Cambridge IGCSE · Chemistry 0620 · Notes

Water and fertilisers

Read online at **pastopic.com/cambridge/chemistry-0620/notes/water-and-fertilisers**

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Read first: **Formulae and equations**, **Reversible reactions and equilibrium**

What you need to know

By the end of this topic you should be able to:

1. **Describe the chemical tests for water.** Water turns anhydrous copper(II) sulfate from white to blue, and anhydrous cobalt(II) chloride from blue to pink.
2. **Describe how to test whether water is pure** by measuring its melting point or its boiling point. Pure water melts at exactly 0 °C and boils at exactly 100 °C.
3. **Explain why practical chemistry uses distilled water rather than tap water**: distilled water contains fewer chemical impurities.
4. **State what water from natural sources (rivers, lakes, the sea, the ground) can contain**: dissolved oxygen, metal compounds, plastics, sewage, harmful microbes, nitrates from fertilisers, and phosphates from fertilisers and detergents.
5. **State which of these substances are good for living things**: dissolved oxygen, which aquatic life needs, and some metal compounds, which provide minerals that life needs.
6. **State which of them can be harmful, and why**: some metal compounds are toxic; some plastics harm aquatic life; sewage contains harmful microbes that cause disease; nitrates and phosphates lead to deoxygenation of the water, which damages aquatic life. You do not need the details of how deoxygenation happens.
7. **Describe how the domestic water supply is treated**: sedimentation and filtration remove solids, carbon removes tastes and odours, and chlorination kills microbes.
8. **State that ammonium salts and nitrates are used as fertilisers.**
9. **Describe how NPK fertilisers supply the elements nitrogen, phosphorus and potassium** for better plant growth.

Everything in this topic is Core: there is no Extended-only content. Paper 4 still asks it, usually as one-mark "choose from this list" parts.

Understand it

Testing for water

Many colourless liquids look like water, so you need a **chemical test**. Two salts change colour when water is added to them without its water:

- **anhydrous copper(II) sulfate** turns from **white to blue**;
- **anhydrous cobalt(II) chloride** turns from **blue to pink** (it is often used soaked into paper, "cobalt chloride paper").

Anhydrous means "without water". A **hydrated** salt has water molecules held in its crystals (the water of crystallisation). Hydrated copper(II) sulfate is blue and hydrated cobalt(II) chloride is pink. Heating a hydrated salt drives the water off and leaves the anhydrous salt; adding water turns it back again. The change goes both ways, which is why these are reversible reactions:

$$\underset{\text{white}}{\mathrm{CuSO_4}} + 5\mathrm{H_2O} \rightleftharpoons \underset{\text{blue}}{\mathrm{CuSO_4 \cdot 5H_2O}} \qquad \underset{\text{blue}}{\mathrm{CoCl_2}} + 6\mathrm{H_2O} \rightleftharpoons \underset{\text{pink}}{\mathrm{CoCl_2 \cdot 6H_2O}}$$

To remember which way the colours go: the salt **with** water is the coloured one you often see in a bottle (blue copper sulfate crystals, pink cobalt chloride).

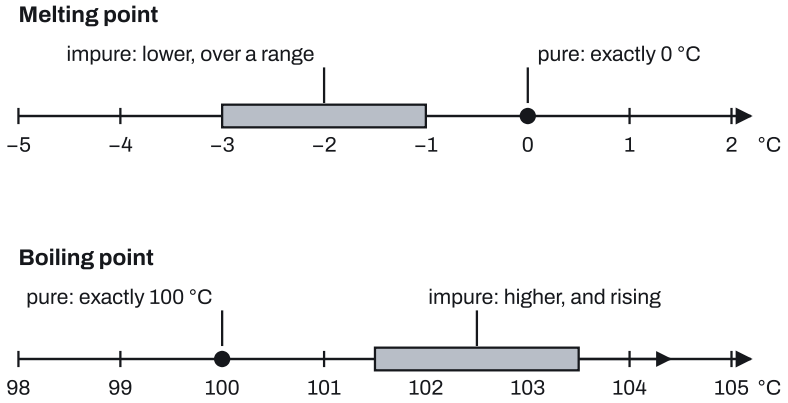
These tests show that water is **present**. They do not show that it is **pure**: sea water, tap water and orange juice all turn anhydrous copper(II) sulfate blue.

Is the water pure?

A pure substance melts and boils at one exact temperature. Dissolved impurities change this:

- they **lower the melting point** and make the solid melt over a **range** of temperatures;
- they **raise the boiling point**.

So to test whether water is pure, measure its melting point or its boiling point with a thermometer and compare it with the value for pure water. **Pure water melts at exactly 0 °C and boils at exactly 100 °C.** A sample that melts below 0 °C, or over a range, or boils above 100 °C, is impure.



A pH of 7, no solid left on evaporating, or a colour change with cobalt(II) chloride do **not** prove water is pure. Only the melting point or boiling point does.

Distilled water and tap water

Tap water is safe to drink, but it still has substances dissolved in it: salts from the rocks it flowed over and chlorine compounds from treatment. In an experiment these could react or leave a residue and spoil the results. **Distillation** (boiling the water and condensing the steam) leaves the dissolved substances behind, so **distilled water contains fewer chemical impurities** than tap water. That is why it is used in practical chemistry.

What natural water contains

Water from rivers, lakes and the ground is never just water. What is in it can help or harm living things:

Substance	Helpful or harmful?	Why
Dissolved oxygen	Helpful	Fish and other aquatic life need it to breathe
Some metal compounds (for example calcium compounds)	Helpful	Provide minerals that life needs
Other metal compounds (for example lead or mercury compounds)	Harmful	Toxic
Plastics	Harmful	Harm aquatic life (animals eat them or get tangled)
Sewage	Harmful	Contains harmful microbes that cause disease
Harmful microbes	Harmful	Cause disease

Substance	Helpful or harmful?	Why
Nitrates (from fertilisers)	Harmful	Lead to deoxygenation of the water, which damages aquatic life
Phosphates (from fertilisers and detergents)	Harmful	Lead to deoxygenation of the water, which damages aquatic life

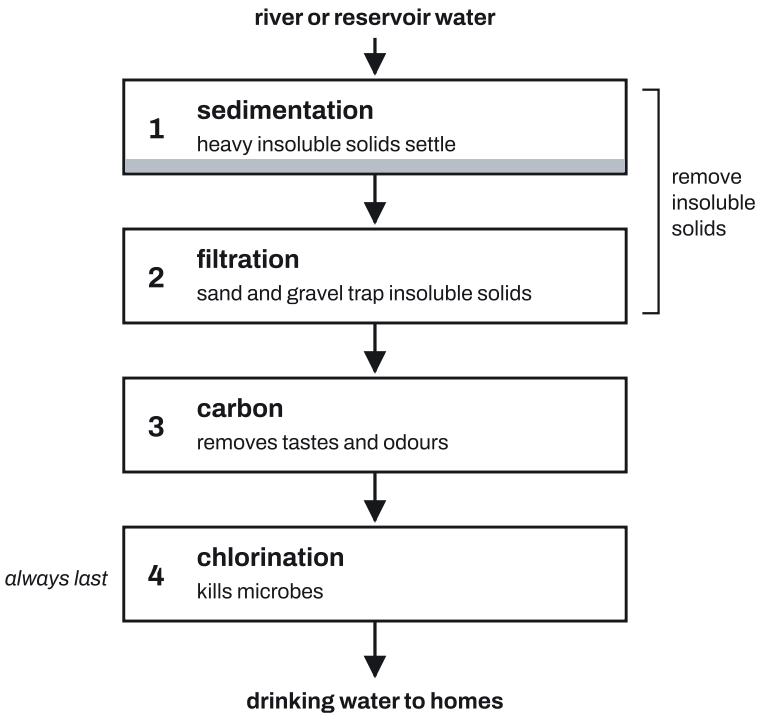
Deoxygenation means the water loses its dissolved oxygen, so fish and other animals die. Nitrates and phosphates washed off fields make water plants and algae grow very fast; when they die and rot, the oxygen gets used up. You don't need these details for the exam. To earn the mark, say that nitrates and phosphates cause deoxygenation of the water, which harms the animals and plants living in it.

Notice that "metal compounds" appear on both sides. Some are needed minerals, some are toxic, so "all dissolved metal compounds are good for life" is false.

Treating the domestic water supply

Water piped to homes (the **domestic water supply**) comes from rivers and reservoirs. It is treated in stages, always in this order:

1. **Sedimentation.** The water stands in a large tank. Heavy insoluble particles (mud, grit) sink to the bottom.
2. **Filtration.** The water passes through beds of sand and gravel. These trap the smaller insoluble particles that did not settle, while the water runs through.
3. **Carbon.** Carbon (a very porous form of it) removes substances that give the water **unpleasant tastes and odours** (smells).
4. **Chlorination.** A small amount of chlorine is added to **kill microbes** (bacteria and other germs) so the water does not cause disease. It comes last so that the water stays protected on its way through the pipes.



Two points are often tested:

- Sedimentation and filtration remove only **insoluble** solids. **Dissolved** substances go straight through, so treated water still contains dissolved salts (and some chlorine compounds). It is safe, not pure.
- Carbon does not kill microbes, and chlorine is not added to change the pH or the taste. Each stage has one job.

Which water must be chlorinated? In exam questions, the answers are water that is **drunk or used for cooking or food**, and **swimming pools**: people swallow it, so any microbes in it could make them ill. Water for washing (a car or clothes), for chemical reactions or for watering plants and crops is not the answer expected.

Fertilisers

Plants take elements from the soil as they grow. When a crop is harvested, those elements leave the field with it, so the next crop has less to use. Farmers add **fertilisers** to put the elements back and so **increase the growth (and yield) of their crops**.

The three main elements plants need are **nitrogen (N), phosphorus (P) and potassium (K)**. A fertiliser that supplies all three is an **NPK fertiliser**. The letters are the chemical symbols, so "NPK" does not mean sodium or sulfur, whatever the other salts in a bag contain.

Fertilisers are salts. **Ammonium salts and nitrates** are the main nitrogen fertilisers. You can tell which of the three elements a salt supplies from its name or formula:

Part of the name	Formula	Supplies
ammonium ...	NH_4^+	nitrogen, N
... nitrate	NO_3^-	nitrogen, N

Part of the name	Formula	Supplies
urea	$\mathrm{CO(NH_2)_2}$	nitrogen, N
... phosphate (and hydrogenphosphate)	$\mathrm{PO_4^{3-}}$ ($\mathrm{HPO_4^{2-}}$)	phosphorus, P
potassium ...	$\mathrm{K^+}$	potassium, K
calcium, sodium, magnesium ...; chloride, sulfate, carbonate, hydroxide		none of the three

So potassium nitrate, $\mathrm{KNO_3}$, supplies K and N but no P. To make an NPK fertiliser it must be mixed with something containing phosphorus, such as ammonium phosphate, $\mathrm{(NH_4)_3PO_4}$. One salt can supply two of the elements, but none of the salts you will meet supplies all three; that is why NPK fertilisers are **mixtures** of salts.

Nitrates and phosphates from fertilisers are also the main source of these ions in rivers: rain washes the fertiliser off the fields. This is the link to deoxygenation above.

Key facts and formulas

"Given" means the exam paper prints it. "Learn it" means you must remember it. Chemistry 0620 has no formula sheet, so everything here must be learned.

Formula	Status
Anhydrous copper(II) sulfate: white → blue with water	Learn it
Anhydrous cobalt(II) chloride: blue → pink with water	Learn it
Heating the hydrated salt reverses it: blue $\mathrm{CuSO_4 \cdot 5H_2O}$ → white $\mathrm{CuSO_4}$; pink → blue for cobalt(II) chloride	Learn it
Pure water melts at exactly 0 °C and boils at exactly 100 °C; impure water melts below 0 °C (over a range) and boils above 100 °C	Learn it
Distilled water has fewer chemical impurities than tap water	Learn it
Treatment order: sedimentation → filtration (remove solids) → carbon (tastes and odours) → chlorination (kills microbes)	Learn it
Must be chlorinated: water that is drunk or used for cooking or food, and swimming pools (not washing a car or clothes, chemical reactions or watering plants)	Learn it
Sewage → harmful microbes → disease; nitrates and phosphates → deoxygenation → damage to aquatic life	Learn it
Dissolved oxygen is essential for aquatic life; some metal compounds provide essential minerals	Learn it

Formula	Status
Nitrates come from fertilisers; phosphates from fertilisers and detergents	Learn it
NPK = nitrogen, phosphorus, potassium; ammonium salts and nitrates are fertilisers	Learn it
Mass in a new volume $= \text{mass in table} \times \frac{\text{new volume}}{\text{table volume}}$	Learn it

How to do it

In the questions we have tagged for this topic (124 questions, 2021–2025, from all four papers), the types came up this often. 29 of the 124 questions mix types, so the counts add up to 194.

Question type	Questions
Choose the compound or mixture to use as a fertiliser (usually NPK)	26
State what a water-treatment stage or substance does	23
Test for water with anhydrous copper(II) sulfate or cobalt(II) chloride	22
Link a water pollutant to its harmful effect	17
Name the elements in NPK fertilisers, or the one a compound supplies	16
Scale a mass in a water sample to a different volume	15
Pick out and name ions from a table of ions in water	14
Order, name or identify the stages of water treatment	14
Sort substances in natural water into helpful and harmful	13
Test whether water is pure using melting or boiling point	10
Decide which uses of water must be chlorinated	7
Explain why farmers use fertilisers	5
Explain why distilled water is used in practical chemistry	5
State a source of nitrates or phosphates in water	4
Hydrated and anhydrous salts in the water test	3

1. Choose the compound or mixture to use as a fertiliser (26 questions)

Almost all multiple choice.

1. For each compound, write which of N, P and K it supplies, using the table in "Understand it": ammonium, nitrate or urea → N; phosphate → P; potassium → K. Ignore the rest of the name.

2. For a pair, combine the two lists. The right answer has **all three** letters.
3. Check the other options fail: each should be missing at least one of N, P, K.

For example, calcium nitrate + potassium chloride gives N and K only: no phosphorus, so it is not NPK.

Variations you will meet:

- **One compound is given; choose the second.** List what the first supplies and pick the one that adds the missing elements. With ammonium sulfate (N only), you need a compound with both P and K, such as potassium phosphate.
- **The soil needs only some of the elements** ("needs phosphorus and potassium"): choose the compounds that between them give exactly those, for example ammonium phosphate (P) and potassium nitrate (K).
- **Which single compound contains two NPK elements?** Potassium nitrate (K and N) or ammonium phosphate (N and P).
- **Which substance is used as a fertiliser?** An ammonium salt or a nitrate, such as ammonium nitrate. Elements on their own (potassium metal), acids and oxides are not fertilisers.
- **Theory, from a table of ions:** "give the formulae of two ions that could be combined with potassium ions to make an NPK fertiliser" needs $\mathrm{PO_4^{3-}}$ **and** a nitrogen ion, $\mathrm{NH_4^+}$ or $\mathrm{NO_3^-}$. Copy the formulae with their charges.

2. State what a water-treatment stage or substance does (23 questions)

Learn one job per stage, in these words:

Stage or substance	Its job
Sedimentation	Insoluble solids settle out (remove solids)
Filtration (sand and gravel)	Removes insoluble solids
Carbon	Removes tastes and odours
Chlorine / chlorination	Kills microbes (bacteria)

Variations you will meet:

- **"State why …"** or **"Name a substance that …"**: one short answer from the table. "Cleans the water" or "purifies it" is too vague to score.
- **Match each stage to its reason** with lines. All three right usually earns 2 marks, one right earns 1.
- **True or false statements** (multiple choice). The traps: "sedimentation (or filtration) removes **dissolved** substances", "carbon kills bacteria", "chlorine lowers the pH" or "chlorine removes tastes". All false.
- **What is still in the water leaving the works?** Dissolved (soluble) substances, including chlorine compounds; not bacteria and not insoluble solids.
- **Explain how a sand filter works:** the gaps between the sand grains are too small for the insoluble particles, which are trapped, while the water passes through.

- **Paper 4:** the symbol of the element used to kill microbes is **Cl**.

3. Test for water with anhydrous copper(II) sulfate or cobalt(II) chloride (22 questions)

1. **Name the reagent**, with the word **anhydrous**: anhydrous copper(II) sulfate, or anhydrous cobalt(II) chloride.
2. **Give the colour change "from … to …"**: white to blue for copper(II) sulfate; blue to pink for cobalt(II) chloride.

In theory questions this is 1 mark for the reagent and 1 for the colour change; either reagent is accepted, but the colours must match the reagent you chose.

Variations you will meet:

- **Multiple choice colour grids:** the wrong options reverse a colour change or swap the two salts. Check both directions.
- **Which substances detect water?** The two anhydrous salts. Litmus and methyl orange are acid–base indicators, not tests for water.
- **Identify the product:** "a liquid that turns anhydrous copper(II) sulfate blue", or the substance cobalt chloride paper detects in the gases from a burning fuel: **water**.
- **Paper 4 lists:** name the compound used to test for water (anhydrous copper(II) sulfate or cobalt(II) chloride), or the metal whose sulfate is used (copper).

4. Link a water pollutant to its harmful effect (17 questions)

Learn the pairs exactly as the syllabus gives them:

- **sewage** → contains **harmful microbes** which cause **disease**;
- **nitrates** and **phosphates** → **deoxygenation** of the water → **damage to aquatic life**;
- **plastics** → harm aquatic life;
- **some metal compounds** → are **toxic**.

Variations you will meet:

- **"State why X is harmful"**: give the effect above. For nitrates, "toxic" or "poisonous" is too vague; write "cause deoxygenation of the water, which harms aquatic life".
- **"Suggest a source of the harmful microbes"**: sewage.
- **Which pollutants lead to deoxygenation?** Nitrates and phosphates (not microbes, not metal compounds).
- **Draw lines** from each pollutant to its effect.
- **Paper 4:** from a list, the compound that causes deoxygenation is a nitrate or phosphate (for example sodium phosphate).

Do not mix up **nitrates** (in water, from fertilisers: deoxygenation) with **oxides of nitrogen** (in air: acid rain, smog). That belongs to air quality.

5. Name the elements in NPK fertilisers, or the one a compound supplies (16 questions)

1. The three elements are **nitrogen, phosphorus and potassium**. Give **element names** (or the symbols N, P, K), not ions or compounds: "nitrate" or "phosphate" is wrong here.
2. If one is given in the question ("fertilisers contain nitrogen; name two other elements"), give the other two, not the one you were given.

Variations you will meet:

- **Why "NPK"?** It provides the three main elements needed for improved plant growth.
- **Which element does urea (or ammonium sulfate) provide?** Nitrogen.
- **A statement check on potassium nitrate:** it supplies potassium and nitrogen, so it can be used as a fertiliser, but it does **not** contain all three elements.
- **Linked to ion tests:** a fertiliser that gives ammonia when warmed with sodium hydroxide contains nitrogen (ammonium ions); a lilac flame test shows potassium. The tests themselves are in the identification of ions topic.
- **Paper 4:** from a list of elements, the one that is a main part of fertilisers (nitrogen from Period 2; phosphorus from Period 3; potassium).

6. Scale a mass in a water sample to a different volume (15 questions)

Paper 3, 1 mark. The table gives the mass of each ion in one volume of water; you need the mass in another volume.

1. Find the mass of the right ion in the table, and the table's volume.
2. Multiply by $\frac{\text{new volume}}{\text{table volume}}$.
3. Give the answer in the table's unit (mg or g).

For example, 6.4 mg of an ion in 800 cm³ gives, in 300 cm³: $6.4 \times \frac{300}{800} = 2.4$ mg.

- The new volume can be **bigger** than the table's (the mass goes up) or **smaller** (it goes down). Check your answer moves the right way.
- The same method works for the **total** mass of salts left when sea water evaporates.
- It is simple proportion only: no moles, no relative formula masses.

7. Pick out and name ions from a table of ions in water (14 questions)

Paper 3, 1 mark per part.

1. **Read the question for "positive" or "negative", "highest" or "lowest".** Examiners say the most common error is choosing a positive ion when the question asks for a negative one.

- **Positive ions** (cations): metal ions and **ammonium**, for example $\mathrm{Na^+}$, $\mathrm{Ca^{2+}}$, $\mathrm{NH_4^+}$.
- **Negative ions** (anions): names ending **-ide** or **-ate**, and hydrogencarbonate, for example $\mathrm{Cl^-}$, $\mathrm{NO_3^-}$, $\mathrm{HCO_3^-}$, $\mathrm{SO_4^{2-}}$.

2. Look down only that kind of ion and pick the largest (or smallest) mass. Write its **name** if asked to name it.
3. **Name** ↔ **formula**: learn these, with their charges.

Name	Formula	Name	Formula
ammonium	$\mathrm{NH_4^+}$	sulfate	$\mathrm{SO_4^{2-}}$
nitrate	$\mathrm{NO_3^-}$	carbonate	$\mathrm{CO_3^{2-}}$
phosphate	$\mathrm{PO_4^{3-}}$	hydrogencarbonate	$\mathrm{HCO_3^-}$
chloride	$\mathrm{Cl^-}$	hydroxide	$\mathrm{OH^-}$

- "Sulfate" is $\mathrm{SO_4^{2-}}$, not $\mathrm{SO_2}$ or sulfide ($\mathrm{S^{2-}}$).
- **Sea-water tables** list whole compounds: name them from the formula, for example $\mathrm{MgSO_4}$ is magnesium sulfate and $\mathrm{CaCO_3}$ is calcium carbonate.
- **Name the compound made of two ions**, for example $\mathrm{NH_4^+}$ and $\mathrm{SO_4^{2-}}$: ammonium sulfate.

8. Order, name or identify the stages of water treatment (14 questions)

1. Learn the order: **sedimentation** → **filtration** → **carbon** → **chlorination**. Chlorination is always last.
2. On a flow chart with gaps, fill each gap from the order: the stage before carbon is filtration (or sedimentation); the stage after carbon is chlorination.

Variations you will meet:

- **Choose the correct sequence** in multiple choice: sedimentation first, chlorination last.
- **Name the two unlabelled stages** after a sedimentation tank: filtration, then chlorination. **Distillation** is not a stage in treating drinking water; it is too expensive for a whole town's supply.
- **A pot or bed of sand and gravel with dirty water poured in** shows **filtration**.
- **A diagram of uses and processes:** muddy water is filtered to clear water (good enough for crops), then chlorinated to make disinfected drinking water.

9. Sort substances in natural water into helpful and harmful (13 questions)

- **Helpful:** dissolved oxygen (essential for aquatic life) and some metal compounds (such as calcium compounds, which provide essential minerals).
- **Harmful:** toxic metal compounds, plastics, sewage, harmful microbes, nitrates, phosphates.

Variations you will meet:

- **Circle the gas essential for aquatic life:** oxygen (not nitrogen, hydrogen or argon).

- **Name two other harmful substances** when some are given: choose from the harmful list, but not the ones already in the question.
- **Multiple choice number sets:** "metal compounds" and "dissolved oxygen" are the beneficial pair; nitrates, phosphates and plastics are harmful.
- **"All dissolved metal ions are beneficial"** is false: some are toxic.

10. Test whether water is pure using melting or boiling point (10 questions)

Usually 2 marks:

1. **Method:** heat the sample (or cool and then warm it) and **measure** its boiling point (or melting point) with a thermometer. **(1)**
2. **Result:** pure water boils at **exactly 100 °C** (melts at **exactly 0 °C**); if it boils above 100 °C (melts below 0 °C or over a range), it is impure. **(1)**

Variations you will meet:

- **Which statement shows a liquid is pure water?** "It boils at 100 °C" (at normal pressure). "Turns anhydrous copper(II) sulfate blue", "turns cobalt(II) chloride pink", "pH 7" and "leaves no solid on evaporation" only show water is there, not that nothing else is.
- **River water with dissolved nitrates**: it still turns anhydrous copper(II) sulfate from white to blue, but its melting point is below 0 °C and its boiling point above 100 °C.
- **Salt water** boils above 100 °C: dissolved salt raises the boiling point.

11. Decide which uses of water must be chlorinated (7 questions)

Multiple choice only. Ask: **will people swallow it?**

- Water that is drunk or used for cooking or food, and swimming pools → must be chlorinated.
- Washing (a car or clothes), chemical reactions and watering plants or crops → not the answers expected; leave them out.
- Given a list of home uses, choose the use where the water is drunk or goes into food (for example cooking).

Some questions put this in a flow chart: muddy river water → filtration → clear water (used for crops) → chlorination → disinfected water (used for drinking).

12. Explain why farmers use fertilisers (5 questions)

Paper 3, 1 mark: **to increase crop growth (yield)**, or **to replace the elements (nitrogen, phosphorus, potassium) taken from the soil by earlier crops**. "To help plants", "to add nutrients" or "to fertilise the soil" are too vague; changing soil pH or killing pests are wrong.

13. Explain why distilled water is used in practical chemistry (5 questions)

1 mark: distilled water contains **fewer chemical impurities** than tap water (or tap water contains more impurities). If asked to name the process that makes water suitable for practical chemistry: **distillation**. The multiple choice trap is the reverse statement, "tap water has fewer impurities than distilled water".

14. State a source of nitrates or phosphates in water (4 questions)

1 mark: **fertilisers** (washed off fields). Phosphates also come from **detergents**. Give the source, not the harm.

15. Hydrated and anhydrous salts in the water test (3 questions)

Paper 3, given the equation for the water test:

- **Hydrated** means the salt contains water (water of crystallisation) in its crystals; **anhydrous** means without water. "Contains water" alone is too vague: say it is part of the crystals.
- The coloured forms are hydrated: **blue** copper(II) sulfate, **pink** cobalt(II) chloride. The white copper(II) sulfate and blue cobalt(II) chloride are anhydrous.
- To turn the hydrated salt into the anhydrous one: **heat** it. To go back: **add water**.

Worked examples

Example 1

A gardener wants one mixture that provides all three of the main elements needed for improved plant growth. Which mixture should she use? **[1]**

	first compound	second compound
A	potassium hydrogenphosphate, $\mathrm{K_2HPO_4}$	urea, $\mathrm{CO(NH_2)_2}$
B	calcium nitrate, $\mathrm{Ca(NO_3)_2}$	potassium chloride, KCl
C	ammonium sulfate, $\mathrm{(NH_4)_2SO_4}$	sodium phosphate, $\mathrm{Na_3PO_4}$
D	magnesium sulfate, $\mathrm{MgSO_4}$	potassium nitrate, $\mathrm{KNO_3}$

List what each mixture supplies: A gives K and P, then N from urea: **N, P and K**. B gives N and K (no P). C gives N and P (no K). D gives K and N (no P).

Answer: **A (B1)**

Example 2

A lake is next to a farm. After heavy rain, many fish in the lake die. Tests show the lake water now has very little dissolved oxygen.

(a) Name **two** ions, washed from the farm's fields, that could have caused this. **[2]**

(b) Name the substance in the fields that these ions came from. **[1]**

(c) A pipe carrying waste from nearby houses also leaks into the lake. State why this makes the lake water dangerous for people to swim in. **[1]**

(d) Calcium ions are also present in the lake. State why some metal compounds, such as calcium compounds, in natural water are beneficial. **[1]**

(a) Nitrate ions **(B1)** and phosphate ions **(B1)**. They lead to deoxygenation of the water, which kills aquatic life.

(b) Fertilisers **(B1)**.

(c) The waste is sewage, which contains **harmful microbes that cause disease** **(B1)**.

(d) They provide **essential minerals** for living things **(B1)**.

Example 3

The flow chart shows how a small town treats water from a reservoir.

reservoir → sedimentation tank → stage **X** → carbon → stage **Y** → homes

(a) Name stages **X** and **Y**. **[2]**

(b) State why carbon is used. **[1]**

(c) A student boils a sample of the town's tap water and finds that it boils at 100.4 °C. State whether the tap water is pure, and give a reason. **[1]**

(d) Suggest why the student's school uses distilled water, not tap water, to make up solutions. **[1]**

(e) Describe a chemical test that shows the tap water contains water. Give the result. **[2]**

(a) X: filtration **(B1)**. Y: chlorination (adding chlorine) **(B1)**. Chlorination is the last stage, after carbon; filtration follows sedimentation to remove the remaining solids.

(b) To remove tastes and odours **(B1)**.

(c) Not pure, because pure water boils at exactly 100 °C and this sample boils **above** 100 °C, so it has substances dissolved in it **(B1)**.

(d) Distilled water contains fewer chemical impurities than tap water **(B1)**.

(e) Add the sample to anhydrous copper(II) sulfate **(B1)**; it turns from white to blue **(B1)**. (Or: anhydrous cobalt(II) chloride turns from blue to pink.)

Example 4

The table shows the masses of some ions in a 400 cm^3 sample of water from a mountain spring.

name of ion	formula of ion	mass in 400 cm^3 / mg
calcium	Ca^{2+}	9.6
carbonate	CO_3^{2-}	3.2
chloride	Cl^-	5.0
fluoride	F^-	0.4
hydrogencarbonate	HCO_3^-	20.8
magnesium	Mg^{2+}	4.4
potassium	K^+	1.2
sodium	Na^+	4.8
strontium	Sr^{2+}	0.2
	NO_3^-	0.8

(a) Name the **negative** ion with the lowest mass. **[1]**

(b) State the name of the NO_3^- ion. **[1]**

(c) Calculate the mass of sodium ions in 150 cm^3 of the spring water. **[1]**

(d) Name the **two** ions in the table that contain elements supplied by NPK fertilisers. **[1]**

(e) Name the compound made of Ca^{2+} and CO_3^{2-} ions. **[1]**

(a) The negative ions are carbonate, chloride, fluoride, hydrogencarbonate and nitrate. The lowest mass among them is 0.4 mg: **fluoride (B1)**. (Strontium, 0.2 mg, is lower, but it is a positive ion.)

(b) Nitrate **(B1)**.

(c) $4.8 \times \frac{150}{400} = 1.8$ mg **(B1)**.

(d) Potassium (supplies K) and nitrate (supplies N) **(B1)**.

(e) Calcium carbonate **(B1)**.

Common mistakes

- **Reversing the colour changes, or swapping the salts.** Copper(II) sulfate goes white → blue; cobalt(II) chloride goes blue → pink. Examiners report that the cobalt(II) chloride test is the less well known one and is often given copper sulfate's colours. Learn both as "from ... to ...".
- **Leaving out "anhydrous".** The test needs the salt without water; hydrated copper(II) sulfate is already blue.
- **Thinking the water test shows purity.** It shows water is present. Purity needs a melting or boiling point.
- **Saying impure water boils below 100 °C.** Dissolved substances **raise** the boiling point and **lower** the melting point.
- **Ignoring "positive" or "negative" in a table question.** This is the error examiners mention most for this topic: candidates pick the highest (or lowest) ion of the wrong charge. Cross out the other kind of ion first.
- **Using moles in the volume calculation.** It is simple proportion: mass × new volume ÷ table volume. Examiners see mole working, divisions the wrong way round (giving a much bigger answer), and answers out by a factor of ten.
- **Vague answers about pollutants.** "Toxic", "pollutes the water" or "breathing problems" do not score for nitrates or sewage. Write "deoxygenation, damaging aquatic life" for nitrates and phosphates and "harmful microbes that cause disease" for sewage.
- **Confusing nitrates with oxides of nitrogen.** Nitrates pollute water (deoxygenation); oxides of nitrogen pollute air (acid rain).
- **Vague treatment answers.** "Chlorine cleans the water" or "acidifies it" does not score; "kills microbes" does. Carbon removes tastes and odours, not bacteria.
- **Thinking sedimentation or filtration removes dissolved substances.** They only remove insoluble solids.
- **Giving compounds or ions when elements are asked for.** Fertilisers supply the **elements** nitrogen, phosphorus and potassium, not "nitrates" or "phosphates". Examiners also see calcium, sulfur, sodium, hydrogen and oxygen given wrongly, and the element already named in the question repeated.
- **Treating "NPK" as anything but symbols.** N is nitrogen, P phosphorus, K potassium. Sodium (Na) and sulfur (S) are not part of it.
- **Vague reasons for fertilisers.** "To help plants grow" or "to add nutrients" is often too vague; write "to increase crop growth" or "to replace elements removed by earlier crops".

How to get the marks

- **"State"** needs a short answer with no explanation: "chlorination", "fertilisers", "calcium". One word in the right place is enough.
- **"Describe a test"** needs the reagent **and** the result. For water: the anhydrous salt, then the colour change written "from white to blue" or "from blue to pink".
- **"Describe how to test the purity"** needs a method (measure the melting or boiling point) and a comparison with pure water's value (exactly 0 °C or 100 °C), with what an impure sample would show.

- **"Explain why"** questions in this topic want the syllabus reason: fewer chemical impurities; kill microbes; remove tastes and odours; deoxygenation; increase crop growth.
- **"Name"** an ion from a table: write the name (nitrate), not the formula, unless the question asks for a formula. **"Give the formula"**: include the charge (NO_3^-).
- **Use the table.** "Using the information in the table" means the answer is in the table: don't bring in ions that aren't there.
- **Calculations** are 1 mark for the final answer: show the working anyway, and give the unit from the table (mg or g).
- **"Name two"** means two different correct answers; a wrong third answer can cancel a right one, so give only the number asked for.
- **Multiple choice with numbered statements:** decide true or false for **every** statement before looking at the letters.

Quick check

1. State the colour change when water is added to anhydrous cobalt(II) chloride. Name one other anhydrous substance used to test for water and give its colour change.
2. A 750 cm^3 sample of pond water contains 4.5 mg of nitrate ions. Calculate the mass of nitrate ions in 50 cm^3 of the pond water.
3. For each compound, state which of the elements N, P and K it supplies (if any): ammonium chloride, potassium sulfate, calcium carbonate, sodium phosphate. Which of them must be mixed to make an NPK fertiliser?
4. Explain why water for a swimming pool must be chlorinated, but water used to irrigate a field of wheat need not be.
5. A sample of frozen liquid melts gradually between −2.0 °C and −0.5 °C. Is it pure water? Explain.

Answers

1. **Blue to pink.** Anhydrous copper(II) sulfate turns from **white to blue**.
2. $4.5 \times \frac{50}{750} = 0.3$ mg.
3. Ammonium chloride: **N**. Potassium sulfate: **K**. Calcium carbonate: **none**. Sodium phosphate: **P**. Each supplies only one element, so all three are needed: **ammonium chloride, potassium sulfate and sodium phosphate**. Calcium carbonate adds nothing.
4. People swim in pool water and swallow some of it, so it must be free of harmful microbes; **chlorination kills microbes**. Water for crops is not drunk, so it does not have to be chlorinated.
5. **No.** Pure water melts at exactly 0 °C, at a single temperature. This sample melts **below** 0 °C and **over a range**, so it contains dissolved impurities.

Past questions to try

- **0620/33/O/N/24 Q3**: the gas aquatic life needs, pollutant effects, a table of ions with a volume calculation, and the treatment substances.
- **0620/13/O/N/23 Q31**: the tests that show an NPK fertiliser contains potassium and nitrogen.
- **0620/22/F/M/25 Q31**: what river water polluted with nitrates does in the purity and water tests.
- **0620/31/M/J/23 Q3**: harmful substances, a table of ions, and what "hydrated" means in the copper(II) sulfate test.