ChemFactsheet

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Laboratory Chemistry: Summary of Organic Tests

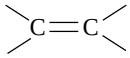
Before reading through this Factsheet you should:
- Have gained practical experience of organic chemistry tests and preparations.
- Have a good understanding and knowledge of organic functional groups and their reactions.

After working through this Factsheet you will be able to:
- Give reagents, conditions and expected observations when carrying out chemical tests for common organic functional groups;
- Use this information in a practical or written exam situation.

Chemical testing is still commonly used in school laboratories for simple organic analysis because:
- The use of expensive modern spectroscopic equipment is not required;
- It provides excellent opportunities to improve practical skills, such as making observations and inferences.

Knowledge and understanding of common organic tests are required in practical and written examinations. The aim of this Factsheet is to provide a summary of these tests, which candidates should be able to recall.

Group: Alkenes (and other unsaturated hydrocarbons)

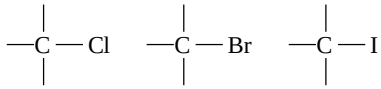


Test: Addition of bromine solution.

Observation: Orange bromine solution decolourises.

Notes: $CH_2{=}CH_2 + Br_2 + H_2O \rightarrow CH_2BrCH_2OH + HBr$
Reference Factsheet 16

Group: Halogenoalkanes



Test: Warm with NaOH (aq).
Add HNO_3 (aq) until just acidic.
Add $AgNO_3$ (aq) dropwise.

Observations: **Chloroalkanes-** White precipitate, soluble in dilute ammonia solution.

Bromoalkanes- Cream precipitate, soluble in concentrated ammonia solution.

Iodoalkanes- Yellow precipitate, insoluble in concentrated ammonia solution.

Notes: Reference Factsheet 16.

Group: Hydroxyl group (in alcohols and carboxylic acids)
— OH

Test: Add PCl_5 to a dry sample of the compound.

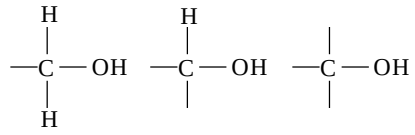
Observations: Steamy white fumes of hydrogen chloride.

Notes: PCl_5 causes nucleophilic substitution reaction of –OH group in alcohol, carboxylic acid or water (hence organic compound must be dry).

e.g. $C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl + HCl + POCl_3$

Reference Factsheet 17.

Group: Alcohols (Primary, Secondary and Tertiary)



Test: Warm with potassium dichromate (VI) acidified with dilute sulphuric acid.

Observations: Primary and secondary alcohols cause **orange** dichromate (VI) ions to be reduced to **green** chromium (III) ions. Tertiary alcohols do not react.

Notes: Potassium dichromate (VII) is an oxidising agent, as it is reduced.
The oxidation of alcohols can be summarised:

Primary alcohol $\xrightarrow{[O]}$ aldehyde $\xrightarrow{[O]}$ carboxylic acid

Secondary alcohol $\xrightarrow{[O]}$ ketone $\longrightarrow$ X

Tertiary alcohol $\longrightarrow$ X

To distinguish between primary and secondary alcohols the products of oxidation should be distilled off and tested for the presence of aldehyde or acid (inferring primary alcohol) or ketone (inferring secondary alcohol).

Reference Factsheet 17.

***Exam Hint**: Exam questions will commonly require you to combine information from organic tests and spectroscopy to determine a compound's identity*

Group: Carboxylic Acid.

Test: Add to sodium hydrogen carbonate solution.

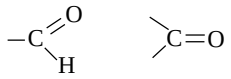
Observations: Carbon dioxide gas evolved, which turns lime water cloudy white.

Notes: $CH_3COOH + NaHCO_3 \rightarrow CH_3COO^-Na^+ + H_2O + CO_2$

Another possibility would be to test the pH of the compound, which would be less than 7 for an acid.

Reference Factsheet 32.

Group: Carbonyl group (aldehydes and ketones).



Test: Add an alcoholic solution of 2,4-dinitrophenylhydrazine (2,4-DNP) acidified with dilute sulphuric acid.

Observations: A red-orange precipitate produced.

Notes: **This test does not distinguish between the two types of carbonyl compound, aldehydes and ketones.**

Reference Factsheet 33

To Distinguish between Aldehydes and Ketones:
There are two tests which can be carried out.

Test 1: Silver Mirror Test : A test for aldehydes.
Warm carbonyl compound with ammoniacal silver nitrate solution (Tollen's reagent).

Observations: If an aldehyde is present a silver mirror is formed on the inside of test tube, or a grey-black precipitate.

Notes: The aldehyde is oxidised to a carboxylic acid, whilst the silver (I) ions are reduced to silver metal.

Ammoniacal silver nitrate has no effect on ketones.
Reference Factsheet 33

Test 2: Fehling's Solution Test : A test for aldehydes.
Warm the carbonyl compound with Fehling's solution.

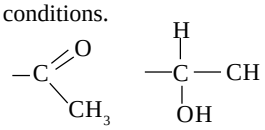
Observations: If an aldehyde is present Fehling's solution turns from blue to red.

Notes: The aldehyde is oxidised to a carboxylic acid, whilst the blue copper (II) ions are reduced to a red precipitate of copper (I) oxide.

Fehling's solution has no effect on ketones.
Reference Factsheet 33.

Acknowledgements: *This Factsheet was researched and written by Kieron Heath.* ***Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU. ChemistryFactsheets*** *may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher.* ***ISSN 1351-5136***

Group: Methyl group next to carbonyl group, or secondary alcohol which would oxidise to such a group in these conditions.



Test: The Iodoform (tri iodomethane) Test.

Warm the compound with a solution of iodine and sodium hydroxide.
(The reagents potassium iodide and sodium chlorate (I) produce a similar effect).

Observations: A yellow precipitate is formed with an antiseptic-like smell.

Notes: The yellow precipitate formed is iodoform, CHI_3.

Reference Factsheet 33.

Practice Questions:

1. What would the expected observation be upon the addition of bromine water to the following chemicals:
   (a) Hexane (b) Hex-2-ene

2. What would the expected observation be upon the addition of 2,4-DNP to the following chemicals?
   (a) Propanone (b) Propane (c) Propanal

3. Pentan-2-ol is warmed with potassium dichromate (VI) dissolved in dilute sulphuric acid and a reaction is observed. The resultant organic product is distilled off and split into two parts. One part is tested with 2,4-DNP solution, and one part is tested with ammoniacal silver nitrate.

   Describe:
   (a) The observation that was made which indicated that a reaction took place between the pentan-2-ol and acidified potassium dichromate (VI) solution.
   (b) The observation made as the distillate was tested with 2,4-DNP.
   (c) The observation made as the distillate was tested with ammoniacal silver nitrate solution.
   (d) Name the distillate.

4. Describe the observations if the following chemicals were warmed with iodine solution and sodium hydroxide.
   (a) Ethane (b) Ethanol (c) Ethanal (d) Propanone
   (e) Propanal (f) Hexan-3-one (g) Hexan-2-one

Answers

1. (a) Two immiscible layers, no observable reaction.
   (b) Two immiscible layers, bromine water decolourises.

2. (a) Red-orange precipitate.
   (b) No observable reaction.
   (c) Red-orange precipitate.

3. (a) Colour change orange to green.
   (b) Formation of a red-orange precipitate.
   (c) No observable reaction.
   (d) pentan-2-one.

4. (a) No observable reaction.
   (b) Yellow precipitate, antiseptic smell.
   (c) Yellow precipitate, antiseptic smell.
   (d) Yellow precipitate, antiseptic smell.
   (e) No observable reaction.
   (f) No observable reaction.
   (g) Yellow precipitate, antiseptic smell.