a) Atomic Structure and Mixtures

b) Periodic Table

c) Structure and Bonding

d) Quantitative Chemistry

e) Chemical Changes

f) Energy Changes

The periodic table and Properties of elements

4.1.2.1 The periodic table

4.1.2.2 Development of the periodic table

4.1.2.3 Metals and non-metals

4.1.2.4 Group 0

4.1.2.5 Group 1

4.1.2.6 Group 7

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DEVELOPMENT OF THE PERIODIC TABLE

John Dalton

1808 – Published table of Elements

Elements were arranged in the order of increasing atomic weights.

John Newland

1864 → Gave Newland law of Octaves

→ arranged elements according to atomic weights.

→ Found similarities in the first elements and the eighth element like octaves

→ Worked well upto calcium

→ Since all the elements were not discovered at that time and he organised all known so the pattern did not fit.

Dmitri Mendleev

1869 → arranged elements according to atomic weights

→ found patterns of similarities within elements

→ Left gaps where the elements did not fit the pattern which later helped to find the undiscovered elements

→ Not all elements fit into this pattern

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Mendleev's Table Shortcomings

→ Argon atoms have a greater relative mass than potassium which will place Argon in the group of sodium and lithium and potassium in the group of noble gases.

→ Many other elements were found not fitting this pattern and were swapped by Mendleev's to maintain the periodicity.

Present Periodic Table

→ Organise the elements in the order of increasing atomic number

→ All the shortcoming due to atomic weights were solved by organising the elements in the order of increasing atomic number.

→ Heavy atoms are due to the presence of different isotopes of the elements.

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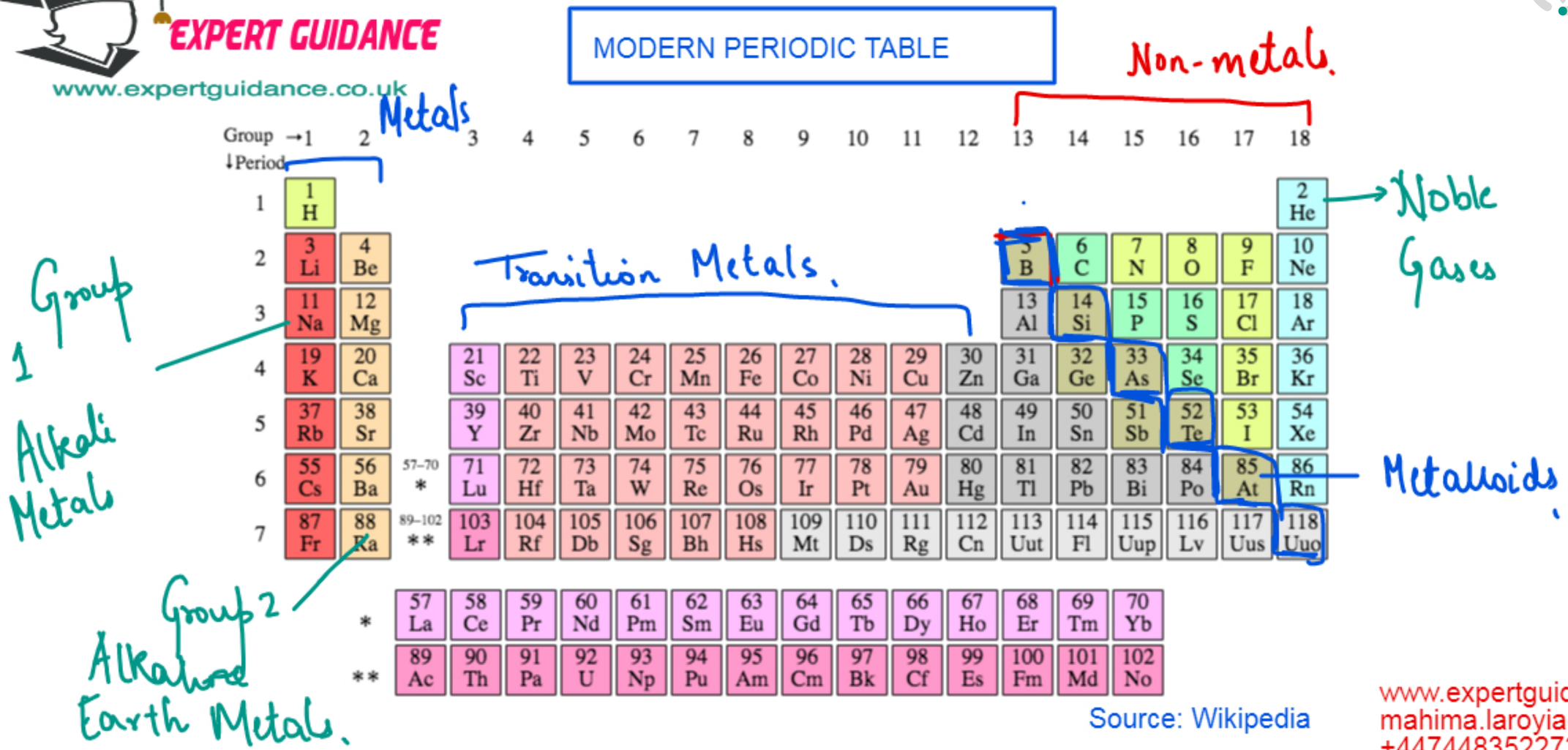
MODERN PERIODIC TABLE



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Metals and Non Metals

BASIS	METALS	NON METALS
Appearance	They are Shinny and lusturous	They are dull in apperance
Position	Found in the left.	Found in the right
Conductors	Metal are good conductors	Non-metals are insulators except graphite
Malleability	Metals are Malleable	Non metals are not malleable
Ductility	Metals are ductile	Non metas are ductile
Ions	loose electrons and form + ions	gain electrons and form - ions
Density, mp and bp	They have high densities, mp and bp	They have low density, mp and bp
Examples	Sodium, potassium Group 1, 2 and 3	Carbon , Sulphur Group 4, 5 , 6 and 7

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GROUPS IN THE PERIODIC TABLE

Group Number	Common Name	Reason for the name	Properties	Examples
Group 0	Noble Gas	They are stable as they have full outer shell therefore they do not react.	They are stable, unreacrtive. They have full outershell electronic configuration. They are found at extreme right.	Helium, neon, Argon, Krypton, Xenon, Radon
Group 1	Alkali Metals	They are metals and react with water to form alkali (metal hydroxide)	They are reactive, have one electron in their outermost shell. Loose one electron and form +1 ions to gain full outer shell configuration.	lithium, sodium, potassium, rubidium, cesium, and francium.
Group 2	Alkaline Earth Metals	These metals react with water to form alkalis (metal hydroxide) and they are found mainly in rocks.	They are reactive, have two electron in their outermost shell. Loose two electron and form +2 ions to gain full outer shell configuration.	beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), radium (Ra).
Group 7	Halogens	They react with metals to form salts so they are names are (Halo= salt + Gens= forming)	They are reactive, have seven electrons in their outermost shell. Gains one electron to form -1 ions to gain full outershell configuration	fluorine, chlorine, bromine, iodine, and astatine

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GROUP 1 : Alkali Metals

Elements	Symbol	Electronic Configuration	Properties
Lithium	$_{3}Li^{7}$	2,1	Least Reactive in the series
Sodium	$_{11}Na^{23}$	2,8,1	More reactive than lithium but less reactive then sodium
Potassium	$_{19}K^{39}$	2,8,8,1	More reactive than sodium
Rubidium	$_{37}Rb^{85}$	2,8,8,18,1	Highly reactive
Caesium	$_{55}Cs^{133}$	2,8,8,18,18,1	Too reactive
Francium	$_{87}Fr^{223}$	2,8,8,18,18,32,1	Unstable radioactive reactive

REACTIVITY INCREASES DUE TO INCREASE IN TENDENCY OF LOOSING ELECTRONS

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GROUP 1: Alkali Metals Physical Properties

- They are highly reactive
- Reactivity increases down the group. — because tendency to loose one electron increases down the group due to increase increase in size and decrease in nuclear charge
- They loose one electron and form +1 ions.
- They are stored in kerosene or oil to prevent them reacting from air and water
- They are soft, silvery and shinny.
- They look dull in air as they react with oxygen and form oxide which coats their surface
- Lithium is less reactive and francium is highly reactive.
- They have low melting and boiling point and the melting and boiling point decreases down the group.

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Group 1: Alkali Metals Chemical Properties

[M = Li, Na, K]

REACTION WITH WATER

Reacts with water to metal hydroxide

→ $2M + H_2O \rightarrow 2MOH + H_2$

→ Metal hydroxide are alkali therefore the pH increases. Reactivity increases down the group so potassium reacts violently

→ Fizzing is produced due to the formation of hydrogen.

eg - $2Li_{(s)} + H_2O_{(l)} \rightarrow 2LiOH_{(aq)} + H_{2(g)}$

REACTION WITH OXYGEN

→ Reacts with oxygen to form a metal oxide

$2M + O_2 \rightarrow M_2O$

→ Metal goes dull in air due to this reaction.

$4Li_{(s)} + O_{2(g)} \rightarrow 2Li_2O_{(s)}$

REACTION WITH HALOGENS

→ React with halogens to form metal halides

$2M + X_2 \rightarrow 2MX$ [X = F, Cl, Br, I]

→ Metal halides are while solids but dissolve in water to form colourless solutions.

$2Li_{(s)} + F_{2(g)} \rightarrow 2LiF_{(s)}$

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REACTION WITH WATER

LITHIUM	SODIUM	POTASSIUM
$2Li_{(s)} + 2H_2O_{(l)} \rightarrow 2LiOH_{(aq)} + H_{2(g)}$	$2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$	$2K_{(s)} + H_2O_{(l)} \rightarrow KOH_{(aq)} + H_{2(g)}$
Floats in water due to less denisty than water	Floats in water due to less denisty than water	Floats in water due to less denisty than water
Fizzes due to the formation of hydrogen gas.	Fizzes due to the formation of hydrogen gas.	Fizzes due to the formation of hydrogen gas.
Shape is retained while reacting and gets smaller.	It melts into a call while reacting.	Melts into a ball, catches fire and produces a lilac flame.

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WHY REACTIVITY OF GROUP 1 INCREASES DOWN THE GROUP ?

→ The Reactivity of Group 1 increases down the group as the tendency to loose an electron increases down the group.

React by loosing electron

To loose an electron small nuclear charge greater size of atom and greater shielding is required

FACTORS AFFECTING TENDENCY TO LOOSE AN ELECTRON

→ Nuclear Charge → Great the size of the atom, the outer electron becomes further away from the nucleus decreasing the nuclear charge

→ SHIELDING → More the number of inner electrons due to increases in number of shell greater will be the shielding of the outer electron from the nuclear charge

→ SIZE OF ATOMS → Greater the size of the atom, the outer electron will become further away from the nucleus resulting in decreases in nuclear charge

Down the group the atom size increases due to increase in number of electron shells. This results in the outer electron being further away from the nucleus.
As the outer electron becomes further away from the nucleus the nuclear charge decreases. Increase in number of shells also increases the shielding and shields the outer electron from the nuclear charge.
Therefore, the tendency of atom to loose an electron increases down the group resulting in increase in reactivity down the group.

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GROUP 7 : Halogens (Salt Forming)

Element	Symbol	Electronic Configuration	State at room temperature
Fluorine	$_{9}F^{19}$	2,7	Yellow Gas
Chlorine	$_{17}Cl^{35}$	2,8,7	Green Gas and pale green in solution
Bromine	$_{35}Br^{80}$	2,8,18,7	Volatile brown liquid Yellow in solution
Iodine	$_{53}I^{127}$	2,8,18,18,7	Volatile purple solid Brown in solution
Astatine	$_{85}At^{210}$	2,8,18,32,18,7	Radioactive

REACTIVITY DECREASES DUE TO DECREASE IN ELECTRON AFFINITY

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GROUP 7 : Halogens : Physical Properties

- They are non metals
- They gain an electron to form -1 ions.
- They have low melting and boiling points
- Their melting point increases down the group due to increases in intermolecular forces.
- They are found in pairs and exist as diatomic molecules (X_2)
- They are poisonous and smelly
- Their reactivity increase down the group
- Their density increases down the group.
- They are poor conductors of heat and electricity

HALOGEN REACTION

X [F, Cl, Br, I)

REACTION WITH HYDROGEN

→ They react with hydrogen to form hydrogen halides.

$$X_{2(g)} + H_{2(g)} \longrightarrow 2HX_{(g)}$$

→ Reactivity decreases down the group so fluorine and chlorine reacts explosively and bromine and iodine reacts at higher temperature in the presence of catalyst.

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REACTION WITH METALS

→ They react with metals to form ionic compounds. In Ionic compounds, halogens gain one electron from the metals to form -1 ions and attain noble gas electronic configurations.

eg $Na_{(s)} + Cl_{2(g)} \longrightarrow NaCl_{(s)}$

$Mg_{(s)} + Cl_{2(g)} \longrightarrow MgCl_{2(s)}$

DISPLACEMENT REACTION

- The more reactive halogen displaces the less reactive halogen from its salt
- As the reactivity decreases down the group, the halogen at the top can take the position of the halogen at the bottom in its compounds and will displace the less reactive halogen.

eg $Cl_2 + 2NaBr \longrightarrow 2NaCl + Br_2$ [Yellow solution formed]

- Cl_2 (more reactive)
- 2NaBr (salt of less reactive halogen than Chlorine)
- 2NaCl [chlorine being more reactive has taken the position of less reactive bromine in its compounds)
- Br_2 [bromine being less reactive than chlorine has been displaced by chlorine)

F
Cl
Br
I
Decreasing reactivity

$Cl_2 + 2NaF \longrightarrow$ No reaction.

- F_2 → can displace all halogens
- Cl_2 → can displace all halogen except fluorine
- Br_2 → can displace only iodine

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WHY REACTIVITY OF GROUP 7 DECREASES DOWN THE GROUP ?

React. by electron

→ The Reactivity of Group 7 decreases down the group as the electron affinity or tendency to gain the electron decreases down the group.

FACTORS AFFECTING TENDENCY TO GAIN AN ELECTRON

To gain an electron, smaller nuclear charge smaller size and less shielding is required.

→ Nuclear Charge +

Smaller the size of the atom, greater will be the force of the nucleus as the electron will be closer to the nucleus.

→ SHIELDING →

Less electrons and shells, smaller will be the shielding which will in turn increase the nuclear charge.

→ SIZE OF ATOMS →

Greater the size of the atom, the outer electron will become further away from the nucleus resulting in decreases in nuclear charge

Down the group the atom size increases due to increase in number of electron shells. As a result the nuclear charge decreases.

The size of the atom also increases down the group which makes the nuclear charge weaker

The electron shells also increases which decreases the effective nuclear charge on the incoming electron.

Due to all these factors, the nuclear charge decreases which decreeases the tendency of gaining electrons down the group of halogen making them less reactive.

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COMPARISON BETWEEN GROUP 1 and GROUP 7

GROUP 1 Alkali Metals	GROUP 7 Halogens
a) Have one electron in their outermost shells	Have seven electrons in their outermost shell
b) They are metals	They are non metals
c) They react by loosing electrons	They react by gaining electrons
d) They form +1 ions	They form -1 ions
e) Their reactivitiy increases down the group	Their reactivity decreases down the group
f) Reactivity depends on tendency to loose an electron	Reactivity depends on tendency to gain an electron

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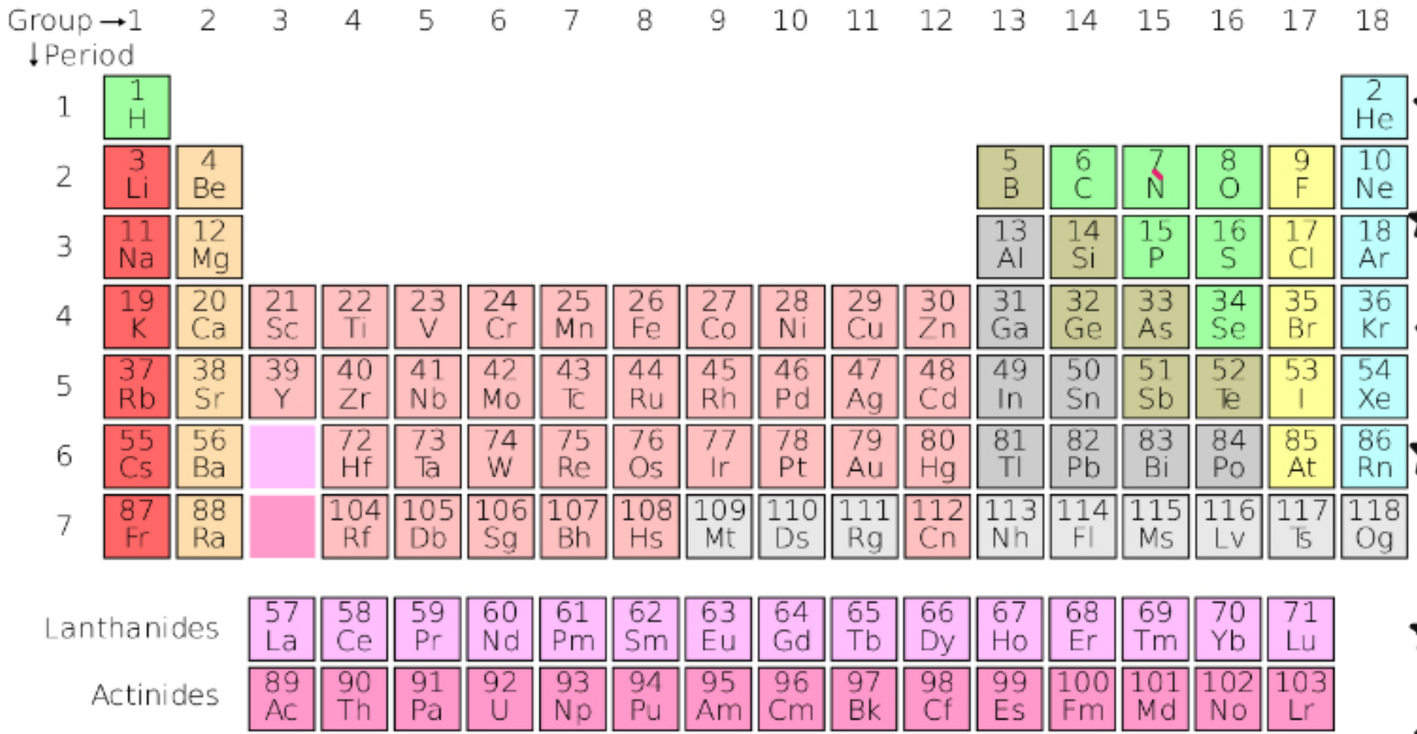
TRANSITION METALS



★ They show the reaction with oxygen, water and halogen like group 1 but they react much slowly than alkali metals.

Found between group 2 and group 3

★ They are hard

★ They are strong

★ They are malleable and ductile

★ They have higher densities than group 1 and group 2 hence they are used in construction purpose like iron.

★ They show variable oxidation states

★ They are used commercially as catalyst

★ They form coloured compounds.

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Periodic Table → A table that shows arrangement of all the known elements in the order of increasing atomic number. The table is organised into periods and groups.

Metals Elements found to the left of the periodic table which are soft, shinny, conductors malleable and ductile. eg Group 1, group 2 and group 3 elements

Non Metals — Elements found to the right of the periodic table which are dull, insulators. Group 4,5,6 and 7 are non metals.

Halogens — Group 7 elements are halogens as they are salt forming.

Alkali Metals — Group 1 elements which react with water to form alkali

Noble Gases — Group 0 elements which are stable and do not react as they have complete outer shell.

Transition Metals — Elements found between group 2 and group 3 which have high densities, show variable oxidation states and form coloured compounds.

Periods — Horizontal rows of the periodic table.

Groups — Vertical columns of the periodic table

Group Number — Indicates the number of electrons in the outermost shell.

Alkali — Bases that are soluble in water.

Displacement Reaction — When a more reactive element displaces the less reactive element from its salt.

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TEST YOURSELF !!!!

Q1 Look at the periodic table and give two examples of each

Metal –

Non Metal

Alkali Metal

Halogens

Noble Gas

Semi metal or metalloid

Metals that form +1 ions

Non metal that form -1 ions

Metal that form +2 ions

Transition metal

Q2 Write the name of most reactive halogen and most reactive alkali metals

Q3 Why the alkali metals gets more reactive down the group

Q4 Why halogens get less reactive down the group

Q5 Write the balanced chemical equation with state symbols of
a) Potassium with water
b) Lithium with oxygen
c) Sodium with bromine
d) Chlorine with hydrogen

Q6 Explain displacement reaction of halogens with examples.

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Q1 Look at the periodic table and give two examples of each

Metal — Li, Na

Non Metal — O_2, F_2

Alkali Metal — K, Li

Halogens — F, Cl

Noble Gas — He, Ar

Semi metal or metalloid — Si

Metals that form +1 ions — Li, K

Non metal that form -1 ions — F, Cl.

Metal that form +2 ions — Mg, Ca

Transition metal — Fe, Cu

Q2 Write the name of most reactive halogen and most reactive alkali metals

Halogen – F Alkali Metal – Fr

Q3 Why the alkali metals gets more reactive down the group

Down the group the atom size increases due to increase in number of electron shells. This results in the outer electron being further away from the nucleus. As the outer electron becomes further away from the nucleus the nuclear charge decreases. Increase in number of shells also increases the shielding and shields the outer electron from the nuclear charge. Therefore, the tendency of atom to loose an electron increases down the group resulting in increase in reactivity down the group.

Q4 Why halogens get less reactive down the group

Down the group the atom size increases due to increase in number of electron shells. As a result the nuclear charge decreases. The size of the atom also increases down the group which makes the nuclear charge weaker. The electron shells also increases which decreases the effective nuclear charge on the incoming electron.

Due to all these factors, the nuclear charge decreases which decreeases the tendency of gaining electrons down the group of halogen making them less reactive.

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Q5 Write the balanced chemical equation with state symbols of
a) Potassium with water
b) Lithium with oxygen
c) Sodium with bromine
d) Chlorine with hydrogen

$2\ K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$

$4\ Li_{(s)} + O_{2(g)} \longrightarrow 2Li_2O_{(s)}$

$2Na_{(s)} + Br_{2(l)} \longrightarrow 2NaBr_{(s)}$

$Cl_{2(g)} + H_{2(g)} \longrightarrow 2HCl_{(g)}$

Q6 Explain displacement reaction of halogens with examples.

When the more reactive halogens displaced the less reactive halogen from its salt.

$F_2 + 2NaCl \longrightarrow 2NaF + Cl_2$

$Cl_2 + 2NaF \not\longrightarrow$ No reaction

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NEXT STEP !!!

- Check the Specification
- Do Exam questions on this chapter

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GCSE Chemistry

Complete Revision Summary

- Rates and Equilbrium
- Organic Chemistry
- Chemical Analysis
- Chemistry of the Atmosphere
- Using Resources

The periodic table and Properties of elements

- Pure Substances
- Formulations
- Chromatography
- Test for Gases
- Test for Cation
- Test for Anions
- Instrumental Analysis

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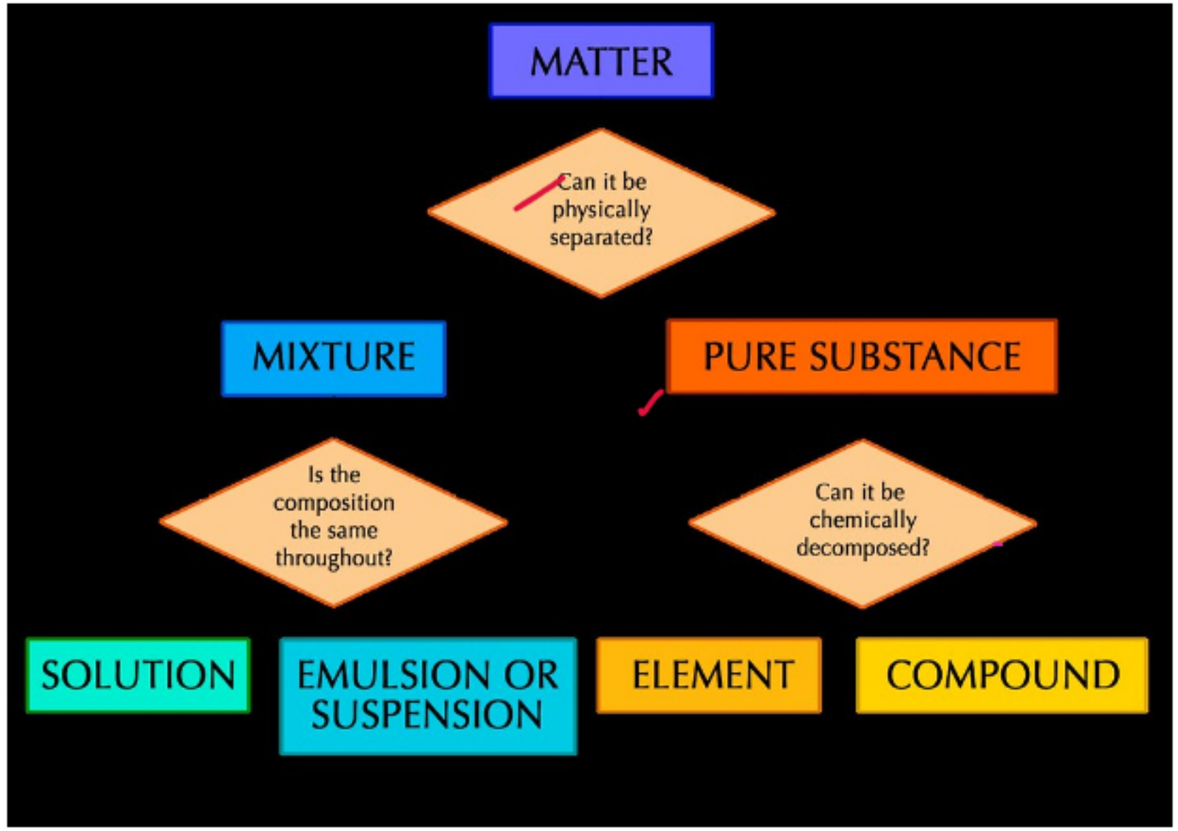
PURE SUBSTANCE



Source: Flickr.com

Pure Substance is an element or a compound that is made up of only one substance.

↓

Pure substances have fixed melting and boiling point. Finding the melting and boiling points will provide the test for purity.

↓

Impurities makes the substance impure and alters the meting and boiling point.

Impurities lowers the melting point but increases the boiling point.

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FORMULATIONS

Mixtures made to make it useful for the mankind.

- Fuels
- Cleaning Agents
- Paints
- Medicines
- Alloys
- Fertilizers
- Foods

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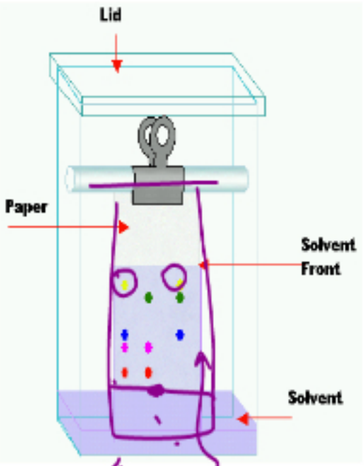
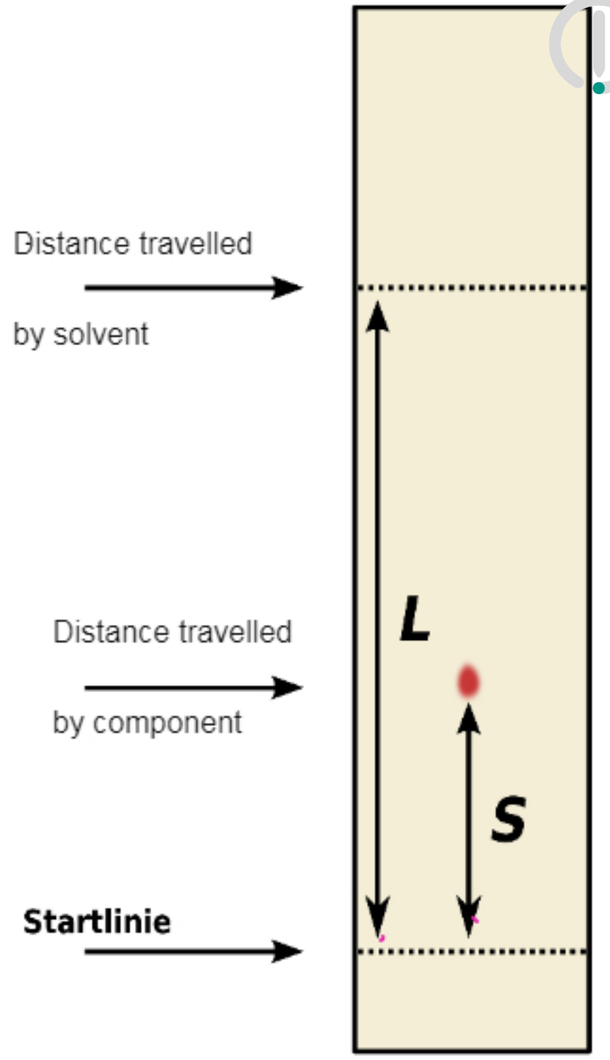
CHROMATOGRAPHY



Source: Wikimedia Commons

- Components in the mixture are separated on the basis of solubilties of different components of the mixture in a suitable solvent.
- A capillary tube is used to spot the mixture on the chromatography paper.
- The paper is put inside a solvent and the solvent is allowed to run up the chromatography paper.
- The component of the mixture which is more soluble in the solvent will travel greater distance and will leave its mark near the top.
- The component which is less soluble will have a mark near the bottom.



$$R_f = \frac{S}{L}$$ ← Distance travelled by solute

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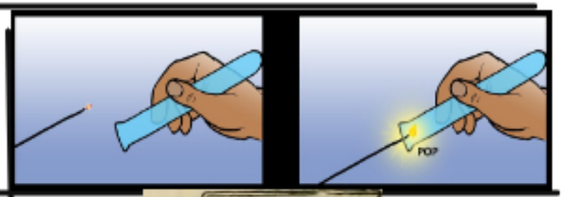
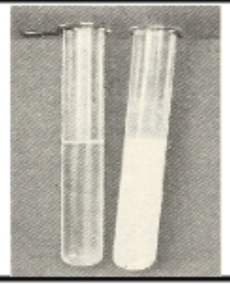
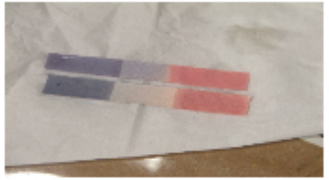
TEST FOR GASES

	Reaction	Test	Observation	
Hydrogen	Metal higher in reactivity than hydrogen react with acid producing hydrogen. $Mg + HCl \rightarrow MgCl_2 + H_2$	Bring a lighted splint to the mouth of the test tube containing hydrogen	The splint burns with the squeaky pop.	
Oxygen	Electrolysis of Water produced oxygen or decomposition of hydrogen peroxide	Bring a glowing splint to the mouth of the test tube containing oxygen.	The glowing splints relights.	
Carbon Dioxide	Metal carbonate with dilute acids produce carbon dioxide $MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$	Pass the gas released to lime water	Limewater will turn milky	
Chlroine	Electrolysis of brine	A damp blue litmus paper held at the mouth of the test tube	Bleached blue litmus paper	

TEST FOR CATIONS

Source: Flickr

Nichrome wire dipped in concentrated hydrochloric acid

↓

Heated

↓

Dipped in acid again

↓

Dipped in metal compound

Touched on the roaring blue bunsen flame

Copper Cu^{2+}	BLUE GREEN
Potassium K^{+}	LILAC
Sodium (Na^{+})	YELLOW
Lithium (Li^{+})	CRIMSON
Calicium (Ca^{2+})	RED

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TEST FOR CATIONS

FLAME TEST

Add Aqueous Sodium Hydorxide

White Precipitate

Al^{3+} Mg^{2+} Ca^{2+}

Soluble.

excess Sodium hydroxide

Insoluble

Flame test

Nocolour red

Coloured Precipitate

Cu^{2+} → Light Blue Precipitate

Fe^{2+} → Light green precipitate

Fe^{3+} → reddish brown precipitate

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TEST FOR ANIONS

Carbonates CO_3^{2-}

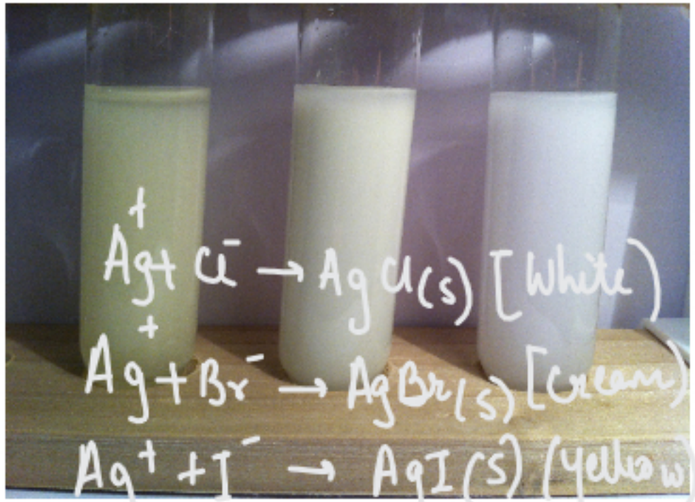
Add dilute acid

Effervescence of Carbondioxide

Pass to limewater

Limewater turns milky

Halides Cl^-, Br^-, I^-



Add dilute nitric acid
Add silver nitrate solution
Precipitate confirms the halide

Yellow precipitate — Iodide Ions — I^-
Cream Precipitate — bromide ions — Br^-
White precipitate — chloride ions — Cl^-

Sulphates SO_4^{2-}

Add dilute hydrochloric acid
Add barium chloride solution
A white precipitate confirms sulphate

$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$ (white)

INSTRUMENTAL ANALYSIS

CHEMICAL TEST	INSTRUMENTAL TEST
Qualitative	Quantitative
Original sample destroyed	Original sample preserved
Less Accurate	More Accurate
Less Sensitive	Fast Accurate and Sensitive

Flame emission Spectroscopy

Each metal forms a chacteristic line spectrum when placed inside a spectrometer.

The line spectrum is compared with the database to detect the metal ion

The absorbance value gives the information about the concentration of metal ions.

Can detect traces of metal ions in sample of air, steel or any other metal.

KEY TERMS

Pure Substance
Has a fixed melting and boiling point

Fixed Points
Same numerical value for boilling and melting?

Formulations
A mixture of elements which are placed together in fixed ratios

Chromatography
The seperation of a mixture using a solvent

Mobile Phase
The liquid or gas that flows through the chromtography paper

Stationary Phase
is contained on the paper and does not move through it

Chromatogram
the results to the seperation of the mixture

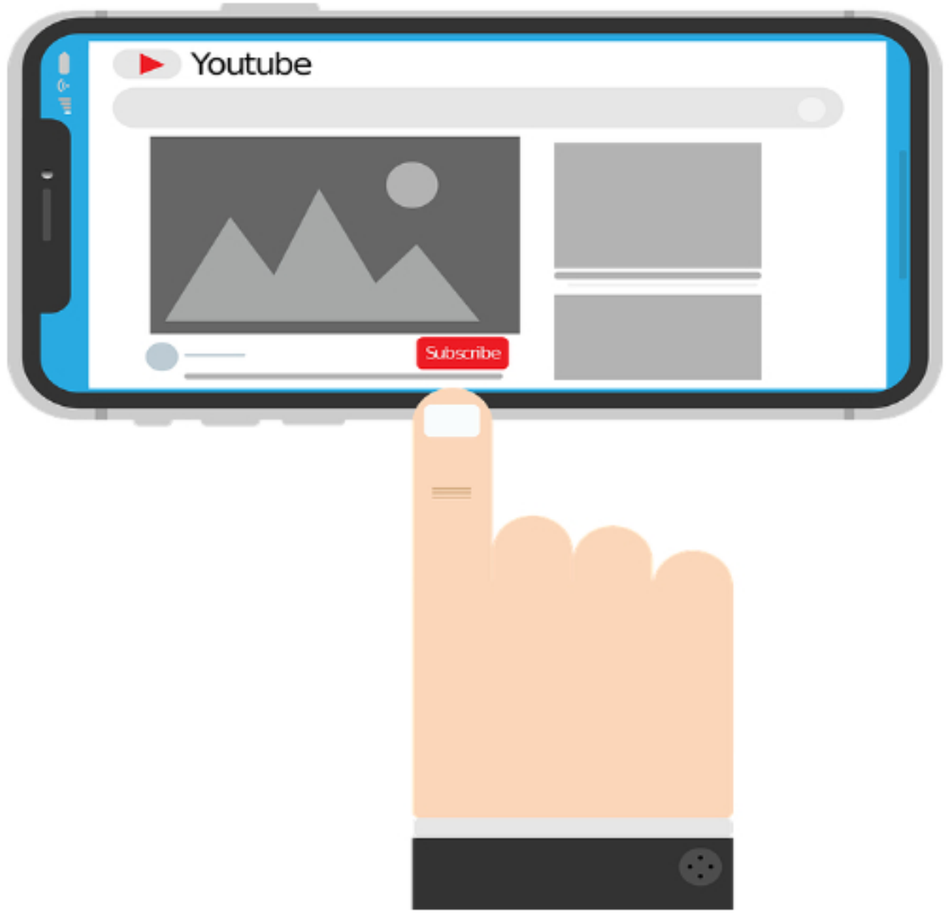
Retention Factor
the amount that each substance travels in comparision to the solvent movement

Flame Test
a test used to detect certain metal ions depending on the colour they burn when placed

Intrumental Analysis
A more accurate and sensitive way of collecting data which is faster than the chemical test and even preserves each of the chemicals used . Its quanitativve.

Flame Emission Spectroscopy
an instrumental analysis method in which each element forms a charateristic line specturm when placed inside a spectrometer, this can be used to compare elements against one another.

NEXT STEP



★ CHECK SPECIFICATION

★ EXAM QUESTIONS ON THIS TOPIC