Analysing and purifying water

Answers, marking points and revision notes | AQA Combined Science 8464 and AQA GCSE Chemistry 8462

GCSE science required practicals

This practical online

Answers

1 State the independent variable and one dependent variable in Jamal and Sofia's investigation. (2 marks)

Independent: the source of the water. Dependent: the mass of dissolved solids (or the pH).

Marking points

- Independent: the source / type of water sample
- Dependent: mass of dissolved solids or pH

2 Explain why the same volume of each water sample must be evaporated. (2 marks)

A larger volume of the same water would contain more dissolved solid. Using 50.0 cm^3 each time means the masses can be compared fairly.

Marking points

- More water would leave more solid
- So the masses can be compared fairly

3 Describe how to measure the pH of a water sample with universal indicator paper. (2 marks)

Dip a clean glass rod in the sample and touch it on a piece of universal indicator paper. Match the colour with the pH chart and record the pH.

Marking points

- Put a drop of sample on the indicator paper (glass rod)
- Compare the colour with the colour chart to read the pH

4 During distillation the delivery tube becomes blocked. Explain the hazard and how to prevent it. (2 marks)

Steam cannot escape, so the pressure builds up in the flask. The bung could shoot out or the glass could break, spraying hot water. Check the tube is clear before heating and never heat a completely sealed system.

Marking points

- Pressure builds up so the bung shoots out / glass breaks / hot water sprays
- Check tube is clear / never heat a sealed system / wear goggles

5 Calculate the mass of dissolved solids in the sea water sample. (1 mark)

1.755 g

Mass of solids = mass after - mass of empty basin

Mass of solids = 49.660 - 47.905 = 1.755 g

Marking points

- 1.755 g

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6 Calculate the concentration of dissolved solids in the sea water in g/dm^3. Use your answer to question 5. Give your answer to 3 significant figures. Show your working. (3 marks)

35.1 g/dm^3

Volume = 50.0 / 1000 = 0.0500 dm^3

Concentration = mass / volume

Concentration = 1.755 / 0.0500 = 35.1

Concentration = 35.1 g/dm^3

Marking points

- Volume = 50.0 / 1000 = 0.0500 dm^3
- 1.755 / 0.0500
- 35.1 g/dm^3

7 Calculate the concentration of dissolved solids in the tap water in g/dm^3. (2 marks)

0.34 g/dm^3

Volume = 50.0 / 1000 = 0.0500 dm^3

Concentration = 0.017 / 0.0500

Concentration = 0.34 g/dm^3

Marking points

- 0.017 / 0.0500
- 0.34 g/dm^3

8 Which sample is pure water? Give two pieces of evidence from the table. (2 marks)

The distilled water. It has a pH of 7.0, and it left no solid behind (0.000 g) when it was evaporated.

Marking points

- pH is 7.0 (neutral)
- No dissolved solid left after evaporation

9 Tap water is potable but is not pure. Use the results to explain what this means. (2 marks)

Potable means it is safe to drink. The tap water left 0.017 g of solid, so it still has some dissolved substances in it, which means it is not pure in the chemical sense.

Marking points

- Potable = safe to drink
- It contains dissolved solids (0.017 g), so it is not pure

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10 Explain how distillation separates pure water from sea water, and why the collecting test tube stands in ice-cold water.

(3 marks)

When the sea water is heated, the water boils and turns into steam, but the dissolved salts do not evaporate and stay in the flask. The steam is cooled in the cold test tube and condenses back into liquid water, which is pure. The ice-cold water keeps the test tube cold so that as much steam as possible condenses instead of escaping.

Marking points

- Water evaporates / boils but the salts stay behind
- Steam is cooled and condenses into pure water
- Ice-cold water keeps the tube cold so more steam condenses

11 A desalination plant takes in sea water with the same concentration as Jamal and Sofia's sample. Use your answer to question 6 to calculate the mass of dissolved solids removed from 2.5 dm^3 of this sea water. Give your answer to 2 significant figures.

(2 marks)

88 g

Mass = concentration x volume

Mass = 35.1 x 2.5 = 87.75

Mass = 88 g (2 significant figures)

Marking points

- Mass = concentration x volume = 35.1 x 2.5
- 88 g

12 **Higher tier**

The balance reads to 0.001 g. Sofia says the result for rainwater (0.002 g) has a much larger uncertainty than the result for sea water (1.755 g). Explain why she is right, and suggest one improvement.

(3 marks)

The resolution of the balance is 0.001 g, which is half of the 0.002 g measured for rainwater, so the uncertainty is a huge fraction of the result. For sea water, 0.001 g is a tiny fraction of 1.755 g. To improve this, evaporate a much larger volume of rainwater, such as 500 cm^3, so the mass of solid is larger compared with the resolution.

Marking points

- The uncertainty / resolution (0.001 g) is a large fraction of 0.002 g
- But a very small fraction of 1.755 g
- Evaporate a larger volume of rainwater so the mass of solid is bigger

13 Jamal did not let the basin cool before weighing it after evaporation. Suggest how this could affect his result, explain why weighing until the mass stays the same is a better method, and say whether any remaining water causes a random or a systematic error.

(3 marks)

A hot basin can make the balance reading unsteady or inaccurate, and some water may still be left in the solid, so the mass of solid could be wrong. Cooling, weighing, warming again and reweighing until two readings match shows that all the water has gone. Water left in the solid always makes the mass too high, so it is a systematic error.

Marking points

- Hot basin / remaining water gives an inaccurate mass
- Heating to constant mass shows all the water has been removed
- Remaining water always makes the mass too high: systematic error

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14 A pupil has collected a sample of distilled water from her distillation of sea water. Plan how she could test whether the distilled water is pure, and say what results she would expect if it is. (6 marks)

First, test the pH with a calibrated pH meter or universal indicator paper. Pure water should have a pH of 7. Next, weigh a clean, dry evaporating basin on a balance reading to 0.001 g, add a measured 50.0 cm^3 of the distilled water and heat it gently until it has all evaporated. Let it cool and weigh again; pure water leaves no solid, so the mass should not change. She could also find the boiling point: heat some of the water in a boiling tube with anti-bumping granules and a thermometer in the liquid, and record the steady temperature when it boils. Pure water boils at 100 °C; dissolved salt would raise the boiling point. Comparing her results with the original sea water, which has a higher pH, leaves a lot of solid and boils above 100 °C, would show the distillation has worked. She should wear goggles and take care with hot glassware.

Marking points (any 6, with the method in a logical order)

- Test pH with indicator paper or pH meter
- Pure water has pH 7
- Evaporate a measured volume in a weighed basin
- Reweigh: no mass of solid left if pure
- Measure boiling point with a thermometer
- Pure water boils at 100 °C
- Compare with the original sea water
- Safety: goggles, care with hot apparatus, gentle heating

How it is marked

- 5-6 marks: at least two suitable tests described clearly, each with the expected result for pure water, organised so that another person could follow the plan.
- 3-4 marks: one test described well with its result, or two tests with little detail or missing expected results.
- 1-2 marks: a relevant idea such as testing the pH or boiling it, with no clear method or expected result.

Revision notes: the method

Aim: To measure the pH and the mass of dissolved solids in water samples from different sources, and to purify salty water by distillation.

Equipment

- water samples (for example tap water, sea water, pond water, rainwater)
- universal indicator paper and colour chart, or a pH meter
- evaporating basins
- balance reading to 0.001 g
- 50 cm^3 measuring cylinder
- Bunsen burner, tripod, gauze and heatproof mat
- conical flask with bung and delivery tube
- test tube in a beaker of ice-cold water to collect the distillate
- thermometer
- safety goggles

Method

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1. Test the pH of each water sample: dip a glass rod in the sample, touch it on universal indicator paper and compare the colour with the chart, or use a calibrated pH meter.
2. Weigh a clean, dry evaporating basin and record its mass.
3. Measure 50.0 cm^3 of the water sample with a measuring cylinder and pour it into the basin.
4. Heat the basin gently over a Bunsen burner or on a water bath until all the water has evaporated.
5. Let the basin cool, then weigh it again. The increase in mass is the mass of dissolved solids.
6. Repeat for each water sample, using a clean basin each time.
7. To purify salty water, put it in a conical flask fitted with a bung and delivery tube that leads into a test tube standing in ice-cold water.
8. Heat the salty water gently until it boils. The steam travels along the tube and condenses in the cold test tube.
9. Test the distilled water collected: its pH should be about 7, and evaporating it should leave no solid behind.

Variables

- **Independent:** The source of the water sample.
- **Dependent:** The pH (indicator paper or pH meter) and the mass of dissolved solids left after evaporation (measured on a balance).
- **Control:** Volume of water evaporated (50.0 cm^3); Same balance for every weighing; Basins clean and dry before weighing; Same method of testing pH for each sample

Hazards

Hazard	What could happen	How to reduce the risk
Hot evaporating basin and boiling liquid	Burns, or hot water spitting out	Heat gently, wear goggles and let the basin cool before moving it, or use tongs
Pressure building up in the flask during distillation	The bung could shoot out, or hot liquid could suck back	Make sure the delivery tube is not blocked and does not dip below the liquid in the collecting tube; add anti-bumping granules
Pond water sample	May contain harmful microorganisms	Wear gloves if needed, never drink any sample, and wash hands afterwards

Key points

- Potable water is safe to drink but is not pure: it still contains small amounts of dissolved substances.
- Pure water has a pH of 7, boils at exactly 100 °C and leaves no solid when evaporated.
- Mass of dissolved solids = mass of basin after evaporating - mass of empty basin.
- Distillation works because water boils and condenses, while dissolved salts stay behind in the flask.
- Concentration in g/dm^3 = mass in g / volume in dm^3; divide cm^3 by 1000.
- Use a balance with good resolution: the masses of solid from fresh water are very small.

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