Overview
Chemical Analysis

Purity, formulations and chromatography

- Pure substances
- Formulations
- Chromatography

Identification of common gases

- Test for hydrogen
- Test for oxygen
- Test for carbon dioxide
- Test for chlorine

Identification of ions by chemical and spectroscopic means (Chemistry only)

- Flame tests
- Metal hydroxides
- Carbonates
- Halides
- Sulfates
- Instrumental methods
- Flame emission spectroscopy

LearnIT!
KnowIT!

Purity, formulations
And chromatography

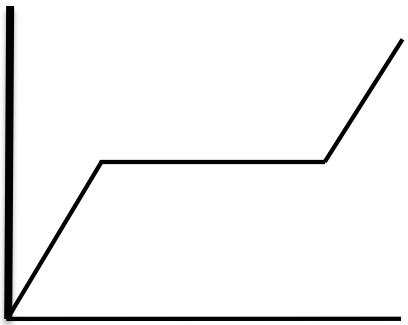
- Pure substances
- Formulations
- Chromatography

Pure substances and Formulations

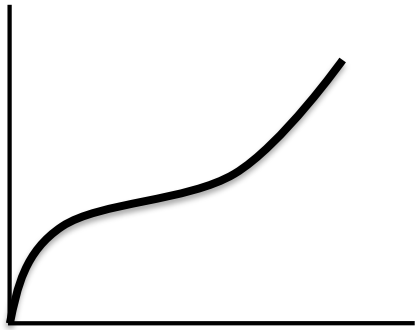
In chemistry, a **pure substance** is a **single element or compound not mixed** with any other substance.

Learn this definition for the exam

Pure substances have **specific** melting and boiling temperatures.
These can be used to distinguish pure substances from mixtures.



Melting point of a pure substance



Melting point of an impure substance

In Science we would not refer a substance such as milk as being pure as it is a mixture of a number of different substances.

A **formulation** is a **mixture** that has been designed as a useful product.

Formulations are made by mixing the components in carefully measured quantities to ensures that the product has the required properties. Formulations include fuels, cleaning agents, paints, medicines, alloys, fertilisers and foods

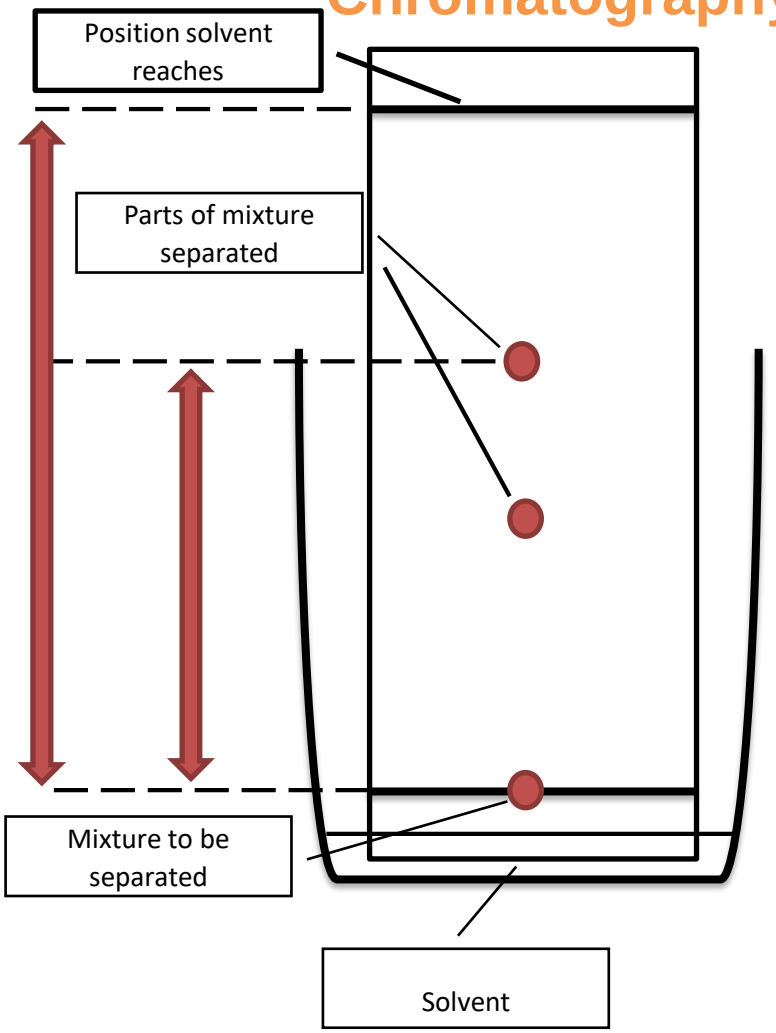
Chromatography

Chromatography can be used to **separate mixtures.**
Chromatography involves a **stationary phase** and a **mobile phase**.

The ratio of the distance moved by a compound (centre of spot from origin) can be expressed as it's R_f value:

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

When calculating the R_f value remember the **solvent will always travel further than the substance** so the **R_f value can never be greater than 1**.



Different compounds have different Rf values in different solvents, which can be used to help identify the compounds. A pure compound will produce a single spot in all solvents.

QuestionIT!

Purify, formulations and chromatography

- Purity
- Formulations
- Chromatography

1. What is a pure substance?

2. How could you distinguish between a pure substance and a mixture?

3. What is a formulation?

4. How are formulations made?

5. Give two examples of formulations.

6. What is chromatograph?

7. What happens in the stationary and mobile phases?

8. State the equation used to find the Rf value.

9. A solvent travels 8cm up the stationary phase, two spots separate out. A travels 6cm up the mobile phase, B travels 4.5cm up the mobile phase. Give the Rf value for both to two decimal places.

AnswerIT!

Purify, formulations and chromatography

- Purity
- Formulations
- Chromatography

1. What is a pure substance?
   A single element or compound, not mixed with any other substance.
2. How could you distinguish between a pure substance and a mixture?
   Pure substances melt and boil at specific temperatures. Melting and boiling point data could be used.
3. What is a formulation?
   A mixture that has been designed as a useful product.
4. How are formulations made?
   Mixing the components in carefully measured quantities to ensure the product has the required properties.
5. Give two examples of formulations.
   Fuels, cleaning agents, paints, medicines, alloys, fertilisers and foods.

6. What is chromatograph?
   Used to help separate mixtures, can give information to help identify substances.
7. What happens in the stationary and mobile phases?
   Stationary phase is the paper; mobile phase is the solvent. Mixture is dissolved in the solvent and moves up the stationary phase.
8. State the equation used to find the Rf value.
   $$Rf = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$
9. A solvent travels 8cm up the stationary phase, two spots separate out. A travels 6cm up the mobile phase, B travels 4.5cm up the mobile phase. Give the Rf value for both to two decimal places.
   A = 0.75, B= 0.56

LearnIT!
KnowIT!

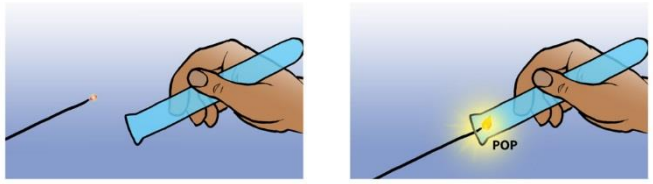
Identification of common gases

- Test for hydrogen
- Test for oxygen
- Test for carbon dioxide
- Test for chlorine

Identification of common gases

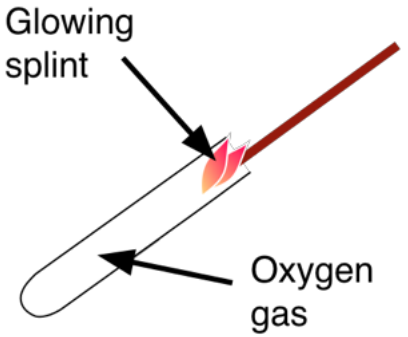
Test For Hydrogen

The test for hydrogen uses a **burning splint** held at the open end of a test tube of the gas. Hydrogen burns rapidly with a **pop sound**.



Test For Oxygen

The test for oxygen uses a **glowing splint** inserted into a test tube of the gas. The splint **relights** in oxygen.



You must learn all of these tests, including how the gas is tested and the positive result that proves that the chemical is the gas you are testing for.

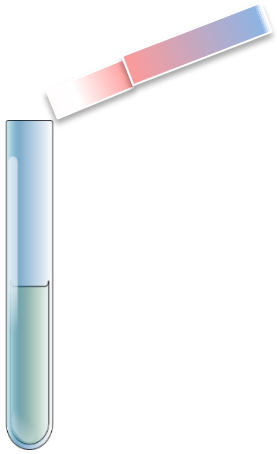
Identification of common gases

Test For Carbon Dioxide

The test for carbon dioxide uses an aqueous solution of calcium hydroxide (**lime water**). When carbon dioxide is shaken or bubbled through limewater the limewater turns **milky** (**cloudy**).

Test For Chlorine

The test for chlorine uses **litmus paper**. When **damp** litmus paper is put into chlorine gas the litmus paper is bleached and turns **white**.



You must learn all of these tests, including how the gas is tested and the positive result that proves that the chemical is the gas you are testing for.

QuestionIT!

Identification of common gases

- Test for hydrogen
- Test for oxygen
- Test for carbon dioxide
- Test for chlorine

Identification of common gases – **QuestionIT**

1. How would you test for oxygen gas?

2. An unknown gas gives out a squeaky pop when a burning splint is put into it. What is the gas?

3. Describe how you would test for carbon dioxide gas.

4. A student wrote down the following description for testing chlorine: “Use litmus paper it turns from red to blue.” Where has he gone wrong?

AnswerIT!

Identification of common gases

- Test for hydrogen
- Test for oxygen
- Test for carbon dioxide
- Test for chlorine

1. How would you test for oxygen gas?
   Glowing splint; splint relights.
2. An unknown gas gives out a squeaky pop when a burning splint is put into it. What is the gas?
   Hydrogen.
3. Describe how you would test for carbon dioxide gas.
   Limewater; turns cloudy/milky.
4. A student wrote down the following description for testing chlorine: “Use litmus paper it turns from red to blue.” Where has he gone wrong?
   Moist litmus paper; litmus paper is bleached, turns white.

LearnIT!
KnowIT!

Identification of ions by chemical means (Chemistry only) Part 1

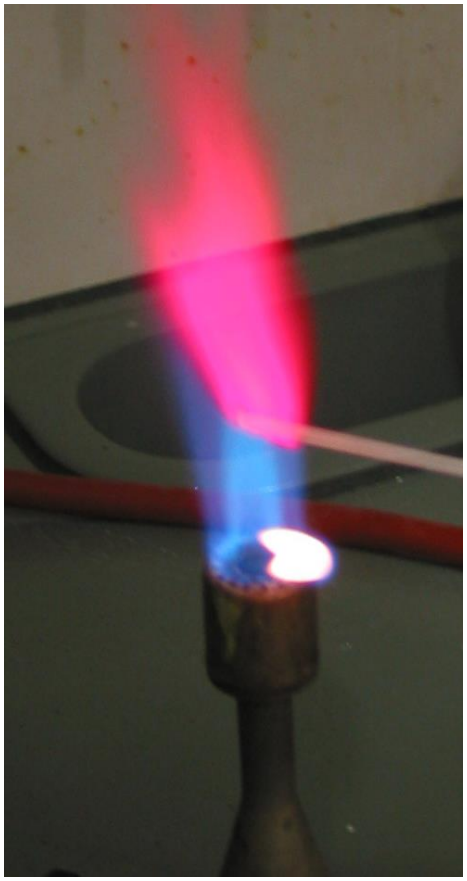
- **Flame tests**
- **Metal hydroxides**

Flame Tests

Flame tests can be used to identify some metal ions (cations).

- **Lithium** compounds results in a **crimson** flame.
- **Sodium** compounds result in a **yellow** flame.
- **Potassium** compounds result in a **lilac** flame.
- **Calcium** compounds result in **orange-red** flame.
- **Copper** compounds result in a **green** flame.

All of these colours are distinctive and can be used to identify these metal ions.



If a sample containing a mixture of ions is tested then some of flame colours can be masked and so will not be seen.

Identification of ions by chemical means Part 1(Chemistry only)

Metal Hydroxides

Sodium hydroxide solution can be used to identify some **metal ions** (**cations**).

Sodium hydroxide is added to a solution of the metal ion to be tested, a **solid precipitate** (often coloured) is formed and can be used to identify the metal ion.

Aluminium, **calcium** and **magnesium** ions form **white precipitates** when **sodium hydroxide solution** is added, but **only** the **aluminium hydroxide** precipitate **dissolves** in ***excess*** sodium hydroxide solution.

Coloured precipitates

Copper (II) ions form a **blue precipitate**.
Iron (II) ions form a **green precipitate**.
Iron (III) ions form a **brown precipitate** when sodium hydroxide solution is added.

Identification of ions by chemical means Part 1 (Chemistry only)

You will be expected to write word and balanced symbol equations for all the precipitation reactions.

Aluminium chloride + sodium hydroxide → aluminium hydroxide + sodium chloride

$AlCl_3$ (aq) + 3NaOH (aq) → $Al(OH)_3$ (s) + 3NaCl (aq)

Calcium chloride + sodium hydroxide → calcium hydroxide + sodium chloride

$CaCl_2$ (aq) + 2NaOH (aq) → $Ca(OH)_2$ (s) + 2NaCl (aq)

Magnesium chloride + sodium hydroxide → magnesium hydroxide + sodium chloride

$MgCl_2$ (aq) + 2NaOH (aq) → $Mg(OH)_2$ (s) + 2NaCl (aq)

Copper(II) chloride + sodium hydroxide → copper (II) hydroxide + sodium chloride

$CuCl_2$ (aq) + 2NaOH (aq) → $Cu(OH)_2$ (aq) + 2NaCl (aq)

Iron (II) chloride + sodium hydroxide → iron (II) hydroxide + sodium chloride

$FeCl_2$ (aq) + 2NaOH (aq) → $Fe(OH)_2$ (s) + 2NaCl (aq)

Iron (III) chloride + sodium hydroxide → iron (III) hydroxide + sodium chloride

$FeCl_3$ (aq) + 3NaOH (aq) → $Fe(OH)_3$ (s) + 3NaCl (aq)

QuestionIT!

Identification of ions by chemical means (Chemistry only) Part 1

- **Flame tests**
- **Metal hydroxides**

1. What is a flame test?

2. What colour flame would the following metal ions have in a flame test?
   a) Lithium
   b) Sodium
   c) Potassium
   d) Calcium
   e) Copper

3. What might cause some flame colours to be masked?

4. What is a precipitate?

5. Sodium hydroxide is used to identify some metal ions. What colour precipitate do aluminium, calcium and magnesium ions form?

6. How is are aluminium ions distinguished from calcium and magnesium ions in the reaction with sodium hydroxide?

7. What colour precipitate do the following ions make with sodium hydroxide?
   a) Copper (II)
   b) Iron (II)
   c) Iron (III)

8. Write the word equation for the reaction between calcium chloride and sodium hydroxide.

9. Write the balanced symbol equation for the reaction between aluminium chloride and sodium hydroxide.

10. What colour would be the precipitates be in the above reactions?

11. How could you distinguish between them?

AnswerIT!

Identification of ions by chemical means (Chemistry only) Part 1

- **Flame tests**
- **Metal hydroxides**

1. What is a flame test?
   Rod dipped in water and then in the compound; placed in flame; observe colour of flame.
2. What colour flame would the following metal ions have in a flame test?
   a) Lithium crimson red
   b) Sodium yellow
   c) Potassium lilac
   d) Calcium orange-red
   e) Copper green

3. What might cause some flame colours to be masked?
   A sample containing a mixture of ions.

4. What is a precipitate?
   A insoluble solid product produced in a liquid.
5. Sodium hydroxide is used to identify some metal ions. What colour precipitate do aluminium, calcium and magnesium ions form?
   White.
6. How is are aluminium ions distinguished from calcium and magnesium ions in the reaction with sodium hydroxide?
   Aluminium hydroxide precipitate dissolves in excess sodium hydroxide solution.
7. What colour precipitate do the following ions make with sodium hydroxide?
   a) Copper (II) blue
   b) Iron (II) green
   c) Iron (III) brown

8. Write the word equation for the reaction between calcium chloride and sodium hydroxide.
   Calcium chloride + sodium hydroxide → calcium hydroxide + sodium chloride
9. Write the balanced symbol equation for the reaction between aluminium chloride and sodium hydroxide.
   $AlCl_3$ (aq)+ 3NaOH (aq) → $Al(OH)_3$ (s) + 3NaCl (aq)
10. What colour would be the precipitates be in the above reactions?
    White.
11. How could you distinguish between them?
    Aluminium hydroxide would dissolve in excess sodium hydroxide.

LearnIT!
KnowIT!

Identification of ions by chemical means Part 2 (Chemistry only)

- **Carbonates**
- **Halides**
- **Sulfates**

Identification of ions by chemical means Part 2 (Chemistry only)

Identifying Carbonates

Carbonates react with **dilute acids** to form **carbon dioxide gas**. Carbon dioxide can be identified with limewater.

Identifying Halide Ions

Halide ions in solution produce **precipitates** with silver nitrate solution in the presence of dilute nitric acid.

Silver **chloride** is **white.**

Silver **bromide** is **cream.**

Silver **iodide** is **yellow.**

Identifying Sulfate Ions

Sulfate ions in solution produce a **white precipitate** with **barium chloride** in the presence of **dilute hydrochloric acid**.

Again you need to remember these colours and be able to write out the word and symbol equations shown on the next slide in the exam. Do not forget the state symbols.

Identification of ions by chemical means Part 2 (Chemistry only)

Halide Ions

Sodium chloride + silver nitrate → sliver chloride + sodium chloride

$NaCl\ (aq) + AgNO_3\ (aq) \rightarrow AgCl\ (s) + NaCl\ (aq)$

Sodium bromide + silver nitrate → silver bromide + sodium chloride

$NaBr\ (aq) + AgNO_3\ (aq) \rightarrow AgBr\ (s) + NaCl\ (aq)$

Sodium iodide + silver nitrate → silver iodide + sodium chloride

$NaI\ (aq) + AgNO_3\ (aq) \rightarrow AgI\ (s) + NaCl\ (aq)$

Sulfate Ions

Barium chloride + sodium sulfate → barium sulfate + sodium chloride

$BaCl_2\ (aq) + Na_2SO_4\ (aq) \rightarrow BaSO_4\ (s) + 2NaCl\ (aq)$

QuestionIT!

Identification of ions by chemical means Part 2 (Chemistry only)

- **Carbonates**
- **Halides**
- **Sulfates**

1. How would you test for a carbonate?

2. How would you test the gas produced by the above reaction?

3. How would you test for halide ions?

4. How could you use the above test to distinguish between halide ions?

5. Silver nitrate is added to an unknown chemical in solution. A cream precipitate is produced. What is the halide ion present?

6. Write the balanced symbol equation for the reaction above.

7. How would you test for sulfate ions?

8. Write the word and balanced symbol equation for the reaction between sodium sulfate and barium chloride.

AnswerIT!

Identification of ions by chemical means Part 2 (Chemistry only)

- **Carbonates**
- **Halides**
- **Sulfates**

1. How would you test for a carbonate?
   React with dilute hydrochloric acid to form carbon dioxide gas.
2. How would you test the gas produced by the above reaction?
   Limewater goes cloudy/ milky.
3. How would you test for halide ions?
   Produce precipitate with silver nitrate in the presence of nitric acid.
4. How could you use the above test to distinguish between halide ions?
   Silver **chloride** = white; silver **bromide** = cream;
   silver **iodide** = yellow.

5. Silver nitrate is added to an unknown chemical in solution. A cream precipitate is produced. What is the halide ion present?
   Bromide.
6. How would you test for sulfate ions?
   Add barium chloride solution in the presence of hydrochloric acid; white precipitate formed.
7. Write the word and balanced symbol equation for the reaction between sodium sulfate and barium chloride.

Barium chloride + sodium sulfate → barium sulfate + sodium chloride

$BaCl_2$ (aq) + Na_2SO_4 (aq) → $BaSO_4$ (s) + 2NaCl (aq)

LearnIT!
KnowIT!

Identification of ions by instrumental methods (Chemistry only)

- **Instrumental methods**
- **Flame emission spectroscopy**

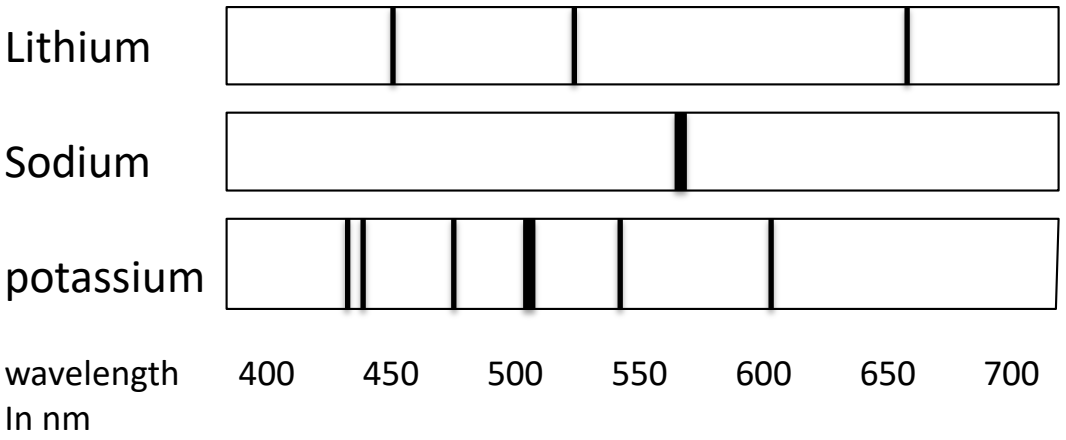
Identification of ions by instrumental methods (Chemistry only)

Elements and compounds can be detected and identified using **instrumental methods**. Instrumental methods are:

- **Accurate**
- **Sensitive**
- **Rapid**

These are the **advantages** of using instrumental methods compared with the earlier chemical tests, you need to know these for the exam.

- **Flame emission spectroscopy** is used to analyse metal ions in solution.
- The sample is **put into a flame** and the **light given out is passed through a spectroscope**.
- The output is a **line spectrum** that can be analysed to **identify the metal ions** in the solution and **measure their concentrations.**



Each metal has their own patterns of bands which allows them to be identified as being present in the solution.

QuestionIT!

Identification of ions by instrumental methods (Chemistry only)

- **Instrumental methods**
- **Flame emission spectroscopy**

1. Give three advantages of instrumental methods for detecting ions compared with chemical methods.

2. What is flame emission spectroscopy used for?

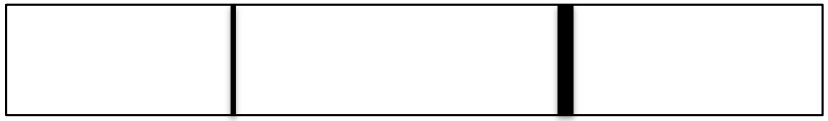
3. How is flame emission spectroscopy carried out?

4. Five different samples were analysed using flame emission spectroscopy, the results are shown below. Which two of the results show the same metal?

A

B

C



D

E

AnswerIT!

Identification of ions by instrumental methods (Chemistry only)

- **Instrumental methods**
- **Flame emission spectroscopy**

1. Give three advantages of instrumental methods for detecting ions compared with chemical methods.

accurate/sensitive/rapid

2. What is flame emission spectroscopy used for?

To analyse metal ions in solution.

3. How is flame emission spectroscopy carried out?.

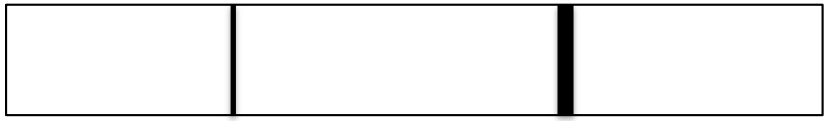
Sample is put into a flame, light given out is passed through a spectroscope, line spectrum produced is analysed to identify metal ions

4. Five different samples were analysed using flame emission spectroscopy, the results are shown below. Which two of the results show the same metal?

A

B

C



D

E

A and D