RAFFLES INSTITUTION RAFFLES PROGRAMME - YEAR FOUR CHEMISTRY

QUALITATIVE ANALYSIS

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Types of Reactions

While we have learnt specific types of reactions such as Neutralisation, Redox, etc, it is important to note that a reaction just refers to chemical change in general. In particular, the formation of a solid, water, or a gas can be considered a chemical change and hence a reaction.

Formation of solid / Precipitation:

While this can occur for specific types of reactions, in general the formation of a solid upon mixing two solutions can be considered a reaction. Recall that aqueous compounds dissociate in water to form their respective cations and anions. When mixing aqueous solutions, it is possible to have a combination of cation and anion that results in an insoluble salt. Thus a precipitate would be produced.
[This can also be thought of as a 'dance' where the ions switch partners and see if any insoluble salt is produced.]

Formation of water:

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

Formation of gas:

Recall these reactions (introduced in Acids and Bases)

Acid - Carbonate:	Acid + Carbonate	→	Salt + Water H2O + Carbon Dioxide CO2
Acid - Reactive Metal:	Acid + Reactive Metal	→	Salt + Hydrogen Gas H2
Acid - Sulfite $(SO_3)^{2-}$:	Acid + Sulfite Salt	→	Salt + Water H2O + Sulfur Dioxide SO2
Base - Ammonium $(NH_4)^+$:	Base + Ammonium Salt	→	Salt + Water H2O + Ammonia Gas NH3

You are also expected to remember the reactants and products / general equation for different types of reactions. These reactions include but are not limited to: Precipitation, Neutralisation, Acid Reactions, Base Reactions, Redox Reactions (Metal + Non-metal, Combustion, Displacement), Decomposition.

QA of Gases

Gas	**Test**
Ammonia NH_3	Moist red litmus → Blue
Carbon Dioxide CO_2	Bubble through limewater (calcium carbonate) → White ppt formed (calcium hydroxide)
Chlorine Gas Cl_2	Moist blue litmus → Red → Bleached
Hydrogen Gas H_2	Extinguishes lighted splint with a 'pop' sound
Oxygen Gas O_2	Relights a glowing splint
Sulfur Dioxide SO_2 (Reducing Agent)	Acidified potassium manganate (VII) $KMnO_4$ (VII) Purple → Colourless **OR** Potassium dichromate (VI) $K_2Cr_2O0_7$ Orange → Green

QA of Cations

Cation	Aqueous Sodium Hydroxide NaOH (aq)	Aqueous Ammonia NH3 (aq)
Calcium Ca2+	White ppt Insoluble in excess	No ppt
Aluminum Al3+	White ppt Soluble in excess; Colourless solution	White ppt Insoluble in excess
Lead Pb2+	White ppt Soluble in excess; Colourless solution	White ppt Insoluble in excess
Zinc Zn2+	White ppt Soluble in excess; Colourless solution	White ppt Soluble in excess; Colourless solution
Copper(II) Cu2+ Blue	Light blue ppt Insoluble in excess	Light blue ppt Soluble in excess; Dark blue solution
Iron(II) Fe2+ Pale green	Green ppt; turns brown on standing Insoluble in excess	Green ppt; turns brown on standing Insoluble in excess
Iron(III) Fe3+ Yellow/Orange	Red-brown ppt Insoluble in excess	Red-brown ppt Insoluble in excess
Ammonium (NH4)+	Ammonia produced on warming	-

Use CALZone for the white salts, With Calcium showing the least observations and Zinc showing the most. Aluminum and Lead can be distinguished using KI Potassium Iodide. Lead Iodide is an insoluble yellow salt while Aluminum Iodide is soluble.
Remember the coloured salts and Ammonium separately.

QA of Anions

Anion	Test	Test Result
Carbonate (CO3)2-	Add dilute acid	Colourless, odourless effervescence (CO2) produced that turns moist red litmus blue Bubble through limewater
Chloride Cl-	Acidify with dilute nitric acid, then add aqueous silver nitrate	White ppt (Silver chloride)
Iodide I-	Acidify with dilute nitric acid, then add aqueous silver nitrate	Pale yellow ppt (Silver iodide)
Sulfate (SO4)2-	Acidify with dilute hydrochloric acid, then add aqueous barium chloride	White ppt (Barium sulfate)
Nitrate (NO3)-	Add aqueous sodium hydroxide then aluminum foil, warm gently	Ammonia produced

Remember the solubility of the anions and link this with the tests and observations. The purpose of acidifying the solution is to remove carbonate ions that could result in a false positive result.

Tips and Answering Techniques

For observations, always talk about colour (of the precipitate and solution).
Always remember to state effervescence if you know the general reaction produces a gas. This observation is commonly forgotten.
Always phrase a non-result as a negative observation. For instance, instead of saying no visible change, make sure to say no precipitate formed, no colour change, white precipitate insoluble in colourless solution, etc.

When the colour of a substance is given, you can make some deductions on the unknowns. This list is not in syllabus and not exhaustive, just that it's good to know and may come in handy.

Colour (Solids)	**Possible Identities**
Black	Copper Oxide CuO, Manganese Oxide MnO2, Metal powder
Blue	Most Copper(II) compounds
Reddish-Brown	Iron(III) Compounds, Copper metal
Green	Copper Carbonate CuCO3, Iron(II) compounds
Yellow	Lead Iodide PbI2, Silver Iodide AgI (pale yellow)
Purple	Potassium Manganate (VII) KMnO4
White	Most compounds of Na+, K+, Ca2+, Zn2+, Al3+, Pb2+ and (NH4)+ Insoluble Sulfates and Chlorides.

Colour (Liquids)	**Possible Identities**
Blue	Aqueous Copper(II) compounds
Brown/Reddish-Brown	Aqueous I2, Br2
Yellow/Brown	Aqueous FeCl3
Purple	Aqueous KMnO4
Red	Aqueous Co(NO3)2, Methyl orange in acid
Violet	Iodine solid dissolved in organic solvent

Other general guidelines:
When aqueous hydrogen peroxide H202 used, oxygen gas usually produced.
When concentrated hydrochloric acid HCl or aqueous sodium chlorate(I) NaClO3 used, chlorine gas usually produced.
When aqueous ammonia used in cation test, ammonia gas will be naturally produced, and hence observation and testing of ammonia gas is irrelevant and not given credit.