Cambridge (CIE) IGCSE Chemistry

Your notes

Water & Water Pollution

Contents

Your notes

Chemical tests for water

Chemical tests for water

- The presence of water is commonly tested for using anhydrous cobalt(II) chloride or anhydrous copper(II) sulfate

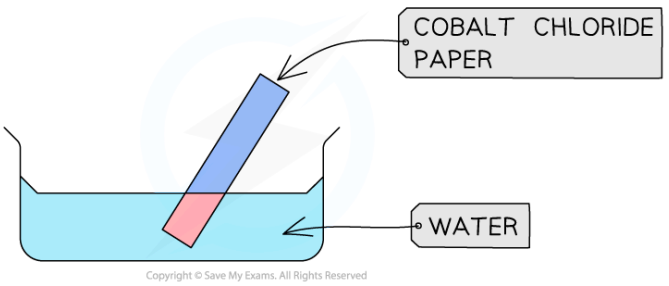
Cobalt(II) chloride

- **Anhydrous** cobalt(II) chloride, $CoCl_2$, is blue
- Hydrated cobalt(II) chloride, $CoCl_2 \bullet 6H_2O$ is pink
- So, anhydrous cobalt(II) chloride can be used to test for water
  - This test is usually done with cobalt chloride paper

anhydrous cobalt(II) chloride + water ⇌ hydrated cobalt(II) chloride

$$\mathbf{CoCl_2\,(s) + 6H_2O\,(l) \rightleftharpoons CoCl_2 \bullet 6H_2O\,(s)}$$

- The presence of water causes a colour change from **blue** to **pink**



Cobalt chloride paper changes from blue to pink in the presence of water

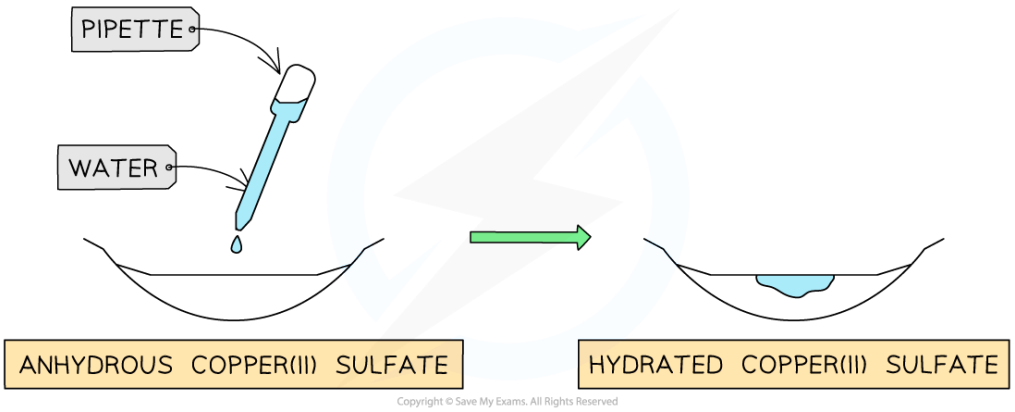
Copper(II) sulfate

- **Anhydrous** copper(II) sulfate, $CuSO_4$ is white
- Hydrated copper(II) sulfate, $CuSO_4 \bullet 5H_2O$, is blue
- So, anhydrous copper(II) sulfate can be used to test for water

anhydrous copper(II) sulfate + water ⇌ hydrated copper(II) sulfate

$$\mathbf{CuSO_4\,(s) + 5H_2O\,(l) \rightleftharpoons CuSO_4 \bullet 5H_2O\,(s)}$$

- The presence of water causes a colour change from **white** to **blue**



Anhydrous copper(II) sulfate changes from white to blue in the presence of water

Your notes

Examiner Tips and Tricks

Core students do **not** need to know the symbol equations.

Purity of water

Testing for purity

- Pure substances boil and melt at specific and sharp temperatures
  - Water has a boiling point of 100 °C and a melting point of 0 °C
- Mixtures have a range of boiling and melting points as they consist of different substances that melt or boil at different temperatures
- Therefore, boiling and melting point data can be used to determine the purity of water
- Impurities tend to **increase the boiling point** of water
  - So, impure water will boil at temperatures above 100 °C
- Impurities tend to **decrease the melting point** of water
  - So, impure water will melt at temperatures **below 0 °C**

What is distilled water?

- Distilled water is water that has been heated to form a vapour, and then condensed back to a liquid
  - This means that it contains very few impurities
- Distilled water is used in practical chemistry because of its high purity
  - Tap water is not typicaly used because it contains more impurities which could interfere with chemical reactions

Your notes

Substances in water from natural sources

- We use water in many aspects of our everyday life:
  - Domestic uses: for drinking, cooking, gardening and general sanitation
  - Agricultural uses: as a drink for animals and watering crops
  - Industrial uses: as a solvent, as a coolant and heated to make steam used to generate electricity
- Water is found in natural sources such as lakes, rivers and underground water sources (groundwater)
- A rock that stores water is known as an **aquifer**
- Water from natural sources may contain a variety of different substances including:
  - Dissolved oxygen
  - Metal ions (E.g. Ca^{2+}, K^{+}, Na^{+}, Mg^{2+})
  - Plastics
  - Sewage
  - Harmful microbes
  - Nitrates from fertilisers
  - Phosphates from fertilisers and detergents
- Many of these substances enter water sources when rain falls and washes them into lakes, rivers or groundwater
- Some of these substances are naturally occurring but many are a direct result of human activities

Photo by Ben Clayton on Unsplash

Your notes

Examiner Tips and Tricks

Despite the term 'natural source', water from these sources may contain lots of impurities and harmful substances and should not be confused with water which is clean and ready for use.

Beneficial & harmful substances in water

- Some of the substances which may be found in natural water sources are beneficial and others may have harmful effects
- **Beneficial substances** include:
  - Dissolved oxygen
    - Essential for aquatic life
  - Metal compounds
    - Some provide essential minerals which are necessary for life, such as calcium and magnesium
- Potentially **harmful substances** include:

- Metal compounds
  - Some are toxic like aluminium and lead
- Some plastics
  - These may be harmful to aquatic life in many ways, e.g. getting trapped in plastic waste, dying of starvation as their stomach is filled with plastic
- Sewage
  - Contains harmful microbes which can cause disease
- Nitrate & phosphates from fertilisers
  - These can promote the growth of aquatic plant life which leads to deoxygenation of water.
  - Ultimately, this can cause damage to aquatic life in a process called eutrophication (you do not need to know the details of this process)

Examiner Tips and Tricks

Metal compounds can be both beneficial and harmful, it depends on the metal within the compound, e.g. calcium, magnesium, potassium and sodium are all metals which are essential for life.

Harmful metals include lead, arsenic and mercury.

Your notes

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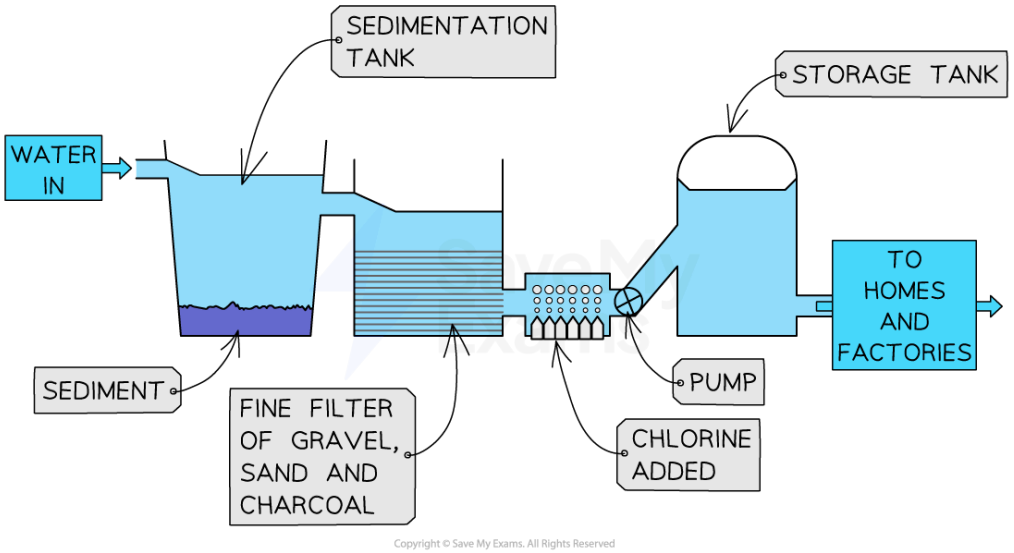
Water treatment

- Untreated water contains **soluble** and **insoluble** impurities
  - Insoluble impurities include soil, pieces of plants and other organic matter
  - Soluble impurities include dissolved calcium, metallic compounds and inorganic pollutants
- The first step of water treatment is **sedimentation / filtration**
  - Water is pumped into sedimentation tanks and allowed to stand for a few hours
  - Mud, sand and other particles will fall to the bottom of the tank due to gravity and form a layer of sediment
  - The water is then **filtered** through sand and gravel to remove smaller particles
- The second step is **filtration / treatment with carbon** (charcoal)
  - This removes unpleasant tastes and odours
- The final step is **chlorination**
  - Bacteria and other microorganisms are too small to be trapped by the filters
  - So, chlorine is carefully added to the water supply to kill bacteria and other microorganisms
  - Cholera and typhoid are examples of bacterial diseases which can arise from the consumption of untreated water

Diagram showing the stages in the treatment of water



The stages of treating water are sedimentation, filtration with carbon and chlorination

Your notes

Examiner Tips and Tricks

Exam questions on water treatment often focus on the purpose of each stage of the process.

Your notes

Fertilisers

NPK fertilisers

- NPK fertilisers contain **nitrogen, potassium** and **phosphorus** for improved plant growth
  - Nitrogen makes chlorophyll and protein and promotes healthy **leaves**
  - Potassium promotes **growth** and healthy **fruit** and **flowers**
  - Phosphorus promotes healthy **roots**
- Fertiliser compounds contain the following water-soluble ions:
  - Ammonium ions, NH_4^+ and nitrate ions, NO_3^-, are sources of soluble nitrogen
  - Phosphate ions, PO_4^{3-} are a source of soluble phosphorus
  - Most common potassium compounds dissolve in water to produce potassium ions, K^+
- Ammonium salts and nitrate salts are commonly used as fertilisers, including:
  - Ammonium nitrate, NH_4NO_3
  - Ammonium phosphate, $(NH_4)_3PO_4$
  - Potassium nitrate, KNO_3
- Different fertilisers contain different amounts of fertiliser compounds
  - So, each fertiliser contains different proportions of nitrogen, potassium and phosphorous

Examiner Tips and Tricks

You may be asked to select a compound or combination of compounds from a list which would be the most effective as a fertiliser.

Look for the compound or combination of compounds that contain the most elements from nitrogen, phosphorous and potassium.