2.30 Using the Earth's Resources and Potable Water: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

Table 1: Approximate energy requirements for producing potable water

Data compiled for Revision Library from typical published ranges for the energy use of water treatment processes; figures are illustrative for use in this question.

Method of producing potable water	Approximate energy required per 1000 dm3 of potable water produced
Standard fresh water treatment (screening, sedimentation, filtration and sterilisation)	0.6 kWh
Desalination by thermal distillation	12.0 kWh
Desalination by reverse osmosis	3.5 kWh

1 Humans rely on natural resources for almost everything they use, from fuel to building materials. Some of these resources are finite and some are renewable.

(a) State whether coal is a finite resource or a renewable resource. **(1)**

(b) State whether wind is a finite resource or a renewable resource. **(1)**

(c) State whether metal ores, such as copper ore, are a finite resource or a renewable resource. **(1)**

(d) State whether timber from a sustainably managed forest is a finite resource or a renewable resource. **(1)**

(Total for Question 1 is 4 marks)

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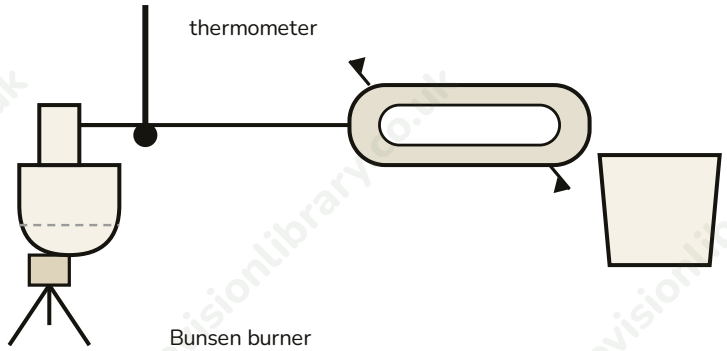
2 Use the information in Table 1 above.

(a) Explain why producing potable water from sea water is generally more expensive than producing potable water from fresh water. **(3)**

(Total for Question 2 is 3 marks)

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3 As part of the same required practical, another student, Ibrahim, sets up apparatus to distil a sample of water collected from a local stream, in order to test how pure it is.



(a) Name two pieces of apparatus, other than a Bunsen burner, tripod and thermometer, that Ibrahim needs to distil the water sample. **(2)**

(b) State the boiling point of pure water at standard atmospheric pressure. **(1)**

(c) Ibrahim's distilled sample was found to boil at exactly 100°C. Explain what this result suggests about the purity of the original stream water sample. **(2)**

(d) Suggest why anti-bumping granules are added to the flask before it is heated. **(1)**

(Total for Question 3 is 6 marks)

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4 Governments and industries are increasingly expected to plan for sustainable development when using the Earth's resources.

(a) Define what is meant by the term 'sustainable development'. **(2)**

(b) Give one reason why using sustainable development is important when extracting and processing the Earth's resources. **(1)**

(Total for Question 4 is 3 marks)

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5 Higher tier only. A coastal town in the south-east of England has very low annual rainfall and no large rivers or reservoirs nearby, so it relies on desalination of sea water to produce enough potable water for its population. A town in the north-west of England, which has high annual rainfall and several large reservoirs, uses only standard fresh water treatment.

(a) Using ideas about resources and sustainable development, suggest why the coastal town continues to use desalination, despite its higher cost, while the town in the north-west does not need to. **(4)**

(Total for Question 5 is 4 marks)

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6 Reverse osmosis is an alternative method of desalinating sea water.

(a) Describe how reverse osmosis is used to produce potable water from sea water. **(2)**

(Total for Question 6 is 2 marks)

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7 A water company evaporates 250 cm^3 of a water sample to dryness in a pre-weighed evaporating basin. Mass of empty basin = 42.16 g. Mass of basin + dry residue (after evaporation) = 42.40 g.

(a) Calculate the mass of dissolved solids in the 250 cm^3 sample. **(1)**

(b) Calculate the concentration of dissolved solids in the original water, in g per dm3 (1000 cm^3). **(3)**

(c) State one reason why this evaporation method would not distinguish between different dissolved substances present in the sample, such as sodium chloride and calcium sulfate. **(1)**

(Total for Question 7 is 5 marks)

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8 Higher tier only. Use the information in Table 1 above. A water company is comparing thermal distillation with reverse osmosis to produce potable water from sea water for a coastal town. Electricity costs the company £0.28 per kWh.

(a) Calculate the cost of producing 5000 dm3 of potable water by thermal distillation. **(2)**

.....

(b) Calculate the cost of producing the same volume of potable water by reverse osmosis. **(2)**

.....

(c) Using your answers to parts (a) and (b), explain which method is more energy efficient for producing potable water from sea water. **(2)**

(Total for Question 8 is 6 marks)

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9 A region is deciding how best to increase its supply of potable water: by investing in further treatment of waste water for reuse, or by building a new desalination plant to treat sea water. Evaluate the processes, cost and environmental impact of producing potable water from waste water, compared with producing potable water from sea water by desalination.

(Total for Question 9 is 6 marks)

10 A water company is deciding how to increase the supply of potable water to a coastal town that currently relies on a nearby reservoir, which is becoming unreliable because of low rainfall. Two options are proposed: (1) build a desalination plant using reverse osmosis to treat seawater, or (2) build a pipeline to transport fresh water from a wetter region further inland. Evaluate the two options.

(Total for Question 10 is 6 marks)

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Mark scheme · 2.30 Using the Earth's Resources and Potable Water: 1-hour Pack

Question 1

(a) finite cao **B1**

(a) Answer: Finite

(b) renewable cao **B1**

(b) Answer: Renewable

(c) finite cao **B1**

(c) Answer: Finite

(d) renewable cao **B1**

(d) Answer: Renewable

Question 2

(a) desalination (by distillation or reverse osmosis) requires much more energy than standard fresh water treatment (e.g. 12.0 or 3.5 kWh per 1000 dm3, compared with 0.6 kWh per 1000 dm3 for standard treatment, ft Table 1) oe **B1**

(a) sea water contains a much higher concentration of dissolved salts than fresh water, so more energy and more specialist equipment (e.g. membranes, distillation plant) are needed to remove them (oe) **B1**

(a) this extra energy use and specialist equipment increases the overall cost of producing potable water from sea water (oe) **B1**

(a) Answer: Desalinating sea water uses much more energy than standard fresh water treatment (see Table 1), because sea water contains far more dissolved salts, which need more energy and specialist equipment (such as membranes or distillation plant) to remove. This extra energy use and equipment increases the cost.

Question 3

(a) any one from: a (round-bottomed) flask, a condenser, a delivery tube, anti-bumping granules, a collecting beaker/vessel, a clamp stand, a heatproof mat **B1**

(a) a second, different item from the same list **B1**

(a) Answer: Any two from: a (round-bottomed) flask, a condenser, a delivery tube, anti-bumping granules, a collecting beaker, a clamp stand, a heatproof mat.

(b) 100°C cao **B1**

(b) Answer: 100°C

(c) dissolved substances raise the boiling point of water above 100°C (oe) **B1**

(c) the distilled sample boiling at exactly 100°C suggests the distillation removed the dissolved solids successfully, i.e. it produced pure water (oe) **B1**

(c) Answer: Dissolved substances raise the boiling point of water above 100°C. Boiling at exactly 100°C suggests the distillation successfully removed the dissolved solids, producing pure water.

(d) to promote smooth, even boiling and prevent the liquid suddenly bumping/spurting out of the flask (oe) **B1**

(d) Answer: To promote smooth, even boiling and prevent the liquid suddenly bumping or spurting out of the flask.

Question 4

(a) development that meets the needs of people today oe **B1**

(a) without stopping/preventing future generations from being able to meet their own needs oe **B1**

(a) Answer: Development that meets the needs of people today without preventing future generations from meeting their own needs.

(b) any suitable reason, e.g. to conserve finite resources for the future, or to reduce damage to the environment (oe) **B1**

(b) Answer: For example, to conserve finite resources so they remain available for future generations.

Question 5

(a) the coastal town has limited access to fresh water (low rainfall, no large rivers or reservoirs), so sea water/desalination may be the only reliable source of potable water available to it (oe) **B1**

(a) the town in the north-west has plentiful fresh water resources (reservoirs and higher rainfall), so standard fresh water treatment is sufficient, and there is no need for the more expensive desalination process (oe) **B1**

(a) desalination is more expensive and uses much more energy (ft Table 1), but may still be necessary where fresh water is a limited/finite local resource, to ensure a secure and sustainable supply (oe) **B1**

(a) for sustainable development, each town uses the method of treatment appropriate to the resources locally available, avoiding unnecessary energy use and cost where standard treatment is sufficient (oe) **B1**

(a) Answer: The coastal town has little fresh water available locally (low rainfall, no large rivers/reservoirs), so desalination may be its only reliable source of potable water, even though it is expensive and energy-intensive. The north-west town has plentiful fresh water (higher rainfall, reservoirs), so cheaper standard treatment is sufficient. For sustainable development, each town should use the treatment method appropriate to the resources locally available.

Question 6

(a) sea water is forced/pumped at high pressure through a partially permeable membrane (oe) **B1**

(a) the membrane allows small water molecules through, but not the larger dissolved ions/salts, which are left behind (oe) **B1**

(a) Answer: Sea water is forced under high pressure through a partially permeable membrane. The membrane allows water molecules through but not the larger dissolved ions, which are left behind.

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Question 7

(a) 0.24 g (42.40 - 42.16) cao **B1**

(a) Answer: 0.24 g

(b) uses the scale factor 1000 / 250 = 4, ecf from (a) **M1**

(b) substitutes: 0.24 x 4 **M1**

(b) 0.96 g/dm3 cao **A1**

(b) Answer: 0.96 g/dm3

(c) the method measures the total mass of all dissolved solids left behind together, without separating or identifying the individual substances present, oe **B1**

(c) Answer: The method only measures the total mass of all dissolved solids together; it does not separate or identify individual substances.

Question 8

(a) 5000 dm3 / 1000 = 5, so energy = 5 * 12.0 = 60 (kWh) oe **M1**

(a) 60 * 0.28 = 16.80, so £16.80 cao **A1**

(a) Answer: £16.80

(b) energy = 5 * 3.5 = 17.5 (kWh) oe **M1**

(b) 17.5 * 0.28 = 4.90, so £4.90 cao **A1**

(b) Answer: £4.90

(c) reverse osmosis is more energy efficient, as it costs less/uses less energy to produce the same volume of potable water (ft from parts a and b) oe **B1**

(c) this is because reverse osmosis does not need to heat and evaporate the water like distillation; it only needs to pump the water under pressure through the membrane (oe) **B1**

(c) Answer: Reverse osmosis is more energy efficient (it costs less to produce the same volume of water), because it does not need to heat and evaporate the water like distillation; it only needs to pump the water under pressure through a membrane.

Question 9

Level 3 A detailed and logically structured evaluation that accurately describes both the treatment of waste water (screening, sedimentation into sludge and effluent, anaerobic digestion of sludge and aerobic treatment of effluent) and desalination of sea water (distillation or reverse osmosis), compares their relative cost and energy use using the data in Table 1, and reaches a well-reasoned, justified conclusion about which approach is more appropriate, recognising that the answer may depend on local circumstances such as water availability. **5-6**

Level 2 Accurate description of at least some stages of waste water treatment and of desalination, with some comparison of cost, energy use or environmental impact, but the evaluation may be one-sided or only partly linked to a conclusion. **3-4**

Level 1 Basic, isolated statements about waste water treatment and/or desalination, with little or no comparison of cost or environmental impact and no supported conclusion. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- Waste water treatment: screening removes large solid objects; sedimentation separates the water into sludge and effluent; sludge is broken down by anaerobic digestion (producing biogas, mainly methane, which can be used as a fuel, and digested solids that can be used as fertiliser); effluent is treated aerobically by bacteria to remove remaining organic matter before release into rivers.
- Treating waste water for reuse requires comparatively little energy (Table 1 gives about 0.6 kWh per 1000 dm3 for standard treatment), because the water is already relatively low in dissolved salts, so it is generally the cheaper option.
- Desalination of sea water uses either thermal distillation (heating and evaporating the water, then condensing it) or reverse osmosis (forcing water through a partially permeable membrane under high pressure).
- Desalination requires far more energy than standard treatment (Table 1 gives 12.0 kWh per 1000 dm3 for distillation and 3.5 kWh per 1000 dm3 for reverse osmosis), making it considerably more expensive.
- Desalination may still be necessary in regions with very limited fresh water or waste water available for reuse, despite the higher cost, to guarantee a secure supply of potable water.
- Environmental considerations: disposal of the concentrated brine (waste salt solution) produced by desalination can harm marine ecosystems if not managed carefully; reusing treated waste water reduces the amount of fresh water that needs to be extracted from rivers, lakes and reservoirs, which can support sustainable development.
- A balanced conclusion should weigh the lower cost and energy use of treating waste water against the fact that desalination may be the only reliable option where fresh water and waste water resources are limited, for example in coastal areas with low rainfall.

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Question 10

Level 3 A balanced evaluation that considers reliability, cost and environmental impact of both options, and reaches a justified recommendation. **5-6**

Level 2 Some evaluation of both options with at least one clear point on each, but the evaluation is not fully balanced or the recommendation is only partly justified. **3-4**

Level 1 Simple, undeveloped points about only one option, or a recommendation with little or no justification. **1-2**

Indicative content:

- Desalination (reverse osmosis) uses the essentially unlimited supply of seawater, so it does not depend on rainfall and remains reliable even during future droughts
- Desalination has a high energy demand and cost compared with treating fresh water, and produces a concentrated brine by-product that can harm marine life if released back into the sea without treatment
- A pipeline from a wetter inland region relies on that region continuing to have a surplus of fresh water, so it is not fully drought-proof if the wider area is affected by low rainfall too
- Building a pipeline involves significant construction cost and disruption over a long distance, plus ongoing energy costs to pump the water, especially if there is a change in elevation
- Taking water from the inland region could also affect the water supply or ecosystems of that region if not carefully managed
- A justified conclusion could recommend desalination for long-term reliability despite higher running costs, or the pipeline if it is cheaper and the inland region has a reliable surplus; either is valid if properly supported

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