ST ANDREW'S SECONDARY SCHOOL

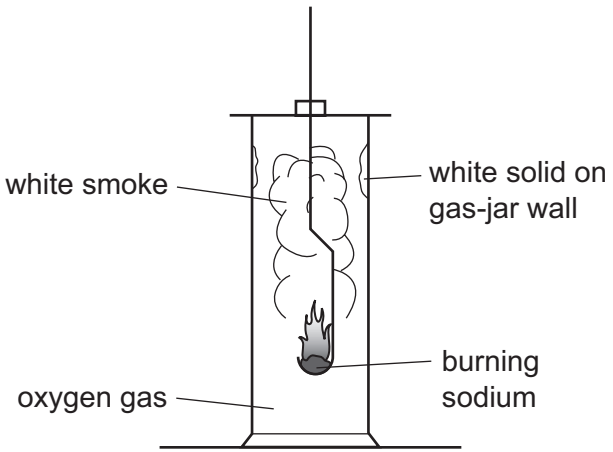
NAME _____ CLASS _____

CHEMISTRY

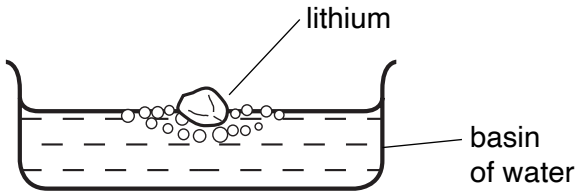
The Periodic Table

Summary of Chemical Reactions

ALKALI METALS (GROUP I ELEMENTS)

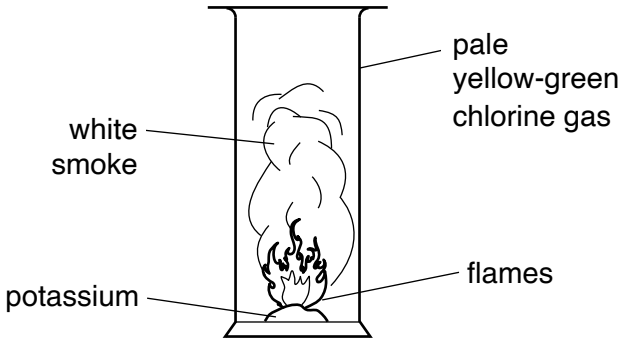
Reaction with Air/ Oxygen gas	**Observations**	**Equations**
	Lithium burns with a red flame producing a white solid. Sodium burns rapidly with a bright, yellow flame producing a white solid. Potassium burns vigorously with a bright, lilac flame producing a white solid. • The white solid is produced as the white smoke observed. • The white solid dissolves in water to produce a colourless solution that turns red litmus paper blue.	Lithium + Oxygen → Lithium oxide $4\ Li + O_2 \rightarrow 2\ Li_2O$ Sodium + Oxygen → Sodium oxide $4\ Na + O_2 \rightarrow 2\ Na_2O$ Potassium + Oxygen → Potassium oxide $4\ K + O_2 \rightarrow 2\ K_2O$

Reaction with Water

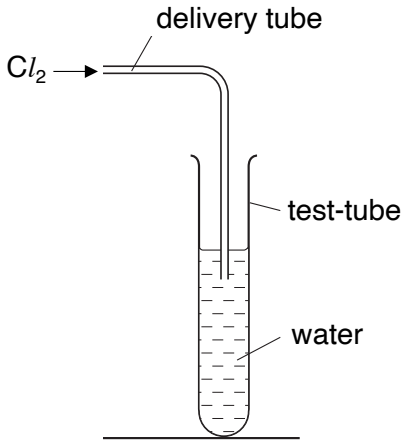
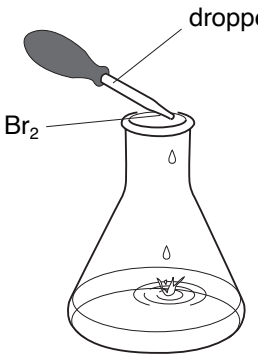
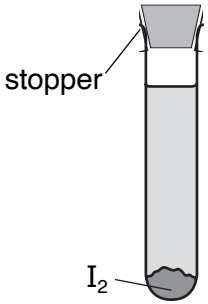


Observations	Equations
Lithium moves slowly and randomly on the water surface with a soft 'hissing' sound. Sodium melts into smaller pieces that moves rapidly and randomly on the water surface with a 'hissing' sound. Potassium burns with a lilac flame that moves very rapidly and randomly on the water surface with a 'hissing' sound before exploding. • A colourless solution is obtained that turns red litmus paper blue. • 'Hissing' sound is the hydrogen gas evolved as effervescence.	Lithium + Water → Lithium hydroxide + Hydrogen $2\ Li + 2\ H_2O \rightarrow 2\ LiOH + H_2$ Sodium + Water → Sodium hydroxide + Hydrogen $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$ Potassium + Water → Potassium hydroxide + Hydrogen $2\ K + 2\ H_2O \rightarrow 2\ KOH + H_2$

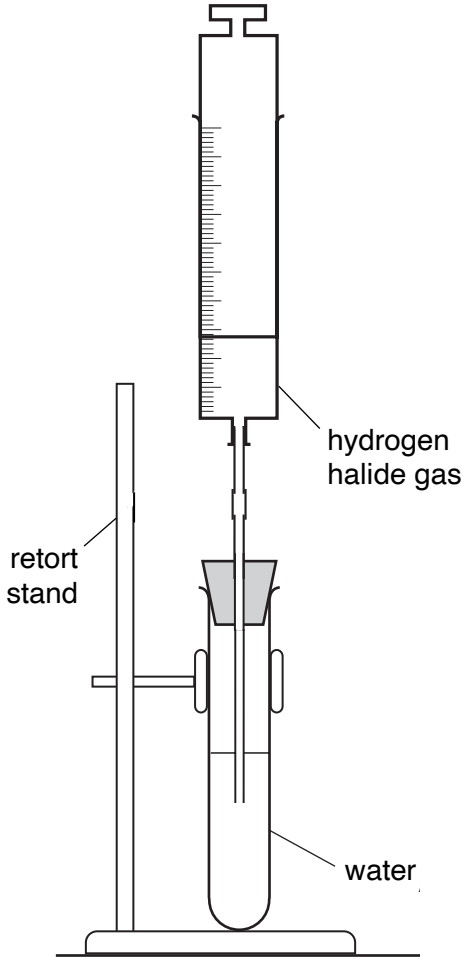
Reaction with Chlorine gas



Observations	Equations
Lithium burns slowly with a red flame producing a white solid. Sodium burns rapidly with a bright, yellow flame producing a white solid. Potassium burns vigorously with a bright, lilac flame producing a white solid. • The white solid is produced as the white smoke observed. • The white solid dissolves in water to produce a colourless solution that has no effect on red and blue litmus papers.	Lithium + Chlorine → Lithium chloride $2\ Li + Cl_2 \rightarrow 2\ LiCl$ Sodium + Chlorine → Sodium chloride $2\ Na + Cl_2 \rightarrow 2\ NaCl$ Potassium + Chlorine → Potassium chloride $2\ K + Cl_2 \rightarrow 2\ KCl$

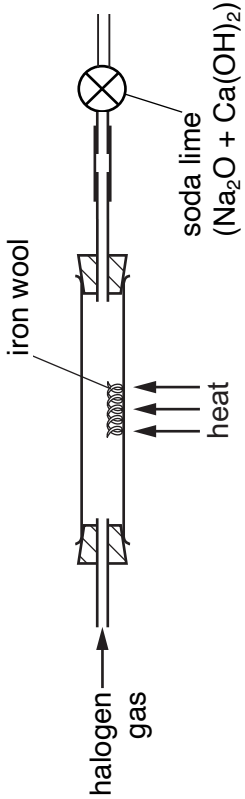
Reaction with Water	Observations	Equations
	Pale yellow-green gas dissolves rapidly to produce a colourless solution. • Turns blue litmus paper red (due to H^+) and then bleaches it (due to ClO^-).	Chlorine + Water → Hydrochloric acid + Hypochlorous acid $Cl_2 + H_2O \rightarrow HCl + HClO$
	Red-brown liquid dissolves slowly to produce a pale-yellow solution. • Turns blue litmus paper red (due to H^+) and then bleaches it (due to BrO^-).	Bromine + Water → Hydrobromic acid + Hypobromus acid $Br_2 + H_2O \rightarrow HBr + HBrO$
	Only a very small amount of the purple-black crystals added dissolves very slowly in water to produce a pale-yellow solution. • No effect on blue litmus paper. This reaction is an example of disproportionation reaction, where a single substance is both oxidised and reduced simultaneously.	Iodine + Water → Hydroiodic acid + Hypoiodus acid $I_2 + H_2O \rightarrow HI + HIO$

Reaction with Hydrogen gas

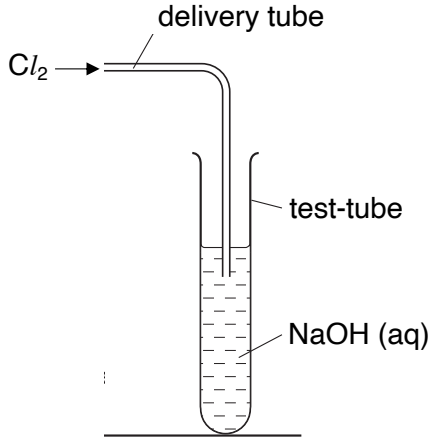
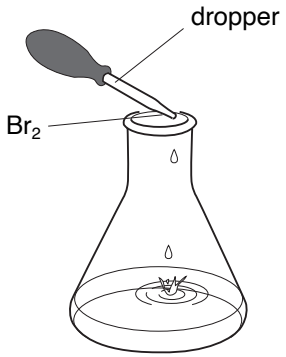
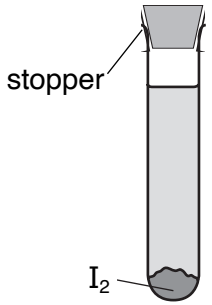


Observations	Equations
Pale yellow-green gas reacts explosively with hydrogen gas in UV light to produce a colourless gas. • Without UV light, this reaction is not explosive and gets much slower.	Chlorine + Hydrogen → Hydrogen chloride $Cl_2 + H_2 \rightarrow 2\ HCl$ (g)
Brown vapour reacts slowly with hydrogen gas to produce a colourless gas. • Br_2 must be vapourised through heating before reaction can start.	Bromine + Hydrogen → Hydrogen bromide $Br_2 + H_2 \rightarrow 2\ HBr$ (g)
Dark purple vapour reacts reversibly and very slowly with hydrogen gas to produce a colourless gas. • I_2 must be vapourised through heating before reaction can start.	Iodine + Hydrogen ⇌ Hydrogen iodide $I_2 + H_2 \rightleftharpoons 2\ HI$ (g)
Each of the colourless hydrogen halide gas produced dissolves readily in water to form acidic solutions.	HX (g) in water → H^+ (aq) + X^- (aq)

Reaction with Iron



Observations	Equations
When chlorine gas passes over the hot iron, it ignites rapidly with a bright flame to produce a yellow solid. When bromine vapour passes over the hot iron, it glows moderately fast and less vigorously to produce a red-brown solid. When iodine vapour passes over the hot iron, it glows dimly and slowly to produce a black solid. • Each halogen oxidises iron to its +3 oxidation state. • Halogens are corrosive and toxic. Soda lime is a basic mixture of sodium hydroxide (soda) and calcium oxide (lime). By reacting with the unreacted halogen gases (after all iron has reacted completely), soda lime prevents any halogen gases being released from the apparatus.	Chlorine + Iron → Iron(III) chloride 3 Cl_2 + 2 Fe → 2 $FeCl_3$ Bromine + Iron → Iron(III) bromide 3 Br_2 + 2 Fe → 2 $FeBr_3$ Iodine + Iron → Iron(III) iodide 3 I_2 + 2 Fe → 2 FeI_3

Reaction with Sodium hydroxide	Observations	Equations
	Pale yellow-green gas dissolves rapidly in sodium hydroxide solution to produce a colourless solution.	Chlorine + Sodium hydroxide → Sodium chloride + Sodium chlorate + Water $Cl_2 + 2\ NaOH \rightarrow NaCl + NaClO + H_2O$
	Red-brown liquid dissolves fast in sodium hydroxide solution to produce a colourless solution.	Bromine + Sodium hydroxide → Sodium bromide + Sodium bromate + Water $Br_2 + 2\ NaOH \rightarrow NaBr + NaBrO + H_2O$
	Purple-black crystal dissolves slowly in sodium hydroxide solution to produce a colourless solution. • Compared to the reactions with water, colourless solutions are produced from all three halogens.	Iodine + Sodium hydroxide → Sodium iodide + Sodium iodate + Water $I_2 + 2\ NaOH \rightarrow NaI + NaIO + H_2O$

DISPLACEMENT REACTIONS: REACTION OF HALOGENS WITH HALIDES

A **more reactive** halogen displaces the **less reactive** halogen from its aqueous halide solution.

$$M_2\,(aq) + 2\,L^-\,(aq) \rightarrow 2\,M^-\,(aq) + L_2\,(aq)$$

	Cl_2	Br_2	I_2
KCl		✗	✗
KBr	✓		✗
KI	✓	✓	

<u>The more reactive halogen (M) is the **oxidising** agent.</u>

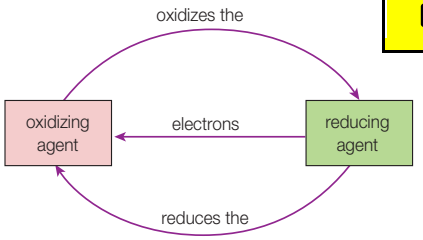
The halogen (existing as a diatomic molecule) undergoes reduction to form compounds known as halides.

- F_2 is the strongest oxidising agent (as it gains electrons most readily)
- I_2 is the weakest oxidising agent

<u>The less reactive halogen (L) is the **reducing** agent.</u>

The halide (aq) undergoes oxidation to form its element as diatomic molecules.

- I^- (ie. potassium iodide, KI) is the strongest reducing agent (as it loses electrons most readily)
- F^- is the weakest reducing agent



	Chlorine, Cl_2	**Bromine, Br_2**	**Iodine, I_2**
Potassium chloride, KCl		No reaction. Bromine is less reactive than chlorine. Hence, it cannot displace chlorine from potassium chloride solution.	No reaction. Iodine is less reactive than chlorine. Hence, it cannot displace chlorine from potassium chloride solution.
Potassium bromide, KBr	$Cl_2\,(aq) + 2\,KBr\,(aq) \rightarrow 2\,KCl\,(aq) + Br_2\,(aq)$ The colourless potassium bromide solution turns red-brown. Chlorine is more reactive than bromine. Hence it displaces bromine from potassium bromide solution.		No reaction. Iodine is less reactive than bromine. Hence, it cannot displace bromine from potassium bromide solution.
Potassium iodide, KI	$Cl_2\,(aq) + 2\,KI\,(aq) \rightarrow 2\,KCl\,(aq) + I_2\,(aq)$ The colourless potassium iodide solution turns brown. Chlorine is more reactive than iodine. Hence it displaces iodine from potassium iodide solution.	$Br_2\,(aq) + 2\,KI\,(aq) \rightarrow 2\,KBr\,(aq) + I_2\,(aq)$ The colourless potassium iodide solution turns brown. Bromine is more reactive than iodine. Hence it displaces iodine from potassium iodide solution.	