ChemFactsheet

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Laboratory Chemistry: Making Observations and Inferences

In practical exams or assessments students are commonly asked to carry out chemical tests, record observations and draw conclusions (inferences) from these observations. The focus of this Factsheet is on the language and background knowledge required to make clear, accurate observations and inferences.

Recording Observations

Observations are made using all of the senses - you must record what is seen,smelled, heard and felt (e.g. temperature changes). You must use the correct chemical language to describe these observations clearly and concisely. Table 1 gives some common key words (with their meanings) used in making observations, with examples of how this information would be used. The table above shows the most common types of observations that are made, but if you notice anything else occurring you should certainly record it. Some reactions can be identified by observations peculiar to them (i.e. silver mirror formed on inside of test tube, or brown ring formed at interface) so everything should be written down.

Table 1. Basic descriptive terms

Key Word	Description	Example	Observation
No observable reaction	Use this phrase when there is no evidence of a reaction occurring. **Never** write 'Nothing happened', as it may just be that the reaction cannot be seen happening.	Place a strip of copper metal into a test tube and add 4-5 cm^3 of water.	No observable reaction.
Solid	A chemical in the solid state. State: • The colour. • Whether powdered, ash, metallic, crystalline (shape of crystals?) or gelatinous.	Gently heat copper powder in a test tube.	A black powdered solid is formed.
Solution	A clear (i.e. transparent) liquid where a solute in dissolved in a solvent. State: • The colour (or colourless)	Place a small amount of copper(II) sulphate into a test tube and add 4-5 cm^3 of water.	A blue solution is formed.
Precipitate	Precipitation occurs when the mixing of aqueous solutions leads to the formation of an insoluble substance. State: • The colour	Place 2-3 cm^3 sodium chloride solution in a test tube and add silver nitrate solution dropwise.	A white precipitate is formed.
Immiscible	Liquids which do not mix, separated at the interface. State: • Descriptions of both upper and lower layers.	Place 3-4 cm^3 iodine solution in a test tube and add hexane dropwise.	The two liquids were immiscible, the colourless hexane on the surface of the dark brown iodine solution. On shaking, the lower aqueous layer decolourised, and a purple solution was formed in the upper organic layer.
Flame	Description of flame when carrying out a flame test. State: • The colour	Carry out a flame test on a sample of barium chloride.	The compound produces an apple-green flame.
Combustion	The burning of a chemical, the exothermic reaction with oxygen. State: • The rate at which combustion occurs. • A description of the flame. • The appearance of any observable reaction products.	Using tongs, heat a magnesium strip in a Bunsen flame.	Magnesium burns quickly with a bright white flame, leaving a solid white ash.
Endothermic/ Exothermic	Whilst we would always expect combustion reactions to be exothermic (so it would not be worth mentioning) sometimes a change of temperature may occur more unexpectedly, and therefore should be noted. State: • Whether reaction is endothermic (temperature drop) or exothermic (temperature rise).	Place 5-6 cm^3 water in a test tube and carefully add concentrated sulphuric acid dropwise.	Colourless solution formed, in an exothermic reaction.
Fumes/vapour evolved	A gas is given off. State: • The colour. • Whether fumes are dense (cloudy) or not dense (misty). • If they have a pungent or choking smell. • The pH, using moist indicator paper. • Check for condensation of vapour (or solid, for sublimation) on side of test tube, and describe it	Place 2g of magnesium nitrate in a test tube and heat. Test products for the presence of oxygen.	Pungent dense brown fumes evolved which turn moist universal indicator paper red. A glowing spill re-ignited when placed in the test tube. A white powdered solid remained in the bottom of the test tube.
Effervescence	Bubbles of gas moving through a liquid. State: • The colour. • Check pH of gas using moist indicator paper and record colour change.	Place 1 or 2 chips of calcium carbonate in a boiling tube and add 5-6 cm^3 dilute hydrochloric acid. Check for presence of carbon dioxide in products.	Effervescence, clear gas evolved which caused moist universal indicator paper to turn green/orange. Lime water changed from colourless to cloudy white when gas was bubbled through.

Tests for gases and ions

At AS and A2 level there are several simple practical tests for simple ions (Table 2) and gases (Table 3) which you are expected to know. These tests are given below, along with the expected observations.

Table 2. Tests for ions

Anion	Test	Observations:
Chloride (Cl^-)	To a solution, add dil. HNO_3, then $AgNO_3$(aq).	White ppt. of AgCl going curdy; greying in bright light.
Bromide (Br^-)	To a solution, add dil. HNO_3, then $AgNO_3$(aq).	Pale cream ppt. of AgBr going curdy; greying in bright light.
Iodide (I^-)	To a solution, add dil. HNO_3, then $AgNO_3$(aq).	Yellow ppt. of AgI going curdy; greying v. slowly in bright light.
Nitrate (NO_3^-)	(a) 'Brown ring' test. To soln add cold $FeSO_4$(aq). Then pour conc. H_2SO_4 carefully down inside of test tube to form lower layer.	Brown ring formed at interface.
	(b) To cold soln or solid add a few copper turnings and then conc. H_2SO_4. Warm.	Brown oxides of nitrogen obtained and a blue soln obtained.
Carbonate (CO_3^{2-}) And Hydrogen Carbonate (HCO_3^-)	To solid or soln. add dil. HCl	Effervescence; colourless gas turning lime water cloudy white.
	To differentiate between CO_3^{2-} and HCO_3^-: To the unheated test soln add a drop of $MgSO_4$.	(a) A white ppt indicates CO_3^{2-}. (b) No ppt indicates HCO_3^-.
Sulphate (SO_4^{2-}) And Hydrogen Sulphate (HSO_4^-)	To soln add dil. HCl and then $BaCl_2$(aq).	White ppt of $BaSO_4$.
	To differentiate between SO_4^{2-} and HSO_4^-: (i) Heat the solid.	(a) Dense white choking fumes of SO_3 obtained readily indicates HSO_4^- (b) SO_3 fumes only on strong heating indicates SO_4^{2-}
	(ii) To soln add Na_2CO_3.	(a) Vigorous effervescence of CO_2 indicates HSO_4^- (b) Slight or no effervescence indicates SO_4^{2-}
Sulphite (SO_3^{2-})	To solid or soln add dil. HCl and warm.	Pungent SO_2 evolved (turning acid dichromate green) but no S pptd
Ammonium (NH_4^+)	Warm gently a little soln or solid with a slight excess of NaOH (aq).	Ammonia evolved (turning red litmus blue).
Sodium (Na^+)	Flame test.	Yellow flame.
Potassium (K^+)	Flame test.	Lilac flame. (crimson viewed through blue glass)
Calcium (Ca^+)	Flame test.	Brick-red flame.
Barium (Ba^+)	Flame test.	Apple-green flame.

Table 3. Tests for simple gases

Gas	Description	Test	Observations:
Hydrogen (H_2)	Colourless, odourless	Ignite using a splint.	'Squeaky pop'. Burns with a pale blue flame.
Oxygen (O_2)	Colourless, odourless	Glowing splint.	Ignites or glows much brighter.
Carbon Dioxide (CO_2)	Colourless, odourless	Bubble through lime water.	Turns cloudy white.
Ammonia (NH_3)	Colourless, pungent	Moist red litmus paper.	Turns red.
Chlorine (Cl_2)	Yellow-green, pungent	(a) Moist litmus paper.	Turns red then bleached white.
		(b) Bubble through KBr(aq).	Solution turns yellow or orange.
Nitrogen Dioxide (NO_2)	Brown, pungent	Bubble through water, then add a little NaOH(aq) to this solution	Colourless solution; no change on addition of alkali.
Sulphur Dioxide (SO_2)	Colourless, pungent	Bubble through acidified (dil. H_2SO_4) dichromate solution	Turns from orange to green, but no precipitate

Making Inferences.
After recording careful observations inferences must be made. These may require the use of data, or may be based upon the tests in tables 2 and 3. The inferences may lead to the complete identification of the unknown compound, but sometimes only specific ions within the compound are identified. Table 4 below provides examples of observations and inferences.

Exam Hint: *- Whilst there is a time limit in practical exams and many practical assessments, you also need to be aware that:*
- *Some reactions take a little time to occur.*
- *Some reactions occur in **two or more observable stages**, and if rushed you will only observe the first stage.*

Table 4. Observations and inferences

Observations	Inferences
On adding dilute nitric acid and silver nitrate solution to a solution of chemical X, a white precipitate was formed which later turned grey.	*Chemical X contains chloride (Cl^-) ions.*
On heating a solution of X with sodium hydroxide solution, a pungent gas is evolved which turns damp red litmus paper blue.	*The gas produced is ammonia. X contains NH_4^+ ions*
On heating solid X, it sublimes	*X is ammonium chloride (since it contains ammonium ions, chloride ions and is one of the few substances to sublime)*
On carrying out a flame test, chemical Y produced an apple-green flame.	*Chemical Y contains barium ions*
When hydrochloric acid is added to solid W , effervescence of a colourless gas occurs. The colourless gas produced burns with a squeaky pop sound.	*The gas is hydrogen. Solid W is a metal above copper in the reactivity series.*
Effervescence was observed on addition of dilute hydrochloric acid to solid Z, and the colourless gas produced turned lime water cloudy white.	*Solid Z is either a hydrogen carbonate or a carbonate.*
On adding a drop of magnesium sulphate to a solution of Z, there was no observable reaction.	*Solid Z is a hydrogen carbonate.*
During a flame test on solid Z, a yellow flame was produced.	*Solid Z contains sodium.* *Solid Z is sodium hydrogen carbonate.*

Practice Questions
1. If two chemicals are added and nothing appears to happen, what observation should be recorded?
2. How would you describe the following common chemicals?
   (a) Sodium chloride. (b) Oxygen.
   (c) Water. (d) Copper.
   (e) Blackcurrant juice.
3. What is an insoluble substance called if formed from a mixture of aqueous solutions?
4. Can a solution be described as cloudy?
5. What test should always be carried out if a gas is produced in a chemical test?
6. Write inferences for the following observations.
   (a) A colourless gas was produced in the reaction which turned moist indicator paper green and ignited a glowing splint.
   (b) A flame test was carried out on the solid, and the flame burned brick red.
   (c) A solution was made up of white solid Q, and a yellow precipitate was made on the addition of dilute nitric acid and silver nitrate. A flame test on solid Q produced a lilac flame.
7. Infer what you can from the observations of these tests on solid K.
   (a) Solid K was placed in a test tube and heated. Brown pungent fumes were evolved which turned moist indicator paper red, and when a glowing splint was put into the test tube it ignited. A white solid was left in the test tube.
   (b) A few copper turnings were added to solid K and then 2-3 cm^3 concentrated sulphuric acid. The mixture was carefully heated and brown pungent fumes were evolved which turned moist indicator paper red, a blue solution was left in the test tube.
   (c) A flame test on solid K produced a brick red flame colour.

Answers.
1. No observable reaction.
2. (a) White crystalline solid.
   (b) Colourless gas.
   (c) Colourless liquid.
   (d) Shiny pink/brown metallic solid.
   (e) Purple solution.
3. A precipitate.
4. No, solutions are clear.
5. A pH test using moist indicator paper.
6. (a) The gas is oxygen.
   (b) The solid contains calcium.
   (c) Solid Q contains the iodide ion (I^-) and the potassium ion (K^+). Solid Q is potassium iodide.
7. (a) Nitrogen dioxide and oxygen gases were evolved.
   (b) Solid K is a nitrate.
   (c) Solid K contains calcium ions (Ca^{2+}). Solid K is calcium nitrate, $Ca(NO_3)_2$.

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