillate from splashing out of the flask

-the water in the condenser flows in the opposite direction to the flow of the vapour.this ensures a permanent cold surface to condense the vapour effectively before the vapour leaves the condenser

*separating liquid-liquid mixtures*

1.Chromatography

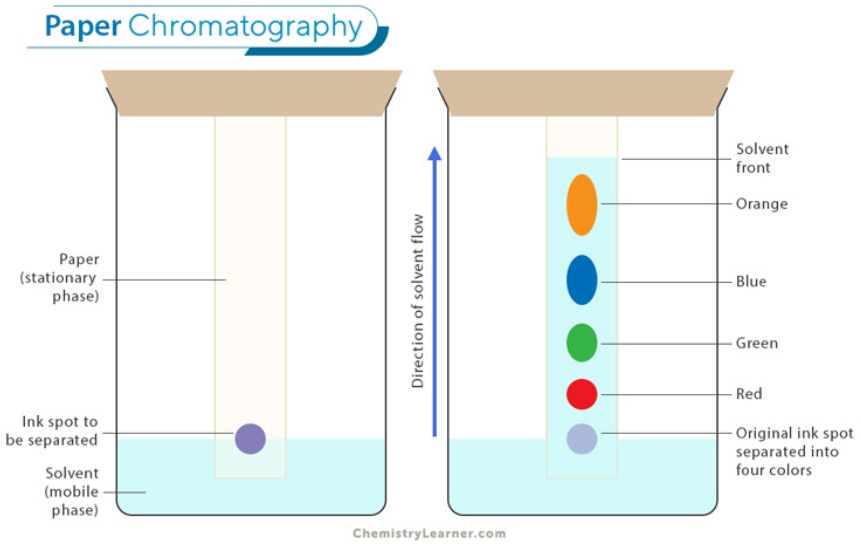
-it is used to separate a liquid-liquid mixture which is based on the extent of solubility of different substances in a given solvent

-when a substance dissolves in a solvent,it will be carried along by the solvent on the paper.

-the solvent is called the mobile phase as it moves across the chromatography paper.the chromatography paper is called the stationary phase as it is placed stationary in the solvent

-the more soluble the substance in the solvent,the further the distance it travels on the paper

-the basic paper chromatography has the following features




| Part | function/description |
|---|---|
| Spot | Shows the component in the sample |
| Starting line | Marks the position in which the sample is placed |
| Solvent | To dissolve the sample |
| Chromatography paper | Allows the separation of components in the sample |

| | |
|---|---|
| Solvent front | Marks the end position of the solvent travelling on the paper |
| Lid | To prevent the evaporation of the solvent |

Reasons for certain procedures when performing paper chromatography

| Procedure | Reason |
|---|---|
| The solvent front should not travel to the edge of the paper | -this prevents the components of the sample being unaccountable on the chromatogram<br>-this also allows the actual distance travelled by the solvent to be measured |
| The solvent front should be as high as possible | -this allows all the components to be fully separated |
| The starting line is drawn with a pencil instead if an ink that is soluble in the solvent | -the pencil is insoluble in the solvent,so it will not be carried by the solvent to interfere with the results<br>-an ink is made up of different dyes that can dissolve in the solvent and separate into different components.they will be carried by the solvent and interfere with the results |
| The sample is applied as small as possible | -when the sample is very small,the tailing and smudging of different components will not occur.in this way,we can identify the respective spots easily |
| The starting line should be above the solvent | -this prevents the sample from dissolving in the solvent so that the components in the sample can be moved along by the solvent on the |

| | |
|---|---|
| | chromatography paper |
| The beaker containing the solvent is covered by a lid | -this prevents the evaporation of the solvent.<br>-it also helps maintain the saturation of the solvent vapour so that the solvent will not evaporate from the paper too quickly.in this way,the separation of the components by the solvent can be more efficiently |

-when a sample remains at the starting line,it indicates that it does not dissolve in the solvent.to improve the experiment,the solvent should be replaced with the one which can dissolve the sample

-the result of the separated components on the chromatography paper is called the chromatogram.

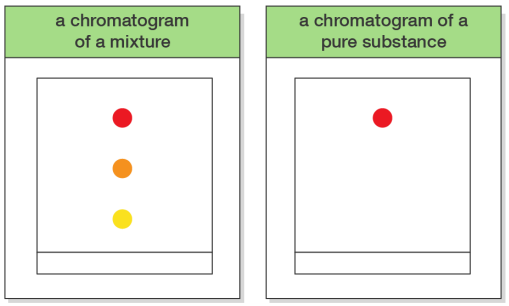
-In a chromatogram,we can deduce the following information :

1.the number of spots indicates the number of substances in the sample

2.any spots which are horizontally matches are likely to be the same substance

3.a single spot produced by a sample indicates that the sample is a pure substance

4.two or more spots produced by a sample indicate that the sample is a mixture




Advantages of using chromatography:

-gives quick and accurate analysis of sample

-requires only a small amount of sample

-able to separate complex mixtures such as food dyes or flavourings

Applications of chromatography

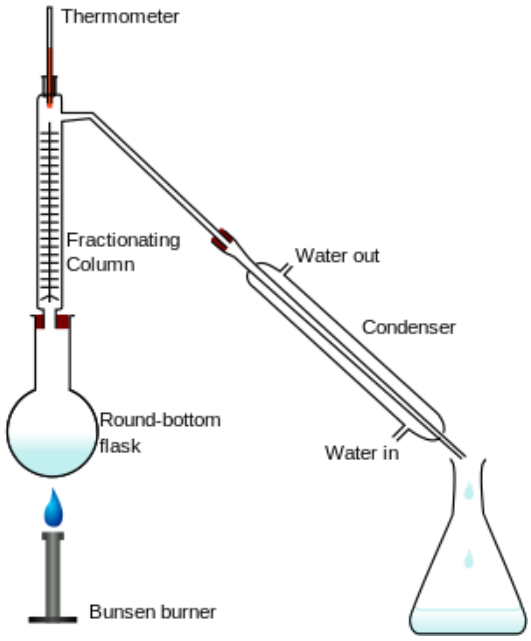
-detecting small amount of banned substances in an athlete's urine or blood sample

-monitoring the use of artificial flavourings and colourings in food industry

-collecting the evidence of crimes such as identifying DNA fragments in forensic science

2.Fractional Distillation

-fractional distillation is used to separate a liquid-liquid mixture which is miscible




-the principle for separating different liquids is based on their different boiling points

-a tall fractionating column is used in the fractional distillation to ensure the separation of different liquid more efficiently

-the tall fractionating column is packed with glass beads or glass rings which increase the surface area for both evaporation and condensation of substances with different boiling points to take palace

How the fractionating column helps separate different liquids efficiently

-it is the hottest at the bottom but cools gradually towards the top part of the column.

-if a vapour reaches a part of the column where the temperature is lower than its boiling point,it condenses and drips back to the distillation flask

-if the temperature at the top is above the boiling point of a substance,the vapour will not condense and drip back.instead,it will continue to flow into the condenser and condense.it will then be be collected as the distillate

-therefore,in fractional distillation,a substance with a lower boiling point can be separated from a substance of higher boiling point effectively

To avoid the contamination of distillate of different substances:

-once the temperature starts to increase above boiling point of the first distillate,it indicates that first distillate has collected completely.therefore,the receiver containing the first distillate must be removed before the substance of higher boiling point starts to distil over

-the closer the boiling points of different liquids,the taller the fractionating column should be used to separate them effectively

-fractional distillation is used largely in the following industries

1.separation of liquid air

2.separation of crude oil

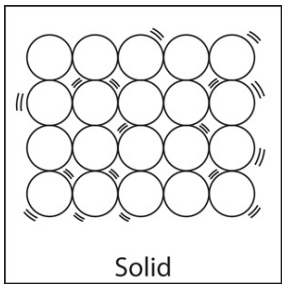
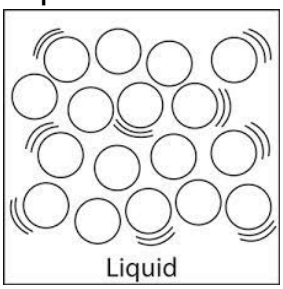
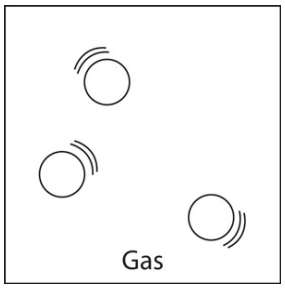
3.separation of ethanol from fermented solution

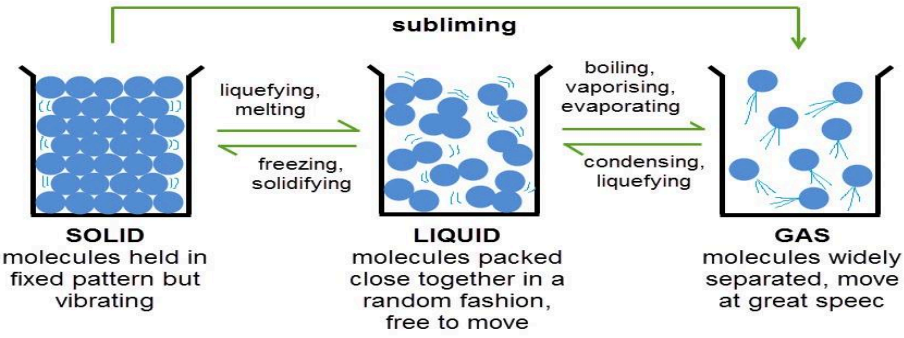
DETERMINING FOR PURITY:

| Methods to test for purity: | pure substance: | Impure substance: |
|---|---|---|
| M.P and B.P | Fixed temperature | Melts at a lower temperature and boils at a range |
| Paper chromatography | Produces a single spot in chromatogram | Produce two or more spots |

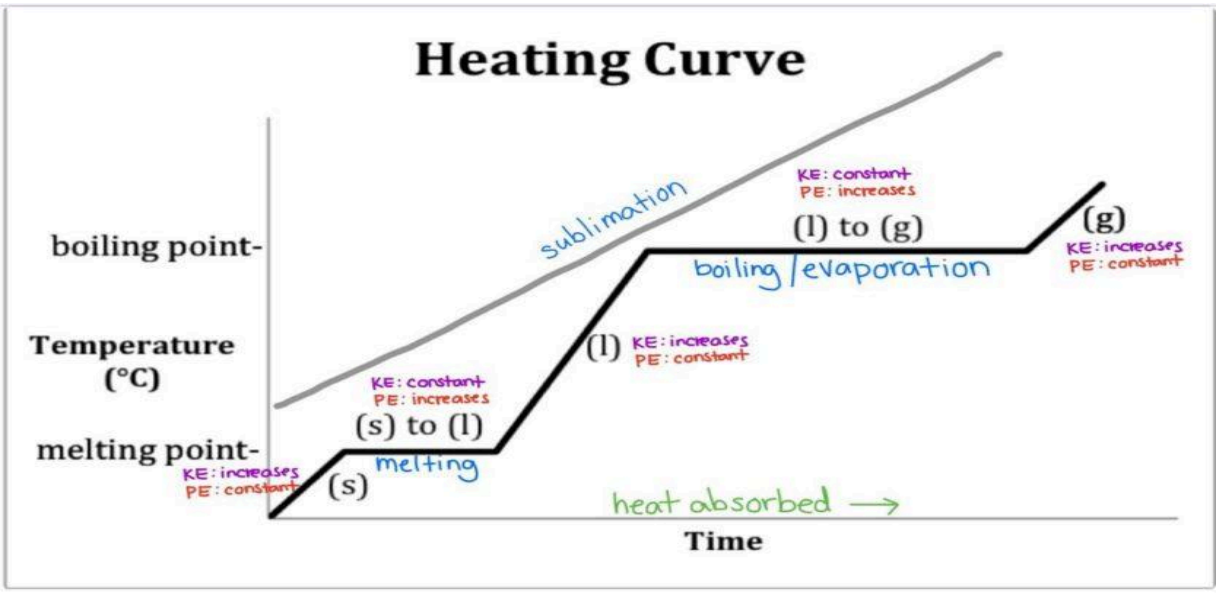
## CHAPTER 2:KINETIC PARTICLE THEORY

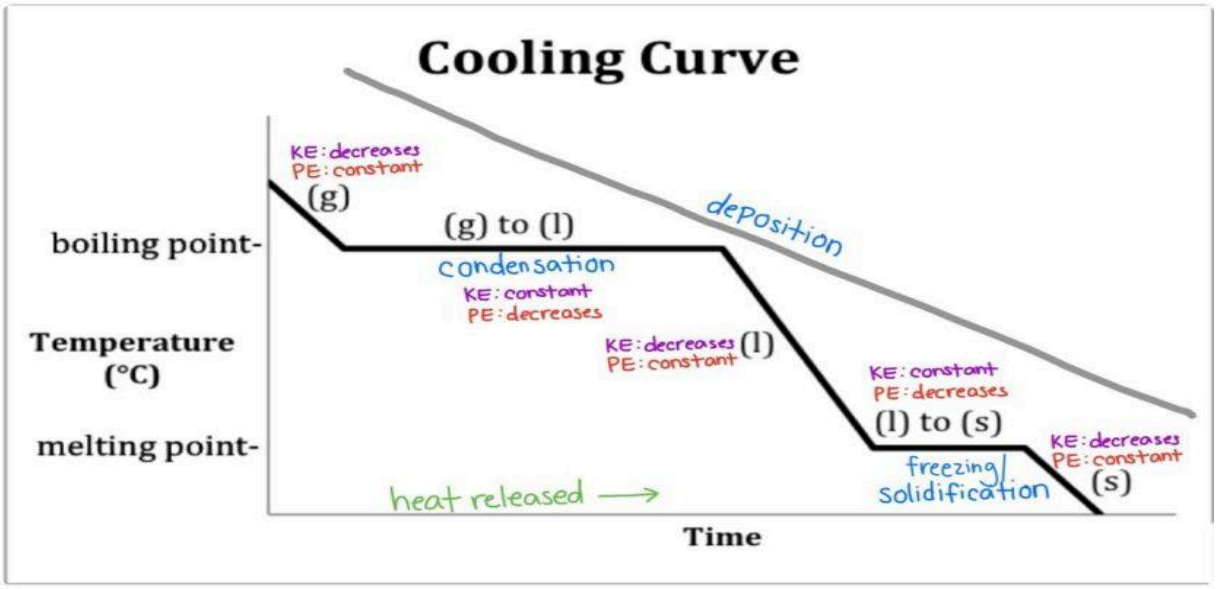
-the kinetic particle theory states that all matter is made up of a large number of tiny particles which are constantly moving in a random manner

| Diagram of particles | Solids:   | Liquids:   | Gases:   |
|---|---|---|---|
| Arrangement of particles | Particles are very closely packed together in an orderly manner | Particles are closely packed together in a disorderly manner | Particles are far apart and have a random arrangement |
| Movement of particles | Particles can only vibrate and rotate about their fixed positions | Particles can vibrate,rotate and move around one another randomly/slide past one another | Particles moves around freely and randomly at high speed in all direction |
| Forces of attraction between particles | Particles are held together by very strong attractive force | Particles are held together by strong attractive force but weaker in solids | Particles are held together by very weak attractive force |




The heating curve:



-temperature is remains constant during melting because thermal energy taken in is used to break the attractive force between the particles.thus,the average kinetic energy of particles remains the same

-temperature remains constant during freezing because thermal energy loss to the surroundings is compensated by the thermal energy given out during the formation of attractive force between the particles.thus,the average kinetic energy of particles remains the same

| process/changes in | Melting (solid to liquid) | Boiling (liquid to gas) | Condensing (gas to liquid) | Freezing (liquid to solid) |
|---|---|---|---|---|
| Occurs at | Melting point | Boiling point | Condensation point | Freezing point |
| Energy of particles | Particles gain energy and vibrate more vigorously | Particles gain energy and move more faster | Particles lose energy and move more slowly | Particles lose energy and move more slowly |
| Arrangement of particles before change in state | Particles gain enough energy to break away from their fixed positions and move around another randomly | Particles gain enough energy to overcome the forces of attraction and break free from one another and move about at very high speed | Particles lose enough energy and the forces of attraction between particles will pull the particles closer to each other and will eventually form a liquid | Particles lose enough energy and the forces of attraction between the particles become stronger.the particles starts to vibrate only i their fixed positions |
| Why temperature remains constant | Heat energy is being absorbed by the particles | Heat energy is absorbed by the particles to | -heat is being released by the particles | Heat energy is released by the particles as |

| | | | | |
|---|---|---|---|---|
| | to overcome the forces of attraction that holds the particles in their fixed positions | overcome all forces of attraction holding the particles together | as they slow down to take up the fixed and disorderly arrangement in the liquid state | they slow down to take up the fixed and orderly arrangement in the solid state |

*Similarity between the liquid and gaseous states:*

-molecules are not confined to moving about their fixed positions

*Difference between the liquid state and the gaseous states:*

-intermolecular forces of attraction between the molecules in a liquid are stronger,while that of the molecules in a gas is much weaker

*Define melting:*

-melting is the process in which a solid,when heated,changes into a liquid

*Define melting point:*

-a melting point is the temperature in which a solid when heated,becomes a liquid

*Define freezing:*

-freezing is a process in which a liquid,when cooled,changes into a solid

*Define freezing point:*

-freezing point is the temperature in which a liquid,when cooled,changes into a solid

*Define boiling:*

-boiling is a process in which a liquid,when heated,changes into a gas

*Define boiling point:*

-boiling point is the temperature in which a liquid when heated,changes into a gas

*Define evaporation:*

-evaporation is the process where a liquid turns into a gas of temperatures lower than the boiling point

*Why does evaporation occur?*

-because some of the particles in the liquid state have enough energy to overcome the forces of attraction holding them together in the liquid state,and escape from the surface of the liquid to form a vapour.

*Difference between evaporation and boiling:*

-boiling occurs throughout the liquid,where evaporation occurs only at the surface of the liquid

-boiling occurs only at a fixed temperature where evaporation occurs at any temperature below the boiling point.

-boiling occurs rapidly but not evaporation

-bubbles are formed when boiling but not during evaporation

*Define condensation:*

-condensation is a process in which a gas/vapour when cooled,changes into a solid

*Define sublimation:*

-sublimation is the process in which a solid when heated changes into a gas/vapour without melting

*Define vapour deposition:*

-vapour deposition isa process in which a gas/vapour when cooled ,changes into a solid

## CHAPTER 3:ATOMIC STRUCTURE


-atom is the smallest particle of an element that can take part in a chemical reaction.
-it is made up of subatomic particles (proton,neutron and electron)

| Subatomic particles | mass | charge | location |
|---|---|---|---|
| proton | 1 | +1 | nucleus |
| Neutron | 1 | 0 | nucleus |
| electron | 1/1840 | -1 | Orbiting around the nucleus |

-electrons are the most important subatomic particles as all chemical reactions involve the electrons.
-number of neutrons=nucleon/mass number - proton/atomic number
-number of nucleon=proton/atomic number + neutron number
-protons and neutrons are not mobile as they are held inside the nucleus
-electrons are mobile as they are not held within the constraints of the nucleus

*Isotopes:*
-isotopes are atoms of the SAME element with the SAME number of protons but DIFFERENT number of neutrons
-isotopes have the same chemical properties as they have the same number of valence electrons.
-isotopes are slightly different in terms of physical properties like density and boiling point as isotopes have different numbers of protons.

Electronic configuration in atoms:

-electronic configuration is the arrangement of electrons in an atom

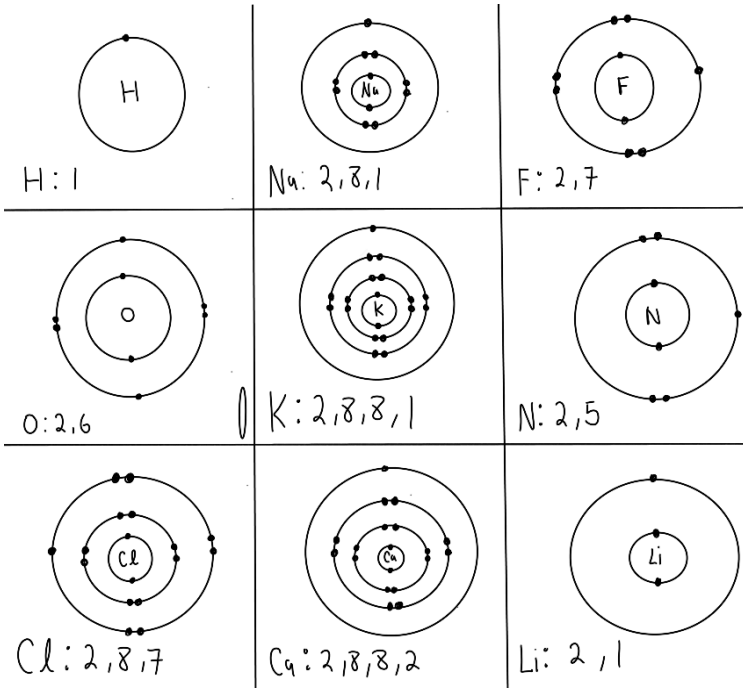
-electrons in the innermost shell,closest to the nucleus,have the lowest energy

-electrons in the outermost shell,furthest away the nucleus,have the highest energy

-the maximum number of electrons in the first shell is 2

-from the second shell onwards,the maximum number of electrons is 8

Eg:Potassium=2,8,8,1




-Valence electrons

-the valence shell OR outermost shell is the electron shell which is the furthest from the nucleus

-the electrons in the valence shell are called the valence electrons or outermost electrons

Stable electronic configurations of noble gases

-when an atom has the maximum number of electrons in the valence shell,it is stable and unreactive.the atom is said to have a stable electronic configuration

-all the elements in group 18/8 of the periodic table have the stable electron configurations.they are called the noble gases

-they are inert and exist as monatomic elements

-Formation of ions

-all atoms are electrically neutral due to an equal number of protons and electrons.the positive charges and the negative charges neutralise each other

-when an atom loses or gains electrons,the number of proteins is not equal to the number of electrons anymore.therefore,the atom will no longer be electrically neutral

-when an atom is not electrically neutral,it is called an ion

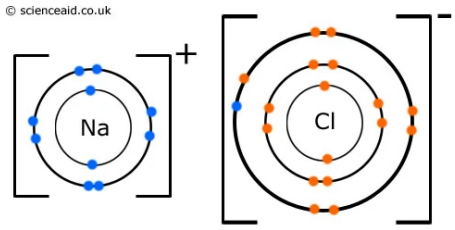
-an ion is a charged particle formed when an atom loses or gains electrons

-two types of ions:

1.cation (metals loses electrons to become cations—-positive ion)

2.anion (non-metals gain electrons to become anions—-negative ion)

-cations and anions join together to form ionic bonding




-From an atom to an ion

-The atoms of most elements do not have a stable electronic configuration because their valence shell is not completely filled,so they do not have the maximum number of valence electrons. As a result,they do not have a stable electronic configuration

-in order to achieve the noble gas electronic configuration,they must either lose or gain electrons so that their valence shells have the maximum number of electrons

In the formation of ions:

-metal lose electrons to form cations

$X \rightarrow X^{2+} + ne^-$

$X = chemical\ symbol\ ,\ n = number\ of\ electrons\ ,\ e^- = electrons$

EG:$Na \rightarrow Na^+ + e^-$

-non-metals gain electrons to form anions

$Y + ne^- \rightarrow Y^{n-}$

$Y = chemical\ symbol\ ,\ n = number\ of\ electrons\ ,\ e^- = electrons$

EG:$F + e^- \rightarrow F^-$

-Hence,electrons are responsible for the chemical properties of an atom

-when an atom formed an ion,the proton number and nucleon number remain unchanged because protons and neutrons are not involved

-Valency electrons

-valency electron refers to the number of valence electrons of an atom involved when forming a chemical bond through gaining,losing or sharing

-Eg:if an atom gains,loses or shares 2 electrons,the valency electron is 2

-valency electron allows us to deduce the chemical formula of a substance

Eg:

-Mg atom lose 2 electrons to form Mg ions→valency is 2

-Cl atoms gains 1 electron to form Cl ions→valency is 1

-when Mg reacts with Cl,it forms magnesium chloride

-the chemical formula of magnesium chloride can be deduced by exchanging their respective valency

## CHAPTER 4:CHEMICAL BONDING & STRUCTURE PROPERTIES OF MATERIALS

*type of bonding*

-when atoms of the same type ot different types chemically joined together,it is known as chemical bonding

-atoms bond together so that they can achieve stable electron configurations of noble gases.

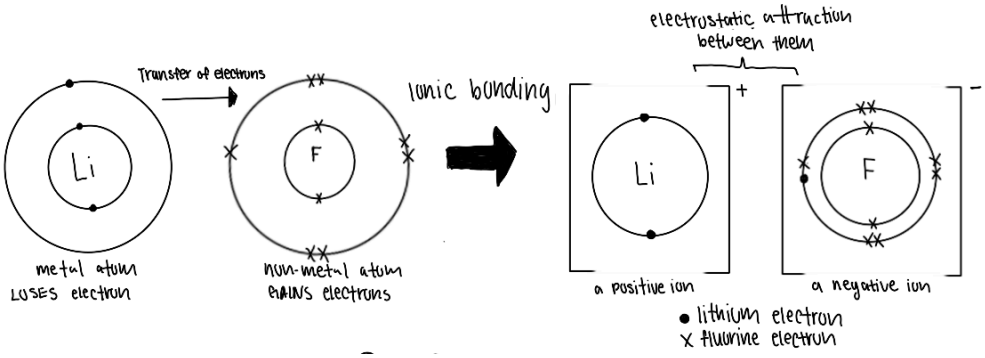
-there are two types of chemical bonding:

1.ionic bonding(between metals and non-metals)

2.covalent bonding(between non-metals)

1.Ionic Bonding

-ionic bonding is the transfer of electrons from a metal atom to a non-metal atom




How ions are formed:

(1) Positively charged ions
-via the loss of electrons
-metals forms positively charged ions

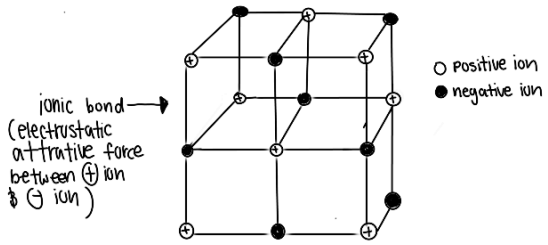
(2)negatively charged ions
-via the gain of electrons
-non-metals forms negatively charged ions

-these oppositely charged ions exert mutual electrostatic attractive forces between them that hold them together

-the compound containing this ionic bond is called the ionic compound

-an ionic compound is electrically neutral because they have no net charge.this means that the sum of positive and negative charge is the same

-ionic compounds have giant ionic crystal lattice structures which is a three-dimensional structure consisting of uncountable alternating positive and negative ions
-the ions are held strongly by ionic bonds in the lattice
-the bigger the charges on the ions,the stronger the electrostatic attractive force




-Properties of ionic substances
-ionic substances have high melting and boiling point as the electrostatic attractive force between the positive and negative ions are very strong.Thus,more energy is required to overcome it.
-ions can only conduct electricity in molten or aqueous states as they are not held strongly at their fixed positions by the ionic bonds in the giant lattice structure unlike the ions in the solid state.electricity is only conducted when ions are mobile.
-most ionic compounds are soluble in water to form aqueous solutions but insoluble in organic solvents
-ionic compounds are hard but brittle.
1.they are brittle because the electrostatic attractive forces between the oppositely charged ions hold them strongly together,so ionic compounds can resist deforming because the ions cannot move easily.
2.they are hard because the strong force applied on ionic compounds can cause the ions to shift away from their lattice positions.when the ions of the same charge approach each other,they repel one another .when the repulsive forces become greater than the attractive forces,the lattice structure are broken down

## 2.Covalent Bonding

-covalent bonding is the sharing of electrons equally between atoms of non-metals in order to attain the electronic configuration

-the chemical bond in covalent molecules is called the covalent bond.the number of covalent bonds between atoms depends on the number of pairs of shared electrons

-Eg:

—single bond:1 pair of shared electrons (H-H)

—double bond:2 pairs of shared electrons (O = O)

— etc…

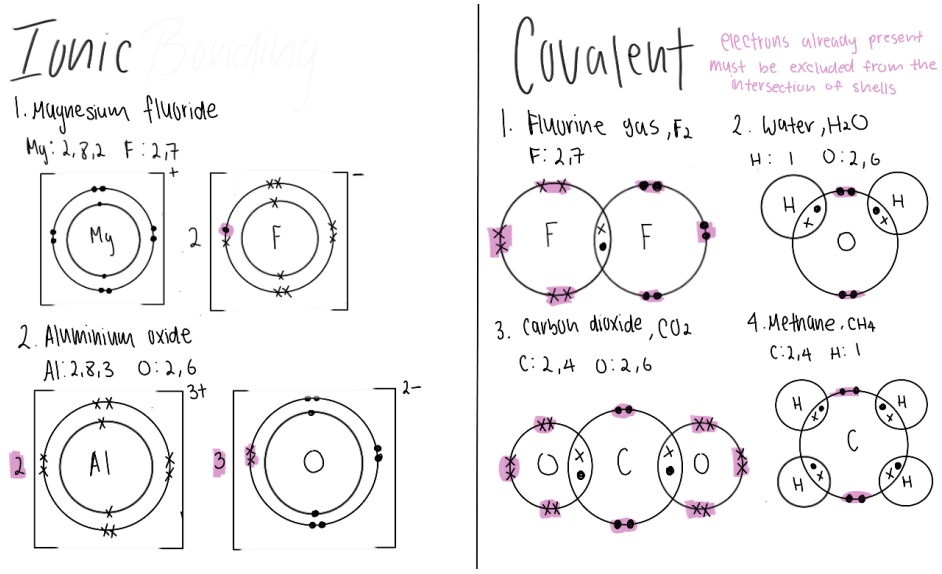
*Properties of covalent substances*

physical properties

-covalent molecules have low melting and boiling point because the intermolecular force between the molecules is very weak,so less energy is required to overcome it.however,the melting points and boiling points increases as the molecule gets larger.Thus,more energy is required to overcome them

-covalent molecules cannot conduct electricity at any state because they are neutral molecules as they do not have ions or delocalised electrons which can move about to conduct electricity.However,certain covalent molecules can dissociate in water to produce mobile ions to conduct electricity.

-most covalent molecules are soluble in organic solvents but not in water



Properties of metals

-in the structure of a pure metal,the same size of atoms are arranged in a regular pattern and are evenly distributed throughout the solid

-due to the regular arrangement of atoms in a pure metal,the layers of atoms can slide over each other easily when a force is applied.this makes a pure metal to be soft ,malleable and ductile

-malleable means that a solid can be beaten or hammered into shapes or thin sheets without breaking

-ductile means that a solid can be stretched or pulled into wires without breaking

-pure metals have high melting and boiling points because the metallic bonds hold the atoms strongly,so a large amount of energy is needed to overcome them

-they are good conductors of electricity and heat because the metal atoms have valence electrons that are free to move throughout the structure

Properties of alloys

-to make pure metals stronger,they are mixed with other elements to form alloys.

-alloy is a mixture of a metal with one or more other elements

-the different size of atom from the other elements disrupt the regular arrangement of the atoms in the pure metal.as a result,alloys have a irregular lattice arrangement

-therefore,a larger force is required to make the layers of atoms slide over each other.as such,an alloy is stronger,harder and less malleable than the pure metal itself.

-as alloys are mixtures,they melt and boil over a range of temperatures

-they are good conductors of electricity and heat because the metal atoms in the alloy have valence electrons that are free to move throughout the structure

-alloys insoluble in water and in organic solvents

Comparison of properties between pure metals and alloys

| Properties | Pure metals | Alloys |
|---|---|---|
| Strength and hardness | -soft and less hard<br>-malleable<br>-ductile | -stronger and harder<br>-less malleable<br>-less ductile |
| Melting and boiling points | -most of them have high M.P and B.P<br>-fixed M.P and B.P | -boils and melts over a range of temperatures as alloys are mixtures |
| Electrical and thermal conductivity in solid state | -good | -good |
| Solubility in water an in organic solvents | -no | -no |

Common alloys and their composition and applications in daily life

| Alloy | Main elements in the alloy | Purpose | Examples |
|---|---|---|---|
| Steel | Iron and carbon | -to increase strength and hardness | -cutlery<br>-building and bridge |
| bronze | Copper and tin | -to increase strength and hardness | -bells<br>-medals |
| brass | Copper and zinc | -to increase strength and hardness | -plumbing<br>-musical instruments |
| Stainless steel | Iron,carbon,nickel and chromium | -to resist corrosion | -utensils<br>-surgical instruments |
| Solder | Tin and lead | -to lower the melting point | -electrical wires<br>-circuit board |

| | | | |
|---|---|---|---|
| Rose gold | Copper and gold | -to improve appearance or produce new colours | -jewellery |

Elements,compounds and mixtures

| | elements | compounds | mixtures |
|---|---|---|---|
| What is it made up of? | Only 1 element | 2 or more elements chemically combined | 2 or more elements and/or compounds chemically combined |
| How is it formed? | Mostly naturally occuring | From chemical reaction | Usually from physically mixing |
| What is the ratio of its constituents? | - | Fixed ratio | No fixed ratio |
| What are the properties like? | - | Has different properties from its constituent elements | Usually has similar properties to its constituent substances |
| Melting and boiling points? | Fixed | fixed | Melts and boils over a range |

*Elements*

-elements can exist as monatomic elements

-we can use M.P and B.P to identify an element

-elements can be classified as metals and non-metals

*Compounds*

-compounds are defined as substances that are made up of two or more elements chemically combined together

-the formation of a compound requires a chemical reaction.therefore,energy change is usually involved
—energy is given out to the surroundings(exothermic)
—energy is taken in from the surroundings(endothermic)
-a compound has its own physical and chemical properties.the properties are different from its constituent elements
-when two elements,a metal and non-metal combine together to form a compound,the name of the non-metal in the compound changes to '-ide'

| Metallic element | Non-metallic element | Name of compound |
|---|---|---|
| Sodium | Chlorine | Sodium chlor**ide** |
| Magnesium | Oxygen | Magnesium ox**ide** |
| Aluminium | Sulfur | Aluminium sulf**ide** |
| Potassium | Iodine | Potassium iod**ide** |

-compounds can only be separated into their constituent elements using chemical methods such as thermal decomposition and electrolysis
—in thermal decomposition,compounds are heated strongly
—in electrolysis,the electric current passes through the compound

*Mixtures*

-mixtures consist of different substances that are not chemically combined together
-a mixture can be separated by physical methods such as filtration,crystallisation.or distillation
-a mixture can consist of either elements only,compounds only or both
-mixtures boils and melts over a range of temperatures

Differences between mixtures and compounds

| Factor | Compound | Mixture |
|---|---|---|
| Separation | -can be separated by chemical methods but not physical methods | -can be separated by physical methods |
| M.P and B.P | -takes place at a fixed | -takes place over a |

| | | |
|---|---|---|
| | temperature | wide range of temperatures |
| Composition | -has a fixed composition | -does not have a fixed composition |
| Properties | -has its own properties which are different from its constituent elements | -has the same properties as its constituent components |
| Formation | -involves chemical reactions | -does not involve chemical reactions |

## CHAPTER 5:THE MOLE CONCEPT & STOICHIOMETRY

Relative Atomic Mass ($A_r$)

-relative atomic mass $A_r$,of an element is defined as the average mass of one atom of an element compared with one-twelfth($\frac{1}{12}$) of the mass of a carbon-12 atom.

-the relative atomic mass has no unit

$$relative\ atomic\ mass\ A_r = \frac{average\ mass\ of\ one\ atom\ of\ an\ element}{\frac{1}{12}\ x\ mass\ of\ a\ carbon{-}12\ atom}$$

Relative Molecular Mass ($M_r$)

-atoms usually combine with one another or with other types of atoms to form molecules or compounds

-relative molecular mass $M_r$,is the relative mass for covalent molecules

— the relative molecular mass $M_r$,of a substance is defined as the average mass of one molecule of that substance compared relative to one-twelfth ($\frac{1}{12}$)the mass of an atom of carbon-12

Relative Formula mass $M_r$

-relative formula mass $M_r$ is the relative mass for ionic compounds($M_r$ is used for both relative masses of covalent molecules and ionic compounds)

-the relative formula mass $M_r$ of a compound is defined as the average mass of one unit of that compound relative to one-twelfth ($\frac{1}{12}$)the mass of an atom of carbon-12

-the relative molecular mass has no unit

$$M_r\ of\ a\ compound\ or\ molecule\ =\ sum\ of\ all\ its\ A_r$$

The mole concept

-when a sample of an element is weighed out exactly to its relative atomic mass ($A_r$) ,the quantity of atoms in the sample is $6x10^{23}$

Eg:

— the $A_r$ of Mg is 24. A sample of 24g of magnesium contains $6x10^{23}$ magnesium atoms

— the $A_r$ of F is 19. A sample of 19g of fluorine contains $6x10^{23}$ fluorine atoms

— the $A_r$ of O is 16. A sample of 16g of oxygen contains $6x10^{23}$ oxygen atoms

-this 'fixed quantity' was discovered by Avogadro,so it was named after him
-$6x10^{23}$ is known as Avogrado's constant
-this fixed quantity can be used to represent the quantity of particles in any substances.the particles can be atoms,molecules,electrons,ions and so on
-in the study of chemistry,this fixed quantity is represented by the term 'mole'
-1 mole represents a quantity of $6x10^{23}$
-hence,one mole is the amount of substance which contains the same number of particles.the particles can be atoms,ions,molecules,electrons and others
-1 mole of any substance contains the same amount of quantity
— 1 mole of Na atoms contains $6x10^{23}$ atoms
— 1 mole of $CO_2$ gas contains $6x10^{23}$ molecules
— 1 mole of Ag ions contains $6x10^{23}$ ions
— 1 mole of electrons contains $6x10^{23}$ electrons

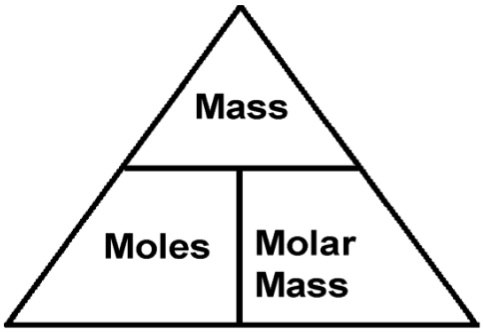
Mole ratio of elements/ions in a molecule or a compound

-the mole concept enables us to compare the mole ratios and the number of the atoms or ions in a molecule or a compound
-Eg:
—1 mole of $H_2O$ contains 2 H atoms and 1 O atom
Hence,in 1 mole of $H_2O$ molecules,it contains:
—2 moles of H atoms or (2x6) x $10^{23}$ H atoms
—1 mole of O atoms or 6 x $10^{23}$ O atoms
—1 mole of $NH_3$ contains 1 N atom and 3 H atoms
Hence, in 0.5 mole of $NH_3$ molecules, it contains:
—0.5 mole of N atoms or (6÷2) x $10^{23}$ N atoms
—1.5 moles of H atoms or ($6 \times \frac{3}{2}$) x $10^{23}$ H atoms

Relationship between mole and reacting mass

-molar mass of a substance is the mass of one mole of the substance.
-the symbol is $M_r$ and its unit is g/mol
-to calculator the number or mole from any given mass of a substance relating to its molar mass:

$$no.\ of\ moles\ of\ a\ substance \frac{mass\ of\ the\ substance}{M_r}$$




(1) Calculate the Mr of MgO

Mr = sum of all Ar

Ar of Mg: 24, Ar of O: 16

Mr = (1×24) + (1×16)

= 40

(2) Calculate the Mr of $HNO_3$

Ar of H: 1, Ar of N: 14, Ar of O: 16

Mr = (1×1) + (1×14) + (3×16)

= 63

(3) Calculate the Mr of $H_2SO_4$

Ar of H: 1, Ar of S: 32, Ar of O: 16

Mr: (1×2) + (1×32) + (4×16)

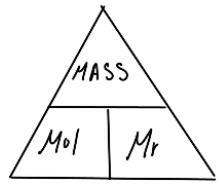
= 98

(4) Calculate the Mr of $CH_3CH_2OH$

Ar of C: 12, Ar of H: 1, Ar of O: 16

Mr: (2×12) + (1×6) + (16)

= 46




Mr = Molar Mass

(5) Calculate the no. of moles for the following atoms

a) 0.6g of carbon

no. of moles = $\frac{mass}{Mr}$

= $\frac{0.6}{12}$

= 0.05 mol

b) 10g of Calcium

no. of moles = $\frac{mass}{Mr}$

= $\frac{10}{40}$

= 0.25 mol

c) 1.7g of Nitrogen

no. of moles = $\frac{mass}{Mr}$

= $\frac{1.7}{14}$

= 0.121 mol

d) 12g of potassium

no. of moles = $\frac{mass}{Mr}$

= $\frac{12}{39}$

= 0.308 mol

(6) Calculate the Mass of the following substances

a) 0.5 mol of NaCl

Mass = Mol × Mr

= 0.5 × (23 + 35.5)

= 29.25

≈ 29.3g

b) 1.25 moles of $Cl_2$

Mass: Mol × Mr

= 1.25 × (35.5 × 2)

= 88.75

≈ 88.8 g

c) 4 moles of $H_2$

mass: Mol × Mr

= 4 × (1 + 1)

= 8g

d) 0.02 mol of $K_2CO_3$

mass = Mol × Mr

= 0.02 × (78 + 12 + 48)

= 2.76g

## CHAPTER 8:ACIDS AND BASES

Acids:

-an acid is a substance that produces hydrogen ions.H+ in aqueous solutions

-acids are classified into two groups,organic/inorganic

-organic acids are found in food and living things

-inorganic acids are found in rocks and minerals

| Acids | Formula | Ions produced in aqueous state |
|---|---|---|
| Ethanoic acid | $CH_3COOH$ | H+ and $CH_3COO$- |
| Hydrochloric acid | HCL | H+ and CL- |
| Nitric acid | $HNO_3$ | H= and $NO_3$- |
| Sulfuric acid | $H_2SO_4$ | $SO4^{2}$- |

-when carbon dioxide gas dissolves in water,it can also form an acid called carbonic acid,$H_2CO_3$

Strong acids and weak acids

-strong acids dissociate completely in water producing a high concentration of hydrogen ions (H+) eg:hydrochloric acid and sulfuric acid

-weak acids dissociate partially in water,producing an low concentration of hydrogen ions(H+) eg:carbonic acid and ethanoic acid

-strength of an acid is the extent of ionisation or dissociation of the acid in water

-concentration of an acid is the amount of acid dissolved in a given volume of water

*Physical Properties of Acids*

1.sour taste

2.able to conduct electricity

-corrosive if concentrated(strong acids)

-able to react with metals,carbonate compounds and bases/alkalis

-turn blue litmus paper,red

To test for the presence of an acid

-use indicators such as litmus paper,universal indicator and pH metre

-reaction with metals,carbonates and bases/alkalis

CHEMICAL PROPERTIES OF ACIDS

*Reaction with metals*

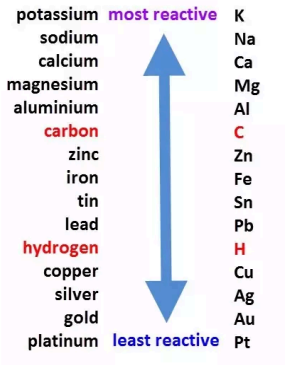
-when metals react with acids(basic and amphoteric),hydrogen gas is produced

General word equation: $acid + metal \rightarrow salt + hydrogen$

-the presence of hydrogen can be tested by using a lighted splint

-the lighted splint extinguishes with a 'pop' sound

-only metals that are above the position of hydrogen in the reactivity series are able to react with acids




Eg:

Word equation:

Magnesium + sulfuric acid → magnesium sulfate + hydrogen

Chemical equation:

$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$

Ionic equation:

$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

Word equation:

sodium + hydrochloric acid → sodium chloride + hydrogen

Chemical equation

$2Na(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2(g)$

Ionic equation:

$2Na(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + H_2(g)$

*Reaction with carbonates:*

-acids react with carbonate compounds to produce salts,carbon dioxide and water

General word equation:

$acid + carbonate \rightarrow salt + water + carbon\ dioxide$

-limewater is used to test for the presence of carbon dioxide

-white precipitate is formed in limewater when carbon dioxide is present

Eg:

Word equation:
iron(II) carbonate +sulfuric acid → iron(II) sulfate + carbon dioxide + water
Chemical equation:
$FeCO_3(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + CO_2(g) + H_2O(l)$
Ionic equation:
$FeCO_3(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + CO_2(g) + H_2O(l)$

Word equation:
Calcium carbonate +nitric acid → calcium nitrate +carbon dioxide + water
Chemical equation:
$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$
Ionic equation:
$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$

*Reaction with bases/alkalis*

-acids react with bases/alkalis to produce salts and water

-the reaction between acids and bases/alkalis is called the neutralisation reaction

General equation: $acid + base/alkali \rightarrow salt + water$

Ionic equation:$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Eg

Word equation:
Sodium hydroxide +sulfuric acid →sodium sulfate + water
Chemical equation:
$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
Ionic equation:
$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

Bases:

-bases are metal oxides that react with acids to produce salts and water

| Chemical names | Chemical formula |
|---|---|
| iron(II) oxide | FeO |
| Magnesium oxide | MgO |
| copper(II) oxide | CuO |
| Lithium oxide | $Li_2O$ |

-most bases are insoluble except bases with group 1 metals and ammonium ion

| Soluble bases | Insoluble bases |
|---|---|
| Bases containing group 1 metals | Bases containing all other metals generally |
| Bases containing ammonium ion ($NH_4^+$) | |

-when a base dissolves in water,it forms metal hydroxide which is called an alkali

-Eg:

**$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$**

(base) (alkali)

-alkalis are substances that release hydroxide ions ($OH^-$) when dissolved in water

Properties of a base

1.soapy feeling

2.turns red litmus paper blue

3.able to conduct electricity

4.corrosie if concentrated

5.reaction with acids to form salt and water

6.reaction with ammonium salts to form ammonia,salt and water

CHEMICAL PROPERTIES OF BASES/ALKALIS

*Reaction with acids*

-bases and alkalis are able to react with acids to form salts and water

-the reaction is called the neutralisation reaction

General equation: $acid + base/alkali \rightarrow salt + water$

Ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

*Reaction with ammonium salts*

-bases and alkalis can react with ammonium salts to produce ammonia gas,salt and water

General word equation:

$base/alkali + ammonium\ salt \rightarrow salt + ammonia + water$

-ammonium salts are fertilisers used to increase the soil fertility

Eg of ammonium salts

| Chemical name | Chemical formula |
|---|---|
| Ammonium chloride | $NH_4Cl$ |
| Ammonium sulfate | $(NH_4)_2SO_4$ |
| Ammonium nitrate | $NH_4NO_3$ |

-damp/moist red litmus paper is used to test for the presence of ammonia gas because it is an alkaline gas.the damp red litmus paper turns blue if ammonia gas is present

Eg:

Word equation:

Lithium hydroxide+ammonium sulfate → lithium sulfate + water

Chemical equation:

$2LiOH(aq)+(NH_4)_2SO_4(aq)\rightarrow Li_2SO_4(aq)+2NH_3(g)+2H_2O(l)$

Ionic equation:

$OH^-(aq)+NH_4^+(aq)\rightarrow NH_3(g)+H_2O(l)$

## MEASURING THE ACIDITY AND ALKALINITY OF A SOLUTION

*The pH scale*

-the pH scale is a measure of the relative acidity or alkalinity of a solution
-the pH of a solution can be determined by using an indicator or a pH metre connecting to a datalogger
-the pH value of a substance depends on the relative concentrations of hydrogen ions ($H^+$) and hydroxide ions ($OH^-$)

| In a solution | | pH value | Name of solution |
|---|---|---|---|
| Concentration of $H^+$ | Concentration of $OH^-$ | | |
| Very high | Very low | 0-1 | Strong acid |
| Moderate high | Moderate low | 2-6 | Weak acid |
| Equal | Equal | 7 | Neutral |
| Moderate low | Moderate high | 8-12 | Weak alkali |
| Very low | Very high | 13-14 | Strong alkali |

*Indicators:*

-an indicator is a mixture of substances which show different colours in different pH of a solution
-universal indicator is an indicator which contains a mixture of substances that are able to give different colour corresponding to different pH values
-the table below shows the colours of universal indicator corresponding to the pH scale

| Types of indicator | Colour observation | | |
|---|---|---|---|
| | Acidic | Neutral | Alkaline |
| Litmus | Red | - | Blue |
| phenolphthalein | Colourless | Colourless | Pink |
| Methyl orange | red (pH<3.5) | Yellow | Yellow |

CONTROLLING pH IN SOILS

-the acidity of soil can be caused by acid rain,fertilisers and microbial activities in the soil

-calcium hydroxide(slaked lime) is used to treat the excess acidity in soils because it reacts quickly with acids.

-this is known as 'liming' the soil

-if the soil is acidic,it affects the growth of healthy plants.however,using too much calcium hydroxide can cause the soil to become alkaline instead and affects the plant growth also

-therefore.it is very important to control the pH in soils carefully

-when calcium hydroxide is added to the acidic soils,it neutralises acids very fast.the soil will not be acidic anymore and plants can grow healthily

-both calcium carbonate(limestone) and calcium oxide(lime) is able to treat acidic soils but not as effective as calcium hydroxide

-calcium hydroxide should not be mixed with fertilisers containing ammonium ions because displacement of ammonia from the fertilisers will take place

OXIDES:

-oxides are compounds of oxygen and one other element

The 4 types of oxides:

-basic oxides(metallic)

-amphoteric oxides(metallic)

-acidic oxides(non-metallic)

-neutral oxides(non-metallic)

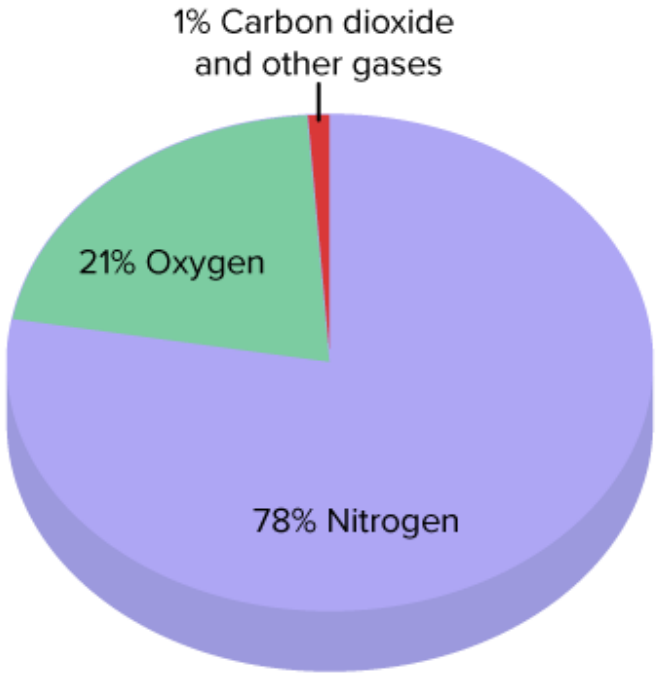
| Type of Oxide | How it forms | Explanation |
|---|---|---|
| Basic oxide | -most metals combine with oxygen (except Zn,Al,Pb)<br>-examples:<br>—copper(II) oxide,CuO<br>—magnesium oxide,MgO<br>-calcium oxide,CaO | -they react with acids only to form salts and water<br>-for example:<br>**$CaO(s)+2HCl(aq)\rightarrow CaCl_2(aq)+H_2O(l)$** |

| | | |
|---|---|---|
| Amphoteric oxide | -metals combine with oxygen<br>-examples:<br>—Zinc oxide,ZnO<br>—Aluminium oxide,$Al_2O_3$<br>—lead(ll) oxide,PbO<br>(ZAP)=Zinc,Alum,Pb | -they react with both bases and acids to form salts and water<br>-for example:<br>When ZnO reacts with NaOH(base),it acts as an acid to produce sodium zincate(salt) and water<br>**$ZnO(s) + 2NaOH(aq) \rightarrow Na_2ZnO_2(aq) + H_2O(l)$**<br>When an amphoteric oxide reacts with HCl(acid),it acts as a base to produce zinc chloride(salt) and water |
| Acidic oxide | -non-metals combines with oxygen<br>-examples:<br>—carbon dioxide,$CO_2$<br>—sulfur dioxide,$SO_2$<br>—phosphorus(V) oxide,$P_2O_3$<br>—silicon dioxide,$SiO_2$ | -they dissolve in water to form an acid.<br>-for example:<br>When $CO_2$ dissolves in water,carbonic acid is formed.<br>**$CO_2(g) + H_2O(l) \rightarrow H_2CO_3(l)$**<br>-they react with bases only to form salts and water<br>-for example:<br>**$SO_2(g) + 2NaOH(aq) \rightarrow Na_2SO_3 + H_2O(l)$** |
| Neutral oxide | -non-metal combines with oxygen<br>-examples:<br>—carbon monoxide,CO<br>—nitric oxide,NO<br>—Water,$H_2O$ | -they do not react with both bases and acids<br>-they are insoluble in water(other than water itself) |

**CHAPTER 13:MAINTAINING AIR QUALITY**

Composition of air:air is a mixture of gas

-since it's a mixture,it can be separated into its components by traditional distillation and because each gas has its own boiling point.




Separation:

As the temperature increases,nitrogen vaporizer first from the liquid air first as it has the lowest boiling point followed by argon and then oxygen

| substance | Boiling point |
|---|---|
| nitrogen | -196 |
| argon | -186 |
| oxygen | -183 |

Uses of oxygen:

-used together with acetylene for welding and cutting

-used in the hospital for patients with breathing difficulties

*Air pollution*

-air pollutants are unwanted chemical substances in the air which can cause harmful effects to the environment and living things

-air pollution is the introduction of sufficient amount of air pollutants that have the harmful effects on living organisms and the environment

-air pollution is the result of natural processes(volcano/lightning activity) and human activities

Air pollutants

-carbon monoxide,sulfur dioxide,oxides of nitrogen,methane,unburnt hydrocarbons and the ozone are examples of air pollutants

1.carbon monoxide—CO

-colourless,odourless and poisonous

-the source of carbon monoxide is due to the incomplete combustion of petrol in car engines.it combines with the haemoglobin in blood to form carboxyhemoglobin which reduces the transport of oxygen thus,leading to death

2.sulfur dioxide—$SO_2$

-colourless,non-flammable gas with a penetrating odour

-the source of sulfur dioxide is due to the combustion of fossil fuels,coal or volcanic activities.it irritates the eyes and lungs hence,causing respiratory problems.it also reacts with water in the atmosphere to form sulfurous acid and is oxidised to form sulfuric acid(acid rain).which corrodes METAL/LIMESTONE(calcium carbonate) buildings or structures and harms aquatic life and plants.

3.oxides of nitrogen—NO or $NO_2$

-NO is colourless and odourless

-$NO_2$ is reddish brown,pungent and non-flammable

-it is produced during combustion at high temperature in vehicle engines as well as in lightning activity.it irritates eyes and lungs,hence,causing respiratory problems.it also reacts with water in the atmosphere to form acid rain thus,corroding METAL/LIMESTONE buildings and harms aquatic life and plants

4.methane——-$CH_4$
-colourless,odourless and flammable
-found in natural gas
-decomposition of plants and animal matters in wetlands and marshes by bacteria in the absence of oxygen,it is one of the GREENHOUSE gases hence,more warming affect than CO2
5.unburnt hydrocarbons
-organic chemicals that vapourise at room temperature
-internal combustion engines of vehicles.the formation of ground-level ozone leads to photochemical smog
6.ozone
-bluish and strong odour
-produced when nitrogen oxides react with unburned hydrocarbons in the presence of sunlight.it irritates the respiratory system hence,breathing difficulties

FORMATION OF ACID RAIN:

Acid rain is formed when sulfur dioxide and nitrogen dioxide dissolve in rain to form acidic compounds
-it harms aquatic life and plants
-corrodes METAL/LIMESTONE structures and buildings

$SO_2+H_2O\rightarrow H_2SO_3$
$H_2SO_3+OR\rightarrow H_2SO_4$
$4NO_2+2H_2O\rightarrow 4HNO_3$

CARBON CYCLE:

Carbon cycle is the mechanism that maintains the level of CO2 in the atmosphere
-the carbon cycle encompasses land,ocean and atmosphere
-the carbon cycle describes a set of processes that regulates the amount of carbon dioxide in the atmosphere.concentration of atmospheric $CO_2$ is thus,maintained through the natural interactions between environment and living things in nature

| Processes that release $CO_2$ | Processes that removes $CO_2$ |
|---|---|
| Combustion of fossil fuels | Photosynthesis |
| Respiration | Dissolving in sea water and uptake into invertible shells |
| Volcanic activity | |
| Weathering of carbonate rocks | |

GREENHOUSE EFFECT/GLOBAL WARMING AND ITS CONSEQUENCES

-the greenhouse effect is the warming of the atmosphere caused by the absorption of infrared radiation by greenhouse gases

-carbon dioxide and methane are the main greenhouse gases

-process of greenhouse effect/increased carbon dioxide leads to global warming

*Climate change and other consequences*

-change in rainfall patterns

-heat waves

-tropical storms

-ocean warming and acidification

-glacial retreat and melting of polar ice caps

## CHAPTER 7:PERIODIC TABLE

The periodic table is the arrangement of elements in the order of increasing proton number.

Groups are the vertical columns of elements.The group number indicates the number of valence electrons an element has.

-all group 1 elements use 1 electron to form positive ion of +1

-all group 2 elements lose 2 electrons to form positive ions of +2

-all group 7 elements gain 1 electron to form negative ions of -1

-all group 8 elements are UNREACTIVE because they have a fully filled valence shell

-Going down a group,there is an increase in metallic properties and decrease in non-metallic properties because they are more likely to lose electrons than gain electrons.this is because the size of the atoms gets larger going down the group,the outermost electrons will also be further away from the attractive force of the nucleus.therefore,an element further down a group will lose its outermost electrons more easily

-Periods are the horizontal rows of elements in the periodic table which indicates the number of shells each element has

-Across a period from left to right,elements change from metal to non-metals.hence,there is a decrease in metallic properties and an increase in non-metallic properties because elements become more and more likely to gain electrons than lose electrons from left to right across the period.

-a period starts with an element with one valence electron and ends with the element with a full valence shell

-all elements in the same period have the same number of electron shells

GROUP 1:ALKALI METALS

-group 1 elements are metals. They are known as alkali metals.

-they are stored beneath oil to prevent them from coming into contact with water because they react spontaneously with moist and the reaction is highly exothermic and violent

-they react with water to form alkaline solutions

General equation:

**Alkali metal+water→alkali+hydrogen**

| Physical properties | Chemical properties |
|---|---|
| -shiny<br>-soft and can be cut with a knife<br>-good conductor of electricity<br>-good conductor of heat<br>-ductile(able to be bent into a wire)<br>-malleable<br>-low density<br>-relative low melting and boiling points compared to other metals in the periodic table | -have 1 valence electron<br>-loses 1 electron to form positive ions +1<br>-reacts vigorously with water to produce alkalis and hydrogen gas<br>-reacts with non-metals to form ionic compounds<br>-reacts with acid to produce salt and water |

Trends going down group 1:

-the M.P and B.P decreases

-density increases

-elements become more and more reactive

-elements become more reactive down the group means that it is more readily to use its valence electron.

-it is easier to lose the valence electron when the size of the atom increases(more shells)hence,a greater tendency to lose its valence electron to form positive ions

-The more readily the atoms lose their valence electrons,the more reactive the element will become.

| Element | m.p | b.p | Density | State at r.t.p |
|---|---|---|---|---|
| Li,lithium | 180 | 1330 | 0.53 | Solid |
| Na,sodium | 98 | 883 | 0.86 | Solid |
| K,potassium | 63 | 774 | 0.97 | Solid |
| Rb,rubidium | <63 | <774 | >0.97 | |

GROUP 17 :HALOGENS

-group 17 elements are non-metallic and are known as halogens which means 'salt formers'

-they exist as diatomic molecules such as $F_2$,$Cl_2$,etc...because they can achieve a stable electronic configuration by sharing electrons through covalent bonding

-diatomic=a molecule consisting of two atoms chemically combined

-they react with metals to form salts called halides

-after the reaction,halogens name changes from '----ine' to '----ide'

| Physical properties | Chemical properties |
|---|---|
| -poor conductor of heat<br>-poor conductor of electricity<br>-brittle in solid states<br>-covalent molecules<br>-low M.P and B.P | -have 7 valence electrons<br>-gain 1 electron to form negative ions -1<br>-form ionic compounds with metals(metal+non metal)<br>-forms covalent compounds with non-metals |

The trends going down group 17

-the physical states changes from gas to solid

-colour intensity increases

-M.P and B.P increases

-reactivity decreases down the group in group 17

-halogens have a high tendency to attract one more electron to attain a fully filled valence shell
-this is because the size of atom increases down the group,it is further away from the attractive force of the nucleus,making it difficult for the nucleus to attract one more electron
-the most reactive is fluorine and the last reactive is astatine because the reactivity decreases as it goes down the group
-this indicates that the more reactive halogen is able to displace the less reactive halogen from its halide solution,this is called the displacement reaction
-a displacement reaction is a reaction in which one element takes the place of another element in the compound.

GROUP 18:NOBLE GASES
-group 18 elements are known as noble gases
-they are unreactive because they have a maximum number of electrons in their valence shell.so,they exist as monatomic elements.

| Physical properties | Chemical properties |
|---|---|
| -monoatomic<br>-colourless<br>-low M.P and B.P<br>-insoluble in water | -unreactive/inert<br>-do not gain/lose/share electrons to form ions/compounds |

APPLICATIONS OF NOBLE GASES:
-helium in balloons
-neon in light bulbs
0argon in tungsten bulbs and in manufacture of steel
-xenon in vehicle headlamps

**CHAPTER 10:REACTIVITY SERIES**

-in the reactivity series,the metals are naked from most reactive to the least reactive.

-the reactivity series is related to the tendency of a metal to form its positive ion,illustrated by its reaction with water,steam and dilute hydrochloric acids

-the easier to lose electrons=more reactive

Reactivity series of metals:

*Reaction with cold water:*

-the most reactivated metals can react with cold water to produce alkaline solution

Metal + water →metal hydroxide + hydrogen

| | |
|---|---|
| Please (K) —potassium<br>Stop (Na) —sodium<br>Calling (Ca) — calcium<br>Me (Mg) —magnesium<br>A (Al) —aluminium<br>Coloured (C) —carbon<br>Zebra (Zn) —zinc<br>I (Fe) —iron<br>Leaders (Pb) —lead<br>Have (H) —hydrogen<br>Cool (Cu) —copper<br>Silver (Ag) —silver<br>Glasses (Au) —gold | K,potassium most reactive<br>Na,sodium<br>Ca,calcium<br>Mg,magnesium<br>Al,aluminium<br>C,carbon<br>Zn,zinc<br>Fe,iron<br>Pb,lead<br>H,hydrogen<br>Cu,copper<br>Ag,silver<br>Au,gold least reactive |

| Metals | Reaction with COLD WATER | |
|---|---|---|
| | Observation | Chemical equation |
| Potassium (K) | Extremely vigorous and explosive with a purple or lilac flame | $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$ |
| Sodium (Na) | Very vigorous and may catch fire | $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) +$ |

| | | |
|---|---|---|
| | | $H_2(g)$ |
| Calcium (Ca) | Quite reactive with cold water | $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2 + H_2(g)$ |
| Magnesium (Mg) | Very slow reaction | $Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$ |
| aluminium,zinc,iron ,lead ,hydrogen,copper,s ilver,gold | No reaction | - |

*Reaction with steam*

-the most reactive metals can react with cold water and steam

-the moderate reactive metals can only react with steam but not with cold water

-the least reactive  metals cannot react with both cold water and steam

-when a metal reacts with steam,the reaction produces metal oxide and hydrogen

Metal + steam →metal oxide + hydrogen

| Metals | Reaction with steam | |
|---|---|---|
| | Observation | Chemical equation |
| potassium to calcium | Reacts explosively with steam | Produces alkali and hydrogen gas |

| | | |
|---|---|---|
| Magnesium | Very fast reaction with a bright white flame | $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$ |
| Zinc | Reacts readily with steam | $Zn(s) + H_2O(g) \rightarrow FeO(s) + H_2(g)$ |
| Iron | Reacts slowly | $Fe(s) + H_2O(g) \rightarrow FeO(s) + H_2(g)$ |
| Lead to silver | No reaction | - |

**REACTIONS WITH DILUTE ACID(HCL)**

-when a metal reacts with HCL,the reaction produces a salt and hydrogen

| Metals | Reaction with dilute HCL | Equation |
|---|---|---|
| K,potassium | Explosive and violent reaction | $2K(s) + 2HCl(aq) \rightarrow 2KHCl(aq) + H_2(g)$ |
| Na,sodium | Very vigorous reaction | $2Na(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2(g)$ |
| Ca,calcium | Vigorous | $Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2\ (g)$ |
| Mg,magnesium | Very fast reaction | $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ |
| Al,aluminium | | - |
| C,carbon | No reaction | - |
| Zn,zinc | Moderate reaction | $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ |
| Fe,iron | Slow reaction | $Fe(s) + 2HCl(aq) \dashrightarrow$ |

| | | |
|---|---|---|
| | | $FeCl_2(aq) + H_2(g)$ |
| Pb,lead | No reaction | - |
| Cu,copper | No reaction | No reaction |
| Ag,silver | | |
| Au,gold | | |

Lead can react with dilute HCL initially(it is above H,more reactive than H).however,the reaction forms an insoluble layer of lead(II) chloride,$PbCl_2(s)$,which coats the lead and prevents Pb from reacting further.therefore,it appears that Pb does not react with dilute HCL

Tendency of forming positive ion

-the more reactive the metal,the greater the tendency of its atoms to lose electrons to form positive ions

-the tendency for a more reactive metal to form positive ions than a less reactive metal can be observed in displacement reaction

Displacement reaction of metals

-a more reactive metal can displace a less reactive metal from its salt solutions

-similarly, a more reactive metal can displace a less reactive metal from its oxide

-the atoms of a more reactive metal lose electrons to form positive ions.the positive ions will enter the solution

-the ions of a less reactive metal in the solution gain electrons and are discharged as atoms of an element

EG:

*What is observed when iron filings are added to $CuSO_4$?*

Reddish-brown solid.the solution turns green due to the iron (II) ions.iron is more reactive than copper as it is above copper in the reactivity series.hence,iron can displace copper from copper(II) sulfate solution

Equation: $CuSO_4(aq) + Fe(s) \rightarrow FeSO_4(aq) + Cu(s)$

Extraction of metals

-metals are found to combine with other elements in the earth's crust called ores and exist mainly as oxides,carbonates or sulfides

-an ore is a mineral or mixture of minerals from which economically viable amounts of metal can be extracted

-the metals must be extracted from their ores so that they can be made into useful substances

-the extraction of metals can be done by one of the following methods

1.electrolysis(K,Na,Ca,Mg)

2.reduction with carbon(Zn,Fe,Ob,Cu,Ag)

-the more reactive the metal is,the harder it is to extract the metal

-the oxides of metals lower in the series are more easily reduced by carbon than the oxides of more reactive metals

Reduction of metallic oxides by carbon

-In the process of reduction,metallic oxides are heated in the presence of reducing agents.

-the reducing agents used in the extraction of these metals are usually carbon

-the metallic oxide is reduced because it loses oxygen atoms to form pure metals

Rusting of iron metal

-when iron changes into brownish orange hydrated iron(lll) oxide caller rust in the presence of both water and oxygen,it is called rusting,

-rusting occurs when the following conditions are fulfilled

1.the presence of oxygen

2.the presence of water

Word equation:

**Iron + oxygen + water →hydrated iron (lll) oxide**

Chemical equation:

**$4Fe(S) + 3O_2(g) + 2\chi H_2O(l) \rightarrow 2Fe_2O_3.\chi H_2O(s)$**

-rusting is an oxidation reaction because iron gains oxygen

-rust formed on the surface of iron and steel objects is a flaky substance that easily crumbles into a powder.once rust flakes off,more iron is exposed to form rust until the metal is destroyed completely

-the speed of rusting increases if salt or acidic conditions are present

Prevention of rusting

| Method | How does it protect | Where is it used |
|---|---|---|
| Cover with oil | It prevents the metal to come into contact with water and oxygen | Machines<br>(can double as lubricant) |
| Cover with paint | it prevents the metal to come into contact with water and oxygen.however,if the paint is scraped off,the iron is exposed to water and oxygen hence rusting would take place | Motor cars<br>Ships<br>Bridges |
| Making stainless steel | Stainless steel contains large amount of Ni and Cr.this alloy does not rust easily.however,it is quite expensive | knives and medical instruments |

**CHAPTER 15:FUELS AND CRUDE OIL**

FUELS:

-fossil fuels are known as hydrocarbons

-hydrocarbons are compounds that only consist of hydrogen and carbon

-they are formed from the decomposition of plants and animals that lived millions of years ago

-fuels are substances which produce a large amount of thermal energy(heat) when they are burnt in the presence of oxygen

-this exothermic reaction is called combustion

-the thermal energy produced can be converted to other forms of energy,such as electrical energy which we use in our daily lives

-natural gas(mainly methane),coal and petroleum are the three main components in fossil fuels

-they are organic compounds because they all contain carbon element as the main component in their structures

-natural gas and crude oil are non-renewable energy sources because they cannot be replenished in a short period of time to meet our rate of use

| Fuel | Appearance | Constituents |
|---|---|---|
| Natural gas | Colourless | Mainly methane($CH_4$) |
| Petroleum | Dark brown black liquid | A mixture of hydrocarbons |

Main issues with using fossil fuels to provide energy:

1.will run out one day as it is limited and non-renewable

2.pollutes the environment

NATURAL GAS:

-a gaseous fossil fuel,mainly consisting methane

-before the natural gas gets transported,it undergoes a process called liquefaction to produce LNG(liquefied natural gas)

-LNG is safer for consumers use compared to the gaseous form of natural gas as it does not burn too easily

-liquids have a smaller volume compared to gases hence,taking up less space when transported thus,natural gas is condensed into liquefied natural gas when transported instead if remaining in its gaseous form

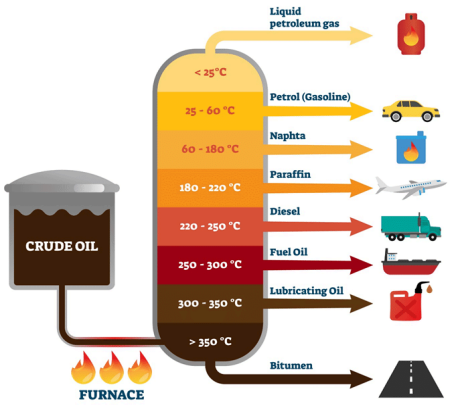
-the word equation for the burning of methane in excess oxygen is:
**Methane + oxygen →carbon dioxide + water**
Eg: **$CH_4(g) + O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$**
-liquefied natural gas (LNG) does not burn too easily,so it can be transported and stored safely.and it also safer for consumers
-as natural gas is odourless,an additive such as tetrahydrothiophene(TNT),which has a pungent smell is added so that leaks can be easily detected

Crude Oil:

-crude oil is also known as petroleum
-consists of mixture of hydrocarbons with different properties
-some can be burnt to produce energy
-others are common starting materials used to synthesise other chemicals like plastic
-crude oil needs to be separated into the different groups of hydrocarbons before each group can be used
-separation of crude oil into different groups of hydrocarbons is compulsory for use because different hydrocarbons burn at different temperatures hence,hydrocarbons that burn under similar conditions can be grouped together

Fractional distillation of crude oil:

-the hydrocarbons in crude oil have different boiling points and are miscible
-fractional distillation can be used to separate crude oil into useful fractions
-fractions with higher boiling points are gathered at outlets further down the column,while fractions with lower boiling points are collected at the topmost outlet.
-the temperature are the highest at the bottom of the fractionating column and decreases towards the top
-lighter fractions are made of fewer carbon atoms=smaller molecular size=weaker intermolecular forces of attraction=small amount of energy is needed to overcome=lower boiling points




-petroleum gas/fuel—for cooking and heating(lowest boiling point)
-petrol— for vehicles
-naptha— for making petrochemicals such as plastics and detergents
-kerosene—for engines in buses,lorries,trains and aeroplanes
-diesel oil for—diesel engines
-lubricating oil for—lubricating machines for making waxes and polishes
-bitumen for making road surfaces and roofing(highest boiling point)

-these fractions can be memorised by a simple acronym:
**P**ink **P**anther **N**ever **K**iss **D**irty **L**ittle **B**oy
Four trends as the fractions becomes heavier(petroleum to bitumen)
1-molecules become bigger due to an increase in the number of C atoms
2-liquids flow less easily(more viscous)
3-liquids burn easily
4-when liquids burn,they burn with a more smokey flame

| Physical properties down the fractions | Explanation |
|---|---|
| Boiling points increases | The intermolecular forces between molecules increase when the size of the molecules increases.hence,more energy is required to overcome the forces |
| Less flammable | The percentage by mass of carbon in the molecules increases when |

| | |
|---|---|
| | the size and mass of the molecules increases,so the hydrocarbons become less flammable |
| High viscosity | The intermolecular forces between molecules increase when the size of molecules increases,so it is more difficult to overcome them.thus,a larger hydrocarbons become thick or waxy,so they do not flow easily |
| Low volatility | The intermolecular forces between molecules increase when the size of the molecules increases,so more heat is required to break these forces to change their physical states |

Uses of different crude oil fractions:

-90% used a fuel

-10% used as petrochemical feedstock(manufacture of plastics,rubber,etc)

-issues arising from competing uses:

-crude oil is limited in supply

-crude oil fractions are needed for the manufacture of daily products

Conservation of crude oil

-reduce the use of fossil fuels in transportation such as using more public transport instead of private vehicles

-use alternative energy resources such as solar energy or nuclear energy

-improve the design of power stations and vehicles so that they are more energy-efficient

Biofuels:

-biofuels are alternative fuels derived from plants or animals to crude oil and natural gas

-ethanol can be produced from the fermentation of plants such as sugarcane

-it is also known as bioethanol when used as an alternative

-they are referred to as renewable energy sources

-renewable energy sources are energy resources that can be replenished in a short period of time or have no risk of depletion
-biofuels are renewable because more plants can be grown after use
-sugarcane plants can be regrown in a short period of time =the ethanol produced is considered renewable
-sugarcane plants absorb carbon dioxide during photosynthesis =burning ethanol is environmentally sustainable

-when ethanol is burnt in excess oxygen,the chemical equation is as follows :
$\mathbf{C_2H_5OH \rightarrow 3O_2 \rightarrow 2CO_2 + 3H_2O}$
-to produce enough bioethanol,a lot of sugarcane needs to be grown and transported
-sugarcane plants can be replaced within a short period of time after it is used.
-an advantage of using bioethanol over crude oil is that the carbon dioxide emitted by bioethanol during combustion can be taken in during photosynthesis
-these processes may require burning fossil fuels and thus produce carbon dioxide
-burning of bioethanol is considered more environmentally sustainable than the use of fossil fuels.This is because carbon dioxide released from the combustion of bioethanol is matched by the plant absorbing the same amount of carbon dioxide for photosynthesis.

*HYDROCARBONS*
Homologous series:
- a family of compounds with the same general formula and similar chemical properties because they have the same functional group and the gradual change of physical properties as a result of increase in size and mass of the molecules.
-a functional group is an atom or combination of atoms which gives organic molecules distinctive chemical properties

| Homologous series | Functional group | | General formula |
|---|---|---|---|
| | Name | Drawing | |
| Alkanes | Carbon-carbon single bonds | —-C—C—- | CnH(2n+2) |
| Alkenes | Carbon-carbon double bonds | -—C=C—- | CnH(2n) |

Molecular formula:
-a molecular formula summarises the types of elements and the total atoms in a molecule but no information on its arrangement of atoms
Structural formula:
-a structural formula shows how atoms are covalently bonded to one another in the molecule.all the bonds are displayed
Naming of organic compounds:
-the name of an organic compound consists of a prefix and a suffix
-the prefix indicates the number of carbon atoms in the compound

| Prefix | Meth- | Eth- | Prop- | But- |
|---|---|---|---|---|
| Number of carbon atom | 1 | 2 | 3 | 4 |

*Alkanes*

-alkanes are obtained directly from the fractional distillation of petroleum
-alkanes are saturated hydrocarbons
-general formula of CnH(2n+2)
-contains carbon-carbon single bonds
-similar chemical properties
-a gradual change in their physical properties
-saturated hydrocarbons indicates that the molecule contains only carbon-carbon single bonds.each carbon atom is covalently bonded to four other atoms,so no new atom can add to it anymore.
-they are hydrocarbons which contain only elements of carbon and hydrogen

| Alkane | Molecular formula | Boiling point | Physical states at room temperature | Condensed formula |
|---|---|---|---|---|
| Methane | $CH_4$ | -162 | Gas | $CH_4$ |
| Ethane | $C_2H_6$ | -89 | Gas | $CH_3CH_3$ |

-alkanes are NOT soluble in water but soluble in most organic solvents such as tetrachloromethane
-they can be used as solvents for other organic compounds.EG,liquid hexane is a solvent for alkenes
-when the size and mass of alkane molecules increases down the homologous series,a gradual change in the following physical properties is observed as well:
1.M.P and B.P INCREASES because the forces of attraction increases as their size increases down the homologous series
2.density INCREASES
3.viscosity INCREASES because of the forces of attraction that increases as their size increases down the homologous series.
-more molecules=more heavy=move slower=less viscous
4.flammability DECREASES

Chemical reactions of alkanes:

-alkanes are generally unreactive because they are saturated

-they can undergo combustion,substitution and cracking reactions

*1.Combustion:*

-the reaction is exothermic

-in complete combustion,alkanes burn with blue flame without smoke

-in incomplete combustion,alkanes burn with yellow smoky flame and produces carbon monoxide and soot (carbon)

-alkanes burn in excess oxygen to produce carbon dioxide and water

Word equation:(complete combustion)

Alkane + oxygen gas → carbon dioxide + water

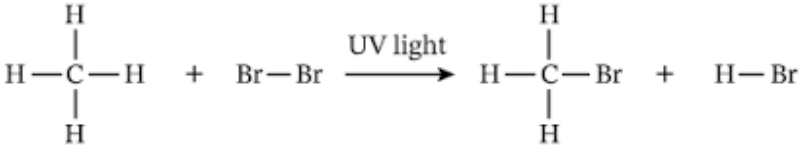
*2.Substitution reaction:*

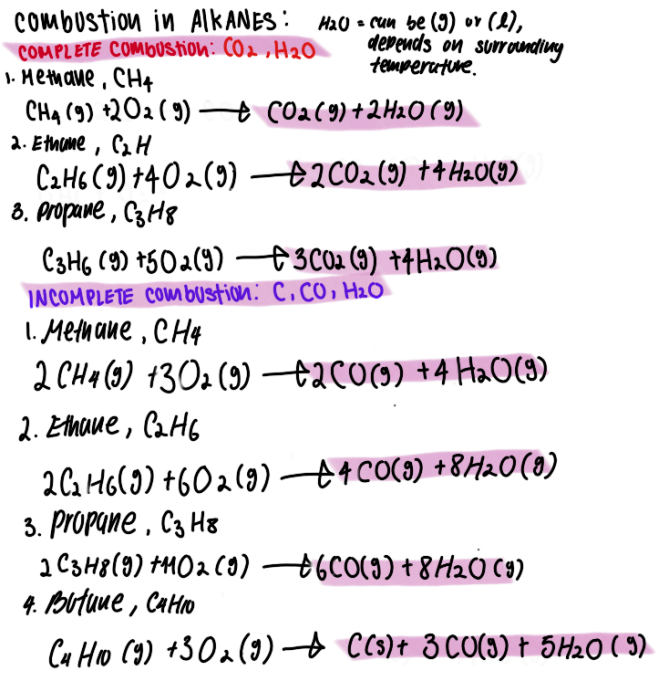
-reaction with halogens(chlorine or bromine) in the presence of UV light as the catalyst

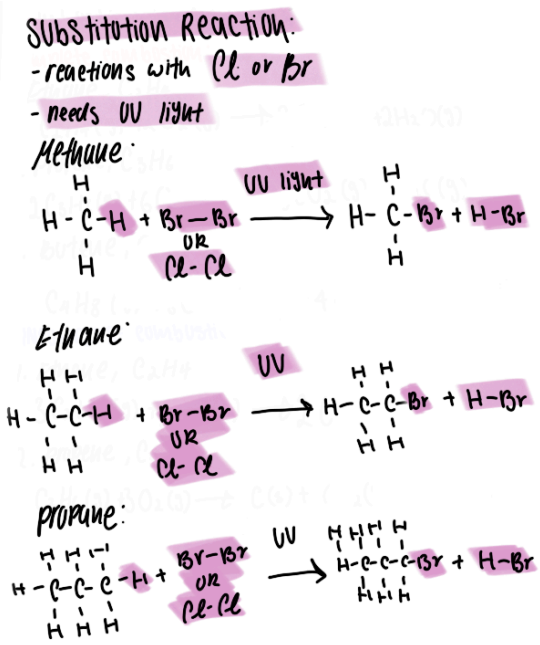
-´photochemical substitution reaction´=the reaction that takes place only in the presence of ultraviolet light/sunlight

-a hydrogen atom is substituted by a chlorine atom to form chloromethane

-each hydrogen in an alkane is displaced one at a time by one molecule of halogen gas




*3.Cracking*

-a process in which larger hydrocarbon molecules,usually alkanes,are broken down into smaller hydrocarbon molecules

-cracking is carried out by using high temperatures and pressures without a catalyst

-it can also be done in lower temperatures and pressures in the presence of a catalyst.this process is called the catalytic cracking which requires

-aluminium oxide $Al_2O_3$ or silicon dioxide $SiO_2$

-temperature -500℃ to 700℃

-a pressure of about 1 atm

-cracking has two different pathways which lead to different product formation

*Possible reaction 1:*

large alkane→mixture of alkenes + alkane

*Possible reaction 2:*

large alkane → mixture of alkenes + hydrogen

<u>Importance of cracking:</u>

-it produces hydrogen for manufacturing of margarine or ammonia in the haber process

-it produces alkenes which are important for making plastics through addition polymerisation
-some fractions from the fractional distillation of crude oil contain alkanes with more carbons and are not very useful
-cracking converts these into shorter-chain alkanes and alkenes
-shorter chain alkenes(ethene and propene) are starting materials for many industrial processes
-shorter-chain alkanes are needed as fuel

*Alkenes*

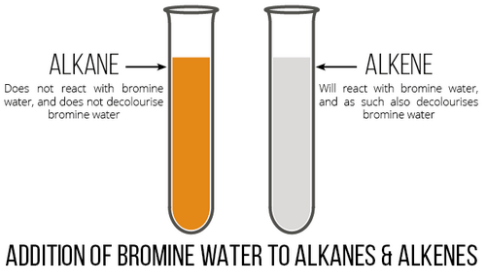
-alkenes are obtained from cracking of alkanes mainly
-alkenes are unsaturated hydrocarbons
-general formula of CnH2n
-contains carbon-carbon double bond
-similar chemical properties
-a gradual change in their physical properties
-unsaturated hydrocarbons indicates that the molecule contains carbon-carbon double bonds
-in these bond,each carbon atom is covalently bonded to three atoms only
-each member differs by 1 C atom and 2H atoms

| Alkene | Molecular formula | Boiling point | Physical states at room temperature | Condensed formula |
|---|---|---|---|---|
| Ethene | $C_2H_4$ | -104 | Gas | $CH_2=CH_2$ |
| propene | $C_3H_6$ | -48 | Gas | $CH_2=CHCH_3$ |
| Butene | $C_4H_8$ | -62 | Gas | $CH_2=CHCH_2CH_3$ |

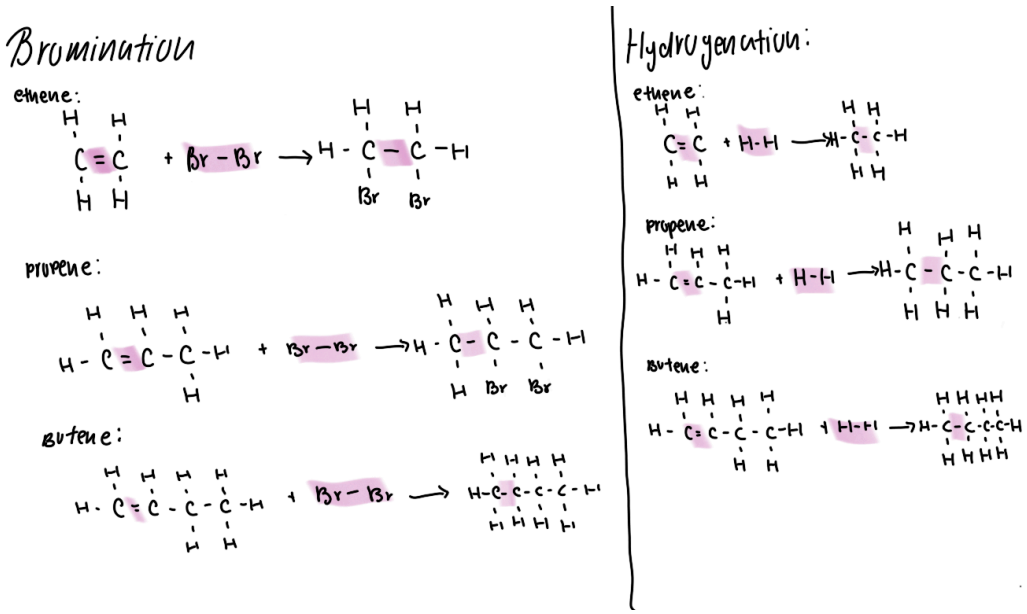
-alkenes are insoluble in water but soluble in most organic solvent
-alkenes are not used as solvents because they are more reactive,so they can interfere with reactions

-they are usually used as starting materials for making products such as plastics and detergent
-when the size of the alkene molecules increases,a gradual change in the following physical properties:
1.M.P and B.P increases as the size of the alkene molecule increases thus,more energy is required to overcome the increasing forces of attraction
2.density increases
3.viscosity increases as their molecular sizes increase
4.flammability decreases
Chemical reaction of alkenes:
*1.Combustion:*
-the reaction is exothermic
-alkenes burn in excess oxygen to produce carbon dioxide and water
-they are more likely to undergo incomplete combustion
-they burn with a sootier flame than alkanes
-in complete combustion,the reaction can be represented by the following word equation:
alkene +oxygen gas →carbon dioxide + water
2.ADDITION REACTION
*2a.addition of hydrogen (hydrogenation)*
-hydrogen is added to carbon-carbon double bond at high temperature and pressure
-a transition metal catalyst such as nickel is used
-alkenes change to alkanes after hydrogen atoms are added
Word equation:
**Alkene + hydrogen →alkane**
2b.addition of bromine(bromination)
-bromine gas or bromine water is brown in colour
-addition of bromine is an important test to distinguish alkanes from alkenes
-when it reacts with alkene or unsaturated hydrocarbons,bromine is decolourised
-in alkanes or saturated hydrocarbons,bromine remain brown.no reaction will take place

For example,



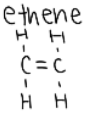
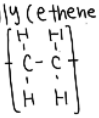
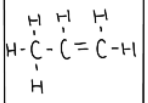
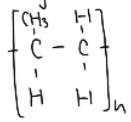
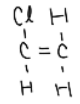
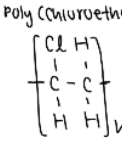

-aqueous bromine is decolourised(observation) when mixed with alkene
-aqueous bromine remains brown when mixed with alkane as it does not react with alkane.
-the more unsaturated fats in oils,the higher the amount of aqueous bromine being decolourised

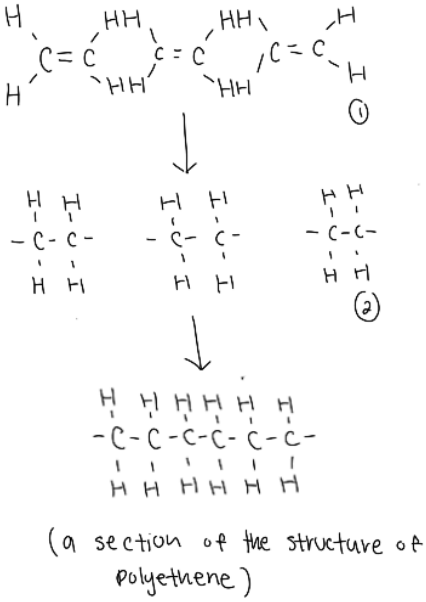



2c.addition polymerisation

-when monomers join together without losing any molecules or atoms,the polymer formed is called an addition polymer.this process is called addition polymerisation
-the process is used to manufacture materials like plastics
-alkenes are unsaturated.they can be used to produce large molecules through polymerisation reaction

High temperature and pressure
ethene——————————————————————————poly(ethene)
catalyst

| MONOMER | POLYMER | USES |
|---|---|---|
| ethene  | Poly(ethene)  | plastic bags, cling film |
| propene  | Poly(propene)  | plastic bottles, containers |
|  | Poly(chloroethene)  | rain coats, synthetic leather for shoes & bags |



(a section of the structure of polyethene)

3.more about cracking in alkanes

-it produces hydrogen for manufacturing of margarine or ammonia in the haber process

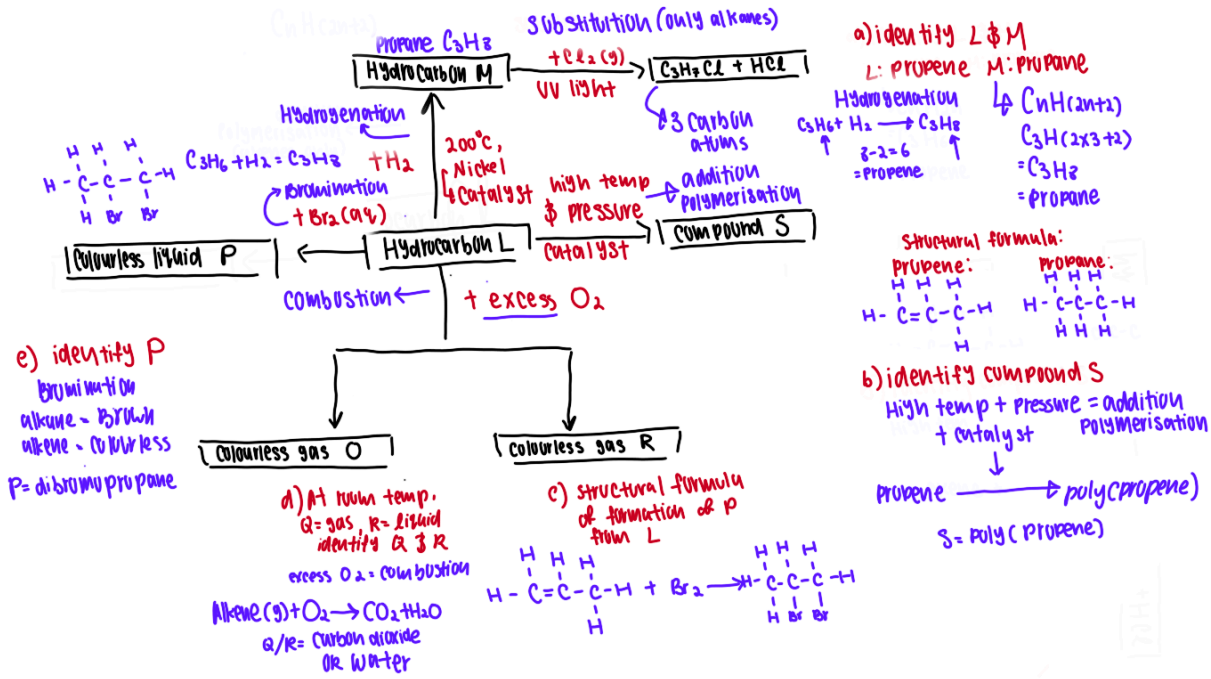
-it produces alkenes which are important for making plastics through addition polymerisation

-some fractions from the fractional distillation of crude oil contain alkanes with more carbons and are not very useful

-cracking converts these into shorter-chain alkanes and alkenes

-shorter chain alkenes(ethene and propene) are starting materials for many industrial processes

-shorter-chain alkanes are needed as fuel




Fats and oils

-hydrogenation is also applied to unsaturated compounds such as fats

-a fat molecule consists of three hydrocarbon chains attached to a backbone of that fat molecule

-the three hydrocarbon chains can be saturated or unsaturated

-when there are 2 or more C=C bonds in the same hydrocarbon chain,it is known as polyunsaturated chain (poly meaning many)

-the greater the level of saturation,the higher the melting point of the fat substance

-fats exists as solids at room temperature because they contain mainly saturated hydrocarbons,so they have a higher melting point than oils

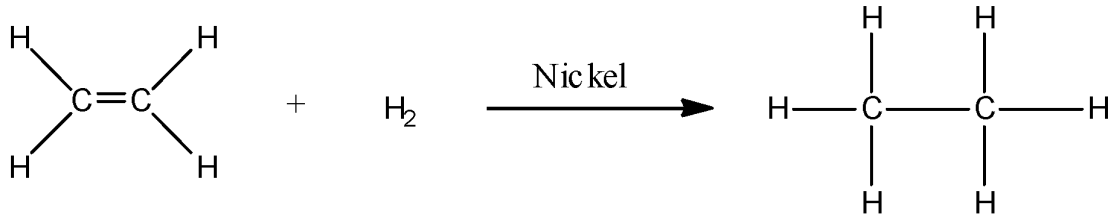
-oils are more unsaturated than fats

-oils exist as liquids at room temperature because they contain unsaturated hydrocarbons,so they have a lower melting point than fats

How saturated and unsaturated hydrocarbons affect the melting point of fats and oils:

-saturated hydrocarbon chains can stack well with one another,so they can come close together.as a result,the intermolecular forces of attraction between them are stronger,so more energy is needed to overcome them

-unsaturated hydrocarbon chains cause the structure of the chain to bend ,so they do not stack well and cannot come close together.as a result,the intermolecular forces of attraction between them are weaker,so less energy is needed to overcome them.
-hydrogenation is used to convert unsaturated hydrocarbons into saturated hydrocarbons.
-vegetable oils are polyunsaturated,so they exist as liquid at room temperature generally
-the molecules in food contain carbon to carbon double bonds
-in making margarine,they are hardened to form solid margarine by adding hydrogen to some of the carbon-carbon double bonds




Unsaturated compound

Saturated compound

-as hydrogenation reduces the unsaturated C=C bonds in the vegetable oil molecules,it causes the melting point of the oil to increase.this allows margarine to exist as a solid at room temperature
-advantages of hydrogenation of oil to make solid margarine:
-it is more convenient to use(easier to spread)
-it will not spoil quickly
<u>problems in the hydrogenation of oil:</u>
-the process can give rise to partial hydrogenation of vegetable oils.this means that margarine still contains some unsaturated hydrocarbons
-this process can cause the formation of trans fats.trans fats have been associated with heart diseases too.