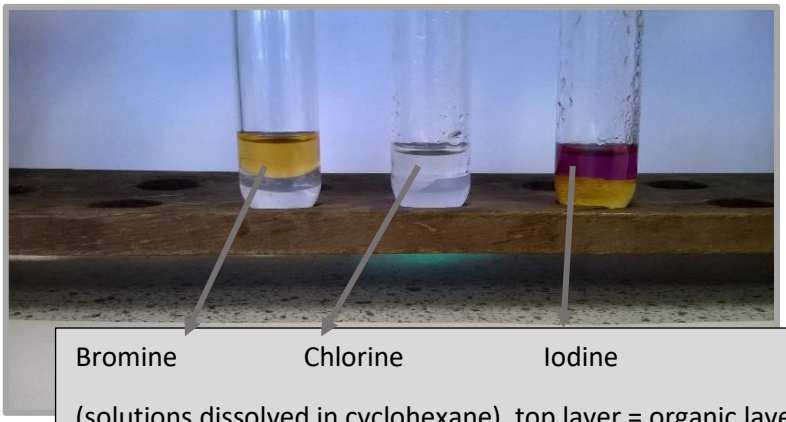
Elements from the Sea: ES 1.2 Reactions of halogens and halides - 15.11.16

Appearance when dissolved in water	
Chlorine	Pale green
Bromine	Orange/Yellow
Iodine	Brown

Chlorine water, Bromine water, Iodide in potassium iodide solution

Iodide in potassium iodide solution, Bromine water, Chlorine water

Reaction 1	Reaction description	Chemical dissolved in cyclohexane	Observations of colour		Other observations
			Top layer	Bottom layer	
The solubility of halogens in water	0.5cm^3 of each halogen was placed into separate test tubes. 0.5cm^3 of cyclohexane was then added to each test tube. The solution was shaken well	1 – Chlorine water	Pale green	Colourless	All reactions formed immiscible liquids separating into layers
		2 – Bromine water	Orange	Colourless	
		3 – Iodine solution	Violet	Orange/yellow	



Bromine Chlorine Iodine

(solutions dissolved in cyclohexane), top layer = organic layer with halogen
Bottom layer = water/excess halogen solution

Reaction 2	Reaction description	Halogen in solution	Halide Solution	Product	Colour observation	
					Top Layer	Bottom Layer
The reaction of halogens with halides	A few drops of chlorine water was added to both 0.5cm^3 potassium bromide and 0.5cm^3 of cyclohexane solution and the test tube shaken well.	Chlorine (Pale green)	Potassium bromide (colourless)	Potassium chloride + Bromine	Orange	Pale green
	A few drops of chlorine water was added to both 0.5cm^3 potassium iodide and 0.5cm^3 of cyclohexane solution and the test tube shaken well.	Chlorine (Pale green)	Potassium iodide (brown)	Potassium chloride + Iodine	Violet	Orange/brown
	A few drops of bromine water was added to both 0.5cm^3 potassium iodide and 0.5cm^3 of cyclohexane solution and the test tube shaken well.	Bromine (Orange/yellow)	Potassium iodide (brown)	Potassium bromide + Iodine	Purple/pink	Pale yellow

(T) = Top layer

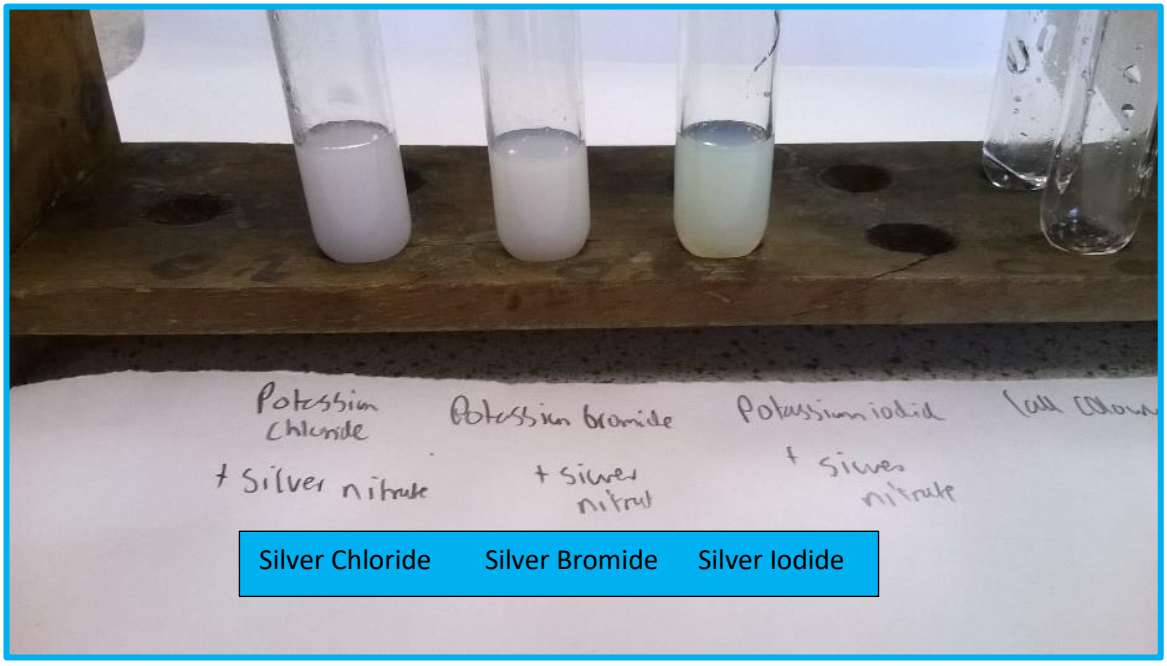
(B) = Bottom layer

Chlorine & Potassium bromide	Chlorine & Potassium iodide	Bromine & Potassium iodide

(All in mixed with cyclohexane)

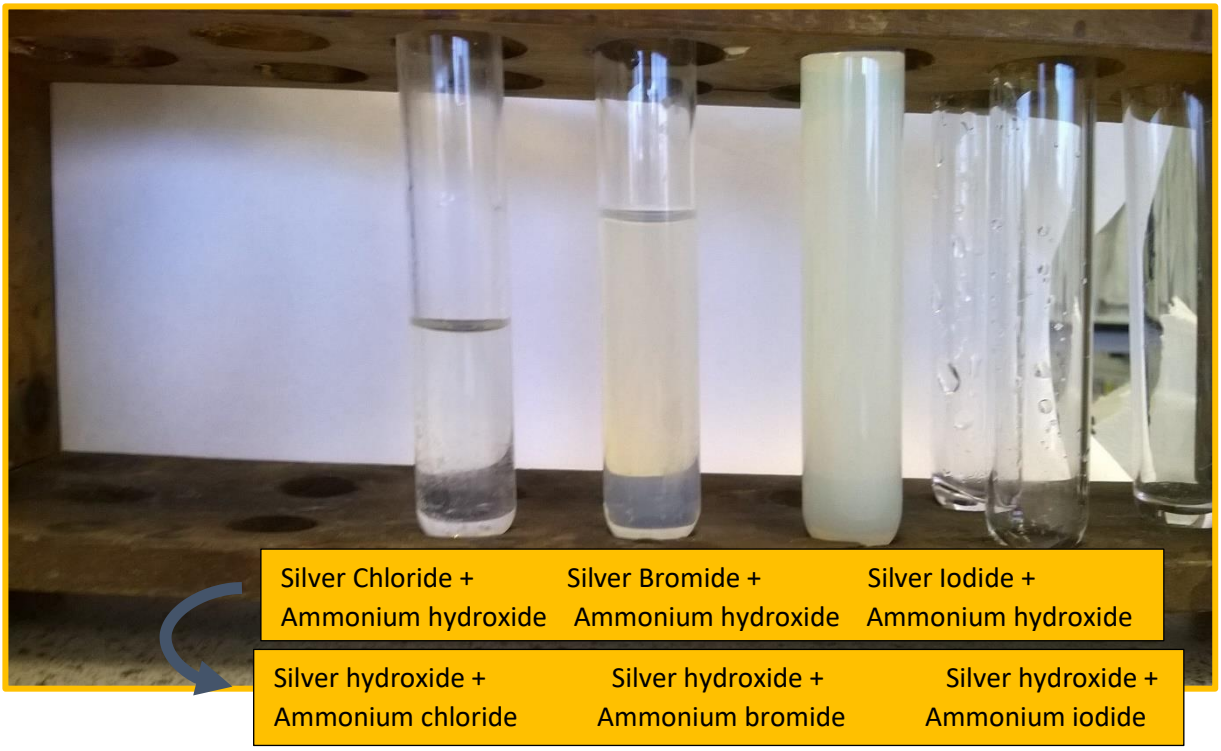
→ Potassium chloride (B) Bromine(T)	***Potassium chloride (B) + Iodine (T)***	***Potassium bromide (B) + Iodine (T)***

Reaction A	Reaction description	Halide Solution	Reagent solution	Product	Observed colour change
The reaction halide ions with silver nitrate ions	A few drops of silver nitrate solution added to 0.5cm^3 of potassium chloride solution.	Potassium chloride	Silver nitrate	Silver chloride + Potassium nitrate	Turned from colourless to white (**White precipitate)**
	A few drops of silver nitrate solution added to 0.5cm^3 of potassium bromide solution.	Potassium bromide	Silver nitrate	Silver bromide + Potassium nitrate	Turned from colourless to cream **(cream precipitate)**
	A few drops of silver nitrate solution added to 0.5cm^3 of potassium iodide solution.	Potassium iodide	Silver nitrate	Silver iodide + Potassium nitrate	Turned from colourless to pale yellow **(pale yellow precipitate)**



Silver Chloride	Silver Bromide	Silver Iodide

Reaction 3 B: Using the end solutions of 3 A in this reaction and adding an ammonium solution					
Reaction	Reaction description	Silver halide solution	Reagent solution	Product	Observed colour change
Adding ammonia to distinguish the 3 halogens (solubility of precipitates)	Continue to add ammonia solution to each of the test tubes (Silver chloride, silver bromide, silver iodide) until there is no more observed change. Stir with a glass rod.	Silver chloride	Ammonium hydroxide	Silver hydroxide + Ammonium chloride	Turned colourless (no precipitate/ precipitate dissolved)
		Silver bromide	Ammonium hydroxide	Silver hydroxide + Ammonium bromide	Reduced opacity – only some precipitate dissolved (sparingly soluble cream precipitate)
		Silver iodide	Ammonium hydroxide	Silver hydroxide + Ammonium iodide	No observed change (precipitate remained insoluble as pale yellow)



Follow-up questions

1) Solubility in water (refer to images for reaction 1)

a) When chlorine is dissolved in water the solution is pale green
When bromine is dissolved in water the solution is orange/yellow
When iodine is dissolved in water the solution is brown

b) Solubility in cyclohexane (refer to images for reaction 2)
Two layers are formed when the halogen solution is dissolved in cyclohexane. The top layer is the organic hydrocarbon layer with the dissolved halogen, the bottom is water/any excess halogen solution.

Results expected:
Chlorine layer = Pale green Bromine layer = Orange/red/brown Iodine layer = lilac

Results obtained:
Chlorine layer = Pale green Bromine layer = Light orange Iodine layer = Purple
The variation could be cause more halogen solution is required to dissolve in order for a more intense colour to be obtained. (more bromine water/higher concentration should be used)

c) Solubility in water

- Chlorine water showed very little evident colour, the distinctive pale green was only just visible against a white background. This suggests there is little chlorine actually dissolved in the solution, hence the low intensity of green.

- Bromine water was stronger in colour (orangey) suggesting that more dissolved in solution.

- Iodine must be the most soluble since the iodine solution had a stronger colour brown. More iodine was dissolved in solution so the colour was more visible.

Solubility in Cyclohexane (refer to images for reaction 2)

- Chlorine showed very little evident colour, the distinctive pale green colour was only just visible in front of a white background. Little chlorine dissolved in the cyclohexane.

- Bromine should have shown a darker, red/orange/brown colour yet it was a light orange. This colour is more intense than that of chlorine's as it is more soluble but it should be darker than the observation – this could be resolved by adding more bromine water/using a higher concentration.

- Iodine showed a distinctive dark purple colour and so was the most soluble with the most intense colour as more iodine dissolved.

Therefore, going down group 7 the solubility in both water and cyclohexane increases

2) a) **Reactions of halogens with halides (refer to images for reaction 3)**
i) Chlorine water and potassium bromide reaction: The chlorine solution was pale green, the potassium bromide colourless. When reacted in the presence of cyclohexane, two layers were formed (immiscible liquids). The top layer was orange (bromine) and the bottom layer pale green (potassium chloride).

ii) Chlorine water and potassium iodide reaction: The chlorine solution was pale green, the potassium iodide brown. When reacted in the presence of cyclohexane , the top layer formed was a dark purple (iodine) and the bottom layer orange/brown (potassium chloride).

iii) Bromine water and potassium iodide reaction: The bromine solution was orange/yellow, the potassium iodide brown. When reacted in the presence of cyclohexane , the top layer formed was a pink/purple (iodine) and the bottom layer light orange (potassium bromide).

b)

For a i) The top layer was orange since bromine was produced which dissolves in the organic solvent to give an orange/red/brown appearance. The bottom layer was pale green because of the chloride ions present in potassium chloride water (dissolves readily in water).

$Cl_{2(aq)} + 2Br^-_{(aq)} \rightarrow Br_{2(aq)} + 2Cl^-_{(aq)}$

For a ii) The top layer was a dark purple colour because iodine was produced which is purple/lilac when dissolved in an organic solvent. The bottom layer was orange/brown since not all of the potassium iodide (brown) dissolved and so the excess formed part of the bottom layer together with some of the chloride ions present in potassium chloride water.

$Cl_{2(aq)} + 2I^-_{(aq)} \rightarrow I_{2(aq)} + 2Cl^-_{(aq)}$

For a iii) The top layer was a light pink colour because iodine was produced which is purple/lilac when dissolved in an organic solvent but there was insufficient amount present to intensify the colour so. The bottom layer was a light orange since the bromide ion present in potassium bromide show an orange/yellow colour in water.

$Br_{2(aq)} + 2I^-_{(aq)} \rightarrow I_{2(aq)} + 2Br^-_{(aq)}$

c) i) In both reactions (b i & ii), each chlorine atom gains one electron to form Cl^- ions and so chlorine is being reduced, hence it is an oxidising agent.

ii) $Cl_{2(aq)} + 2e^-_{(aq)} \rightarrow 2Cl^-_{(aq)}$

3) Reactions of halides with silver nitrate (Refer to images for reaction 3)

a) When silver nitrate is added to a solution of chlorine, the solution forms a white precipitate, making it opaque.
When silver nitrate is added to a solution of bromine, the solution forms a cream precipitate, making it opaque.
When silver nitrate is added to a solution of iodine, the solution forms a pale yellow precipitate, making it opaque.

b) *Silver chloride (white) *Silver bromide (cream) *Silver iodide (pale yellow)

c)

Halide ion tested for	Reagent solution added	Precipitate formed	Colour of precipitate	Ionic equation
Chloride, Cl^-	Silver nitrate	Silver chloride	White	$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$
Bromide, Br^-	Silver nitrate	Silver bromide	Cream	$Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{(s)}$
Iodide, I^-	Silver nitrate	Silver iodide	Pale yellow	$Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

d)

- When ammonium hydroxide solution is added to silver chloride, the solution formed is colourless and so the precipitate dissolved. Silver chloride must be relatively soluble.

- When ammonium hydroxide solution is added to silver bromide, the solution formed was translucent with a slight reduction in the precipitate. Not all of the precipitate was dissolved and so silver bromide must be sparingly soluble (more ammonium would be needed).

- When ammonium hydroxide solution is added to silver iodide, the solution formed showed no change in colour and the pale yellow precipitate remained. The precipitate silver iodide remained so must be insoluble.