Note: Sulfur dioxide and chlorine gas will not be tested during practical examination.

Table 1 - Colour of Substances

Colour of unknown substance	Deduction/Inference
Black	Carbon, copper(II) oxide, iodine crystals, iron(II) oxide or manganese(IV) oxide
Blue	Copper(II) salts
Green	Iron(II) or copper(II) salts
Grey	Powder form of metals like zinc, iron or lead
Purple	Potassium manganate(VII)
Reddish brown/pink	Copper metal
White/colourless crystals	Ammonium, calcium, lead, zinc, sodium or potassium salts
Yellow	Iron(III) salts
Colourless solution [not for identification of cations]	Dilute acids or alkalis, water , hydrogen peroxide, potassium iodide

Table 2 - Solubility of Salts

Type of salt	Solubility
Sodium, Potassium & Ammonium	All are soluble
Nitrate	All are soluble
Chloride	All are soluble except $PbCl_2$ and $AgCl$
Iodide	All are soluble except PbI_2 and AgI
Sulfate	All are soluble except $PbSO_4$ and $BaSO_4$ [$CaSO_4$ is sparingly soluble in hot water]
Carbonate	All are insoluble except those of Na^+, K^+ and NH_4^+
Hydroxide	All are insoluble except those of Na^+, K^+ and NH_4^+

Table 3 - Action of Heat

Most solids undergo changes when heated. These changes often provide a clue to the cation and or anion present in the solid. Remember to **test the gas (if any) liberated** during the heating as it is very often indicates the presence of a certain anion. Also **note the colour of the residue when it is hot and when it is cold.**

*Test: Place a little of the unknown in a **clean, dry** test tube and heat gently at first and then **strongly** until no further changes take place.*

Observation	Gas Evolved	Inference
a) white sublimate at the cooler part of the test tube	---	ammonium salts present
b) white fumes seen; white sublimate at the cooler part of the test tube. On further heating, colourless and pungent evolved turns damp red litmus blue. After some times, the blue litmus turns red.	NH_3 + HCl	ammonium salts present ammonium chloride present
c) colourless and odourless gas evolved rekindles a glowing splint	O_2 only	certain oxides or sodium nitrate or potassium nitrate present
d) colourless, odourless gas evolved turns damp blue litmus red and forms white ppt with lime water	CO_2	carbonates or hydrogen carbonates present (except K_2CO_3 and Na_2CO_3)
e) colourless, odourless vapour evolved turns blue cobalt chloride paper pink. Water droplets formed at the cooler end of the test tube.	water vapour evolved	compounds with water of crystallisation; hydroxides of metals (except KOH and NaOH) or hydrogencarbonates present
f) colourless gas with a characteristic smell of burning sulfur evolved. This gas turns acidified $KMnO_4$ from purple to colourless.	SO_2	sulfites (SO_3^{2-}) present
g) brown, choking gas evolved turns damp blue litmus red. At the same time, a glowing splint is rekindled	NO_2 (often accompanied by O_2)	nitrates present {except KNO_3 and $NaNO_3$}

Colour of Residue	Deduction/Inference
a) white residue	Na^+, K^+, Ca^{2+}, Zn^{2+}
b) white sublimate	NH_4^+
c) yellow when hot and white when cold	Zn^{2+} present. ZnO formed.
d) yellow when hot and yellow when cold	Pb^{2+} present. PbO formed.
e) reddish-brown	Fe^{3+} present. Fe_2O_3 formed.
f) black residue turning reddishbrown on cooling	Fe^{2+} present. FeO formed at first and oxidised to Fe_2O_3.
g) black residue	Cu^{2+} present. CuO formed.

Table 4 - Tests For Acids And Alkalis

To an unknown liquid, add one of the following indicators and check the colour observed.

Indicator	Colour in Acidic Solution	Colour in Alkaline Solution
Litmus	Red	Blue
Methyl orange	Red	Yellow

Table 5 - Test For Strength Of Acids And Alkalis - pH Of Solutions

pH is a number scale used to describe how acidic or alkaline a solution is. The pH of a solution is usually measured by the use of the Universal Indicator, which shows a different colour in solution with different pH.

pH Number	Colour	Acidic/Alkaline
1	red	strong acid
2	red	
3	orange	decrease
4	orange	in acidity
5	yellow	
6	yellow	weak acid
7	green	neutral
8	blue-green	weak alkali
9	blue-green	
10	blue-green	
11	blue	increase
12	blue	in alkalinity
13	violet	
14	violet	strong alkali

Table 6 - Test For Oxidising And Reducing Agents

Redox reactions take place frequently in analytical tests. In a redox reaction, one reagent is oxidised while the other is reduced.

An oxidising agent is a substance that takes up electrons and get reduced.

A reducing agent is a substance that releases electrons and become oxidised.

The tests for oxidising and reducing agents usually involve a chemical change that is easily detected. Nearly all the tests involve a clearly visible colour change.

A. To test for an oxidising agent, a **reducing agent** is added to it. [Let X be the test solution.]

Test	Observation	Inference
a) Aqueous KI To a sample of the test solution X, add aqueous KI	Brown solution seen or black ppt formed.	X is reduced or acidified KI is oxidised by X. *(The colourless iodide ions are oxidised to brown iodine.* $2I^- \rightarrow I_2 + 2e)$
b) Acidified $FeSO_4$ Add dilute H_2SO_4 and freshly prepared $FeSO_4$ solution to the test solution, X	Solution turns from green to yellow	X is reduced or acidified $FeSO_4$ is oxidised by X. *(The pale green iron(II) ions can be oxidised to yellow-brown iron(III) ions.* $Fe^{2+} \rightarrow Fe^{3+} + e)$

B. To test for a reducing agent, an **oxidising agent** is added to it.

[Let X be the test solution.]

Test	Observation	Inference
a) Acidified $KMnO_4$ To a sample of the test solution X, add diluted H_2SO_4 followed by $KMnO_4$ in a dropwise manner	Acidified $KMnO_4$ changes from purple to colourless (Note: Brown ppt of MnO_2 formed if medium is weakly acidic or neutral)	X is oxidised or acidified $KMnO_4$ is reduced by X. *(The purple manganate(VII) ions is reduced to colourless manganese(II) ions in an acid medium.* $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$)
b) Iodine solution Add iodine solution to the test solution, X	Brown colour of I_2 solution turns colourless	X is oxidised or iodine solution is reduced by X. *[The brown solution of I_2 is reduced to colourless iodide ions.* $I_2 + 2e \rightarrow 2I^-$]
c) Fresh iron(III) chloride To a sample of solution X, add $FeCl_3$	Reddish-brown solution turns green	X is oxidised or $FeCl_3$ is reduced by X. *(The reddish-brown iron (III) ions are reduced to green iron(II) ions.* $Fe^{3+} + e \rightarrow Fe^{2+}$)

Sources of Error

When asked to state experimental errors, think of errors that are not caused by your error (e.g., parallax error), but errors that cannot be eliminated due to experimental design (see table below for examples).

Some guiding questions to identify where errors may be introduced:

- **Which measurements were difficult to observe and record accurately?**
  For example, an experiment may require students to record the time taken for a reaction to complete. The time measured may be longer or shorter due to human reaction time in using the stopwatch.

- **Other than the measured variables, what other factors could have affected the results?** For example, in an experiment that investigates the rate of heat loss of a liquid over a period of time, the container that the liquid is placed in cannot completely eliminate heat loss to the surroundings.

After identifying the errors of the experiment, you could then be asked to suggest ways to improve the reliability/validity of the experimental results. The improvements suggested must be able to address the sources of errors identified, and they can include modification to experimental procedures, more rigorous control of variables, or the use of more accurate measuring instruments and/or procedures.

Common sources of errors and how to rectify them

Experiment	Source of error	Effect on results	How to Rectify
Titration	Presence of impurities that may react with titrant solution	A larger than expected volume of titrant is required for complete reaction.	-
	Inconsistent swirling of conical flask	The reaction may be incomplete and cause an error in the results obtained.	Adopt the use of a magnetic stirrer
Speed of reaction	Human reaction time (measurement of time with stopwatch)	Causes time recorded to be longer or shorter than expected	Use a data logger to measure time
	Loss/gain of heat to/from surroundings (if temperature measurement involved)	Decreases/increases final temperature obtained, which can affect the calculations in question	Use a Styrofoam cup instead.
	Inconsistent rate of stirring (if stirring involved)	Affects results obtained	Adopt the use of magnetic stirrer
Salt preparation	Some of the solid crystal products were lost as residue on the glass containers	Decreases final yield of product obtained	-
	Some of the solid crystal products dissolved in cold deionised water used to wash the residue	Decreases final yield of product obtained	-
Gas collection	Gas collected is soluble in water (gas collection using displacement of water)	Causes volume of gas collected to be lesser than expected	Use a gas syringe (instead of displacement of water)/repeat measurements and take average.
QA	Other unknown ions might be present that can interfere with test results	Affects results of tests, leading to wrong conclusions	-
Temperature change	Heat loss from solution to surroundings	Temperature taken is lower than expected	Use a Styrofoam cup instead.