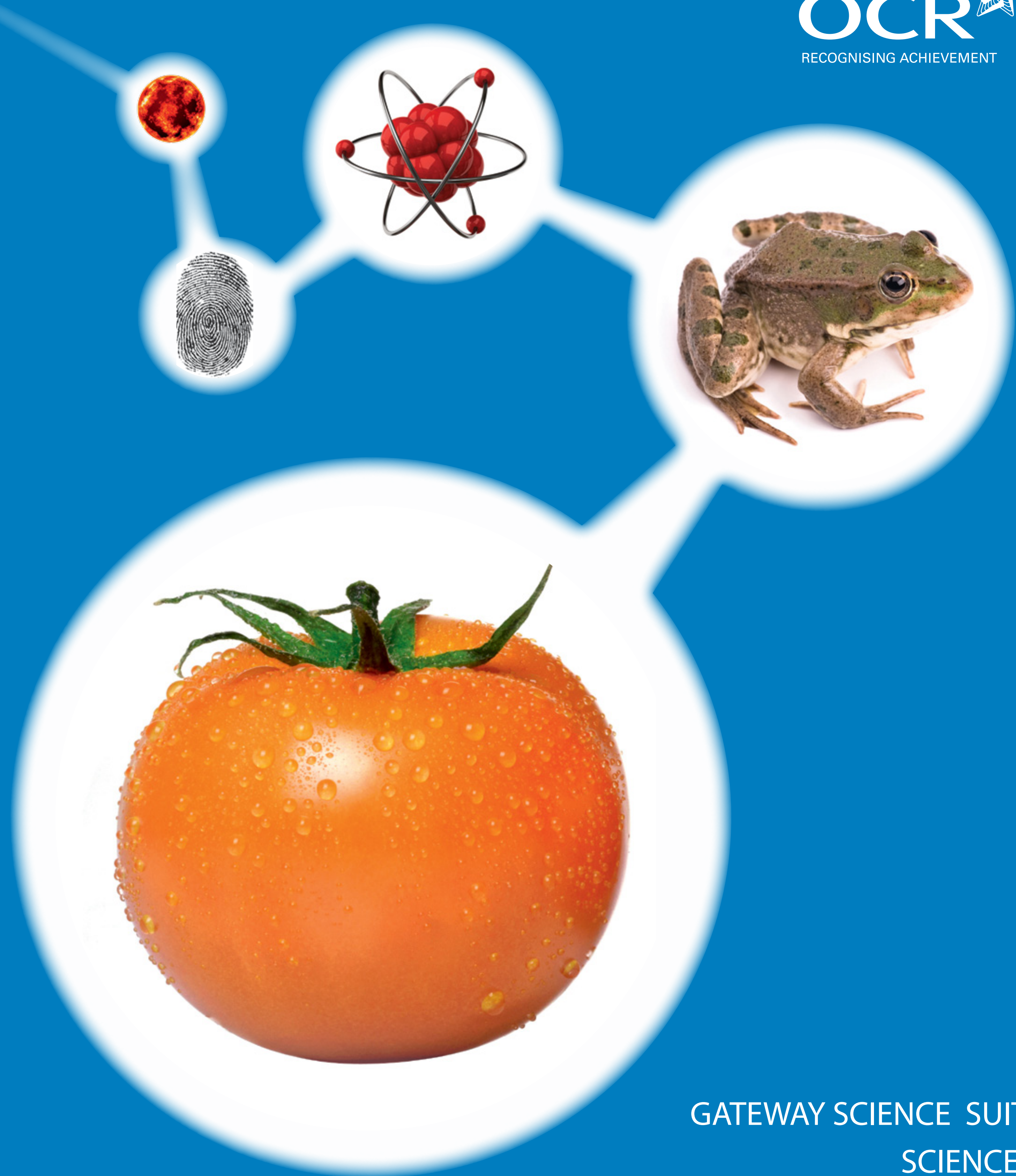


GATEWAY SCIENCE SUITE

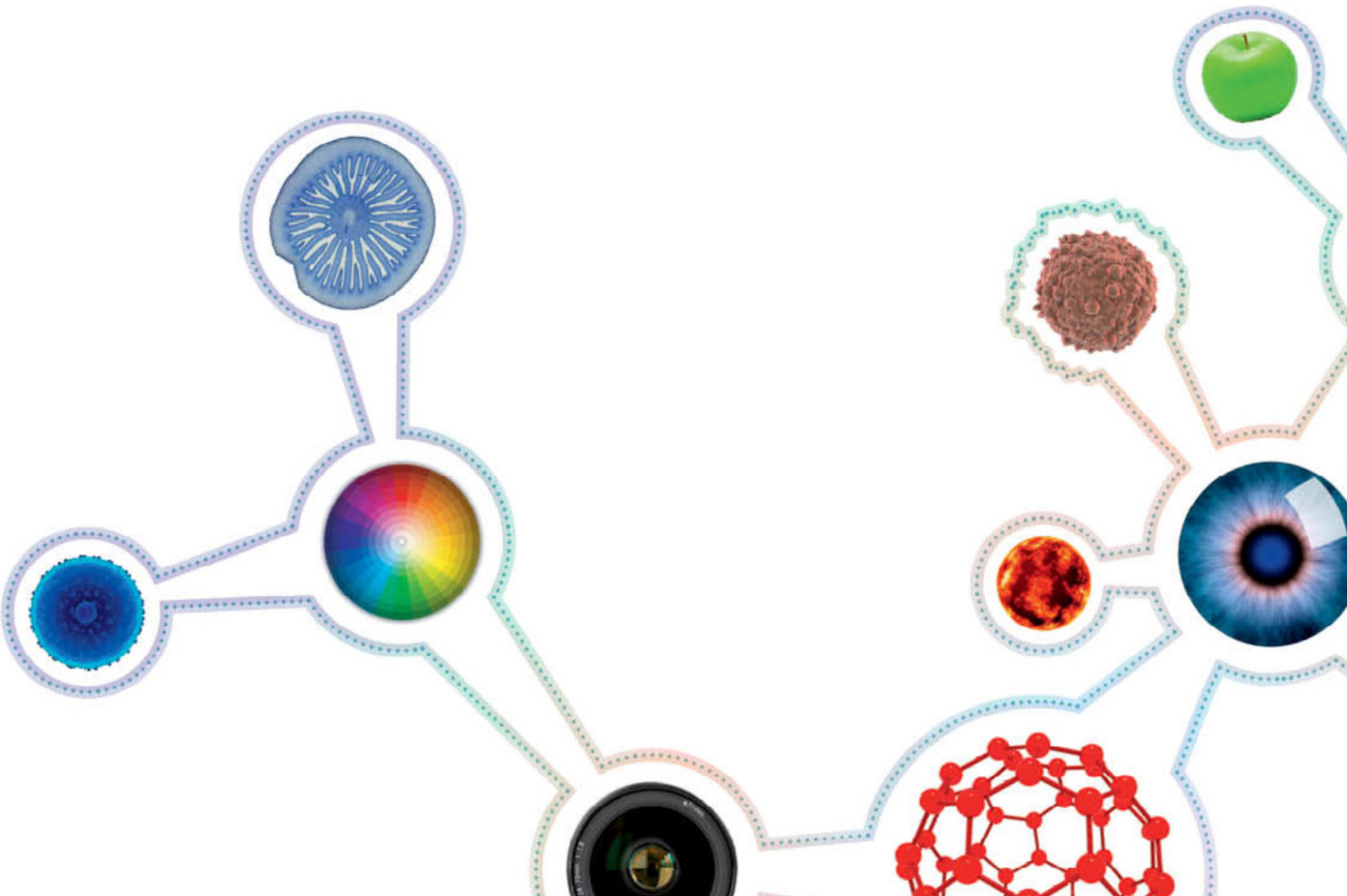
SCIENCE B

CANDIDATE STYLE ANSWERS

VERSION 1 OCTOBER 2011

www.ocr.org.uk/science

INDEX



INTRODUCTION

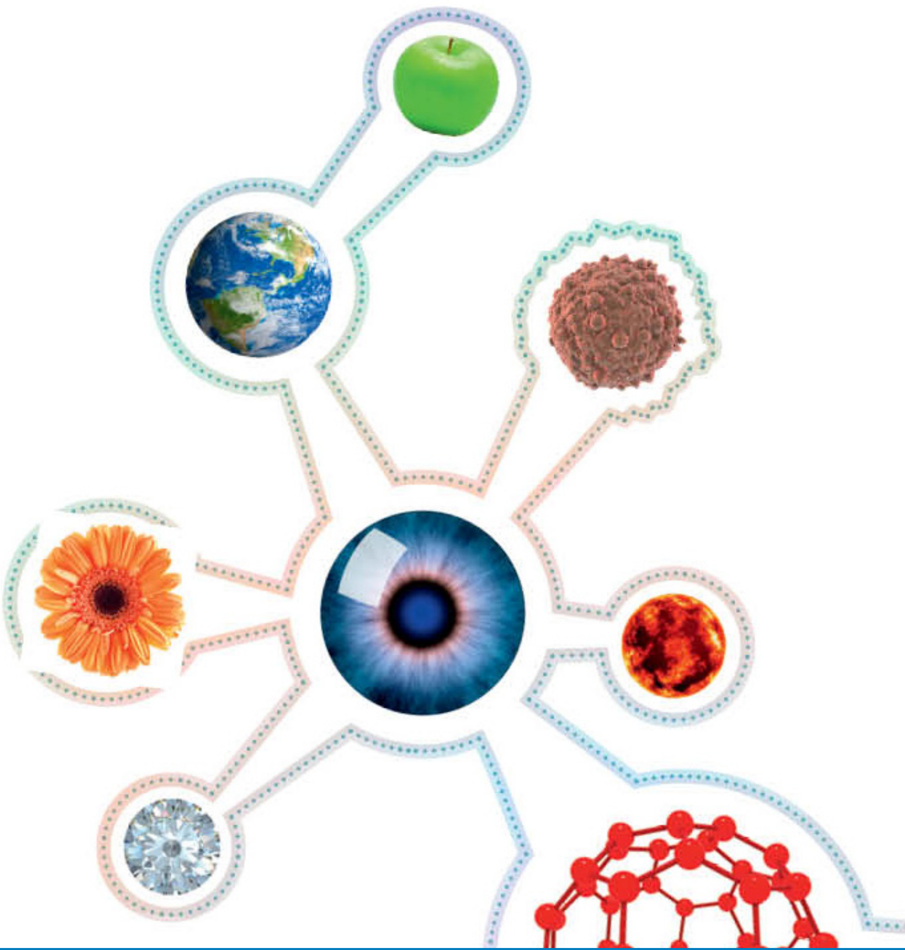
These support materials are intended to support teachers in their marking. There are three candidate style responses with accompanying commentary. These exemplars are based on the published Specimen Assessment Materials (SAMs), which can be downloaded from the relevant OCR webpage for the specification.

The exemplars and commentaries should be read alongside the Specifications and the Guide to Controlled Assessment for GCSE Gateway Science, all of which are available from the website.

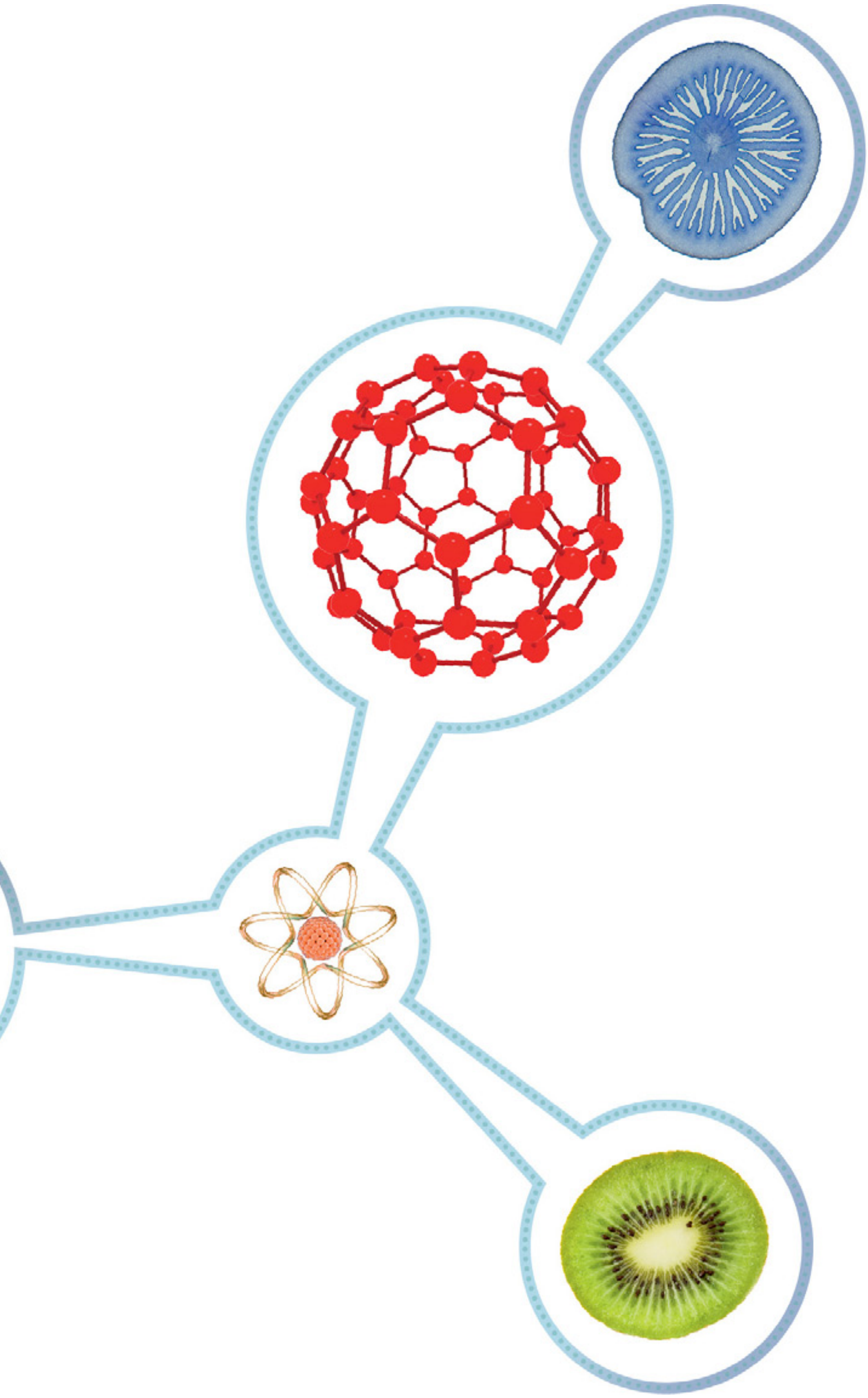
OCR will update these materials as appropriate.

Centres may wish to use these support materials in a number of ways:

- teacher training in interpretation of the marking criteria
- departmental standardisation meetings
- exemplars for candidates to review



CANDIDATE A



Candidate A

Coolants research

Coolants are used in nuclear reactors to transfer the heat energy from the reactor to be used to generate electricity (1) (2). The coolant enters the reactor at a low temperature, heat is transfered to it and it leaves at a high temperature (3). The coolant, often water, needs to be kept at high pressure so that the water doesn't turn to steam at 100°C – the boiling point is higher at higher pressure – meaning that more heat energy can be transfered while the coolant is still liquid (4). When the coolant comes out of the core it goes to a heat exchanger where the energy is transfered to non-radioactive water which will turn to steam and drive the turbine (4) (5).

The amount of coolant needed depends on the type of system used. If using a once-through wet cooling system, where water is readily available, about 90 cubic metres/second (7.8 GL/d) is needed (5). If using a recirculating system, where water is not in such ready supply, about 2 cubic metres/second (173ML/d) is used (5).

Cooling is more efficient with seawater than river water, increasing output by 0.9% (5).

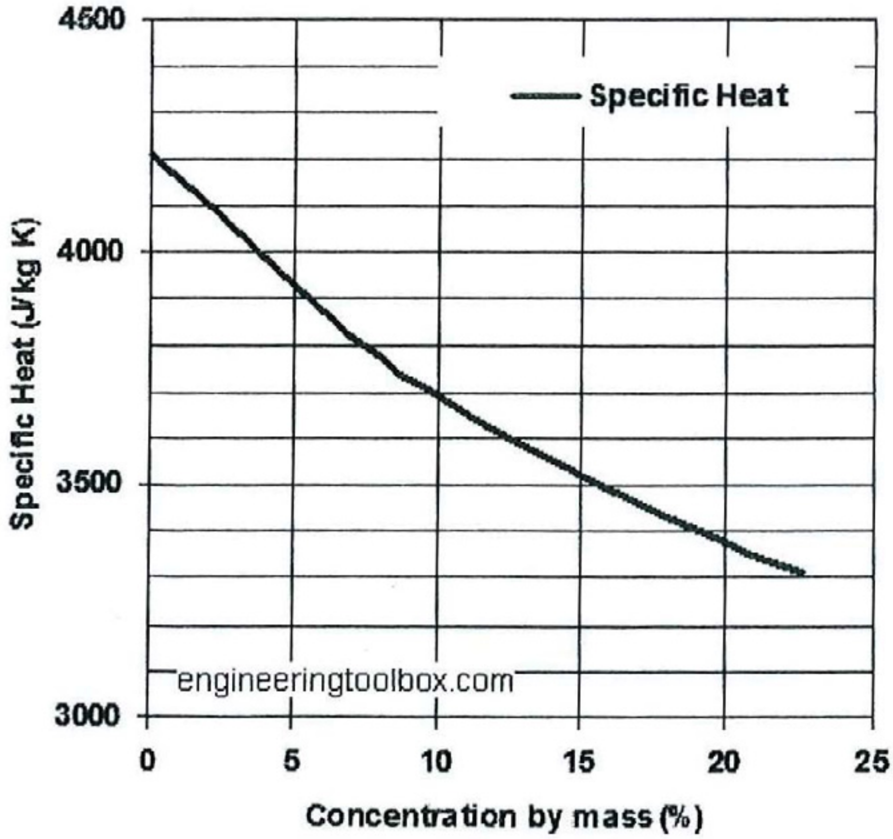
The concentration of salt in seawater is 35g of salts in 965g of water, which is 3.5% (6) (7).

The specific heat capacity varies slightly with temperature but at 20°C, the following values apply:

Fresh water	4.19J/g °C	4.19kj/kg K
Sea water	3.992J/g °C	3.993kj/kg K

This graph shows how the specific heat capacity varies with salt concentration (10):

Candidate A



Specific Heat
4500
4000
3500
3000
Specific Heat (J/kg K)
engineeringtoolbox.com
0
5
10
15
20
25
Concentration by mass (%)

Candidate A

References All downloaded on 4/5/11

1) http://www.world-nuclear.org/info.inf32.html

2) en.wikipedia.org/wiki/Nuclear_reactor_coolant

3) www.britanica.com/EBchecked/topic/421763/nuclear-reactor/45774/coolant - system

4) Library.thinkquest.org/17940/texts/fission_power/fission_power.html

5) www.worldnuclear.org/info/cooling_power_plants_inf121.html

6) www.oceanplasma.org/documents/chemistry.html

7) Iga.water.usgs.gov/edu/whyoceansalty.html

8) www.engineeringtoolbox.com/specific-heat-fluids-d_157.html

9) www.kayelaby.npl.co.uk/general_physics/2_7/2_7_9/html

10) www.engineeringtoolbox.com/sodium-chloride-water-d_1187.html

Candidate A

Plan of experiment

Hypothesis: Salty water heats up more quickly because more concentrated salt solutions have lower specific heat capacities.

Independent variable: Concentration of salt water

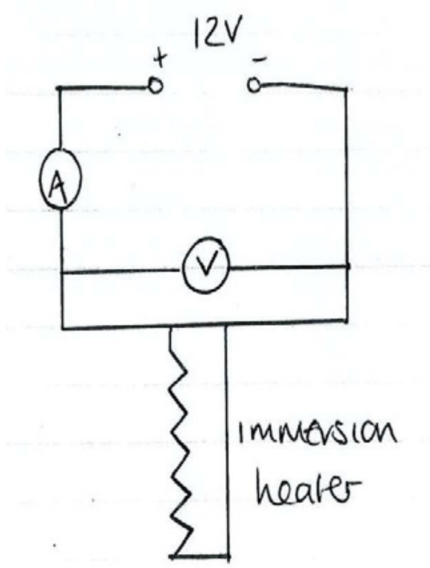
Dependent variable: Time it takes for water to heat by 10°C

Controlled variables: mass of water (150g)
the immersion heater
copper calorimeter
stirring

Equipment:
Immersion heater
Powerpack
Ammeter
Voltmeter
calorimeter
stopclock
thermometer
distilled water
sodium chloride
balance
500ml volumetric flask
Stirrer

Candidate A

Diagram



Method:

1. Set up the circuit with the immersion heater as shown:
2. Measure out 150.0g of solution in the calorimeter.
3. Insert the thermometer and immersion heater into the solution and leave until the temperature remains constant. Record the initial temperature.

2. Switch on the powerpack and the timer.

3. Heat the solution until the temperature rises by 10°C. During this time record the voltage and current in the table. Stir.

4. Switch off the heater + timer. Record the time taken for the 10°C rise in seconds in the table.
5. Repeat for these concentrations of sodium chloride: 0.0%, 2.5%, 5.0%, 7.5%, 10.0%. Repeat each concentration three times.

<u>Making the solutions</u>

The 0.0% solution is distilled water.

The other solutions are made up as follows:

Using the balance, weigh out the following mass of sodium chloride:

sol^{n}	mass sodium chloride
2.5%	12.5g
5.0%	25.0g
7.5%	37.5g
10.0%	50.0g

Candidate A

Add the sodium chloride to a 500ml volumetric flask and make up to 500ml using distilled water.

An immersion heater is used in this method to enable the calculation of the energy input from the voltage, current and time:

energy = v x c x t
supplied

The same calorimeter is used in each experiment. As the water and the thermometer are allowed to equilibrate before heating again the heating of the calorimeter is not an issue. The immersion heater is allowed to cool down in between each experiment.

The range of concentrations chosen covers the value for the salt concentration of sea water at 3.5%.

150.0g of solution chosen to make sure the heater is fully immersed to prevent energy wasted.

Results table

Percentage concentration of sodium chloride%	Voltage V	Current I	Time s	Specific heat capacity J/g °C
0				
0				
0				
2.5				
2.5				
2.5				
5				
5				
5				
7.5				
7.5				
7.5				
10				
10				
10				

Then calculate averages.

Risk assessment

Hazard: working with electric currents

Candidate A

The immersion heater is checked to make sure there are no bare wires so that there is no risk of electrocution. Care must also be taken with the presence of water and working with electricity.

Hazard: Risk of burning from immersion heater

The risk is limited by leaving the immersion heater in the water after switching off to allow it to cool down before removing it.

Hazard: Risk of burning from hot water

The risk is limited by only increasing the temperature of the water by 10°C. This means the final temperature of the water will still be below body temperature.

Safety glasses should be worn, although there is little risk from getting salt water in the eye.

4) Processing data

The energy supplied by the circuit for each experiment is calculated using:

Energy = v x I x t

The specific heat capacity is calculated form the formula:

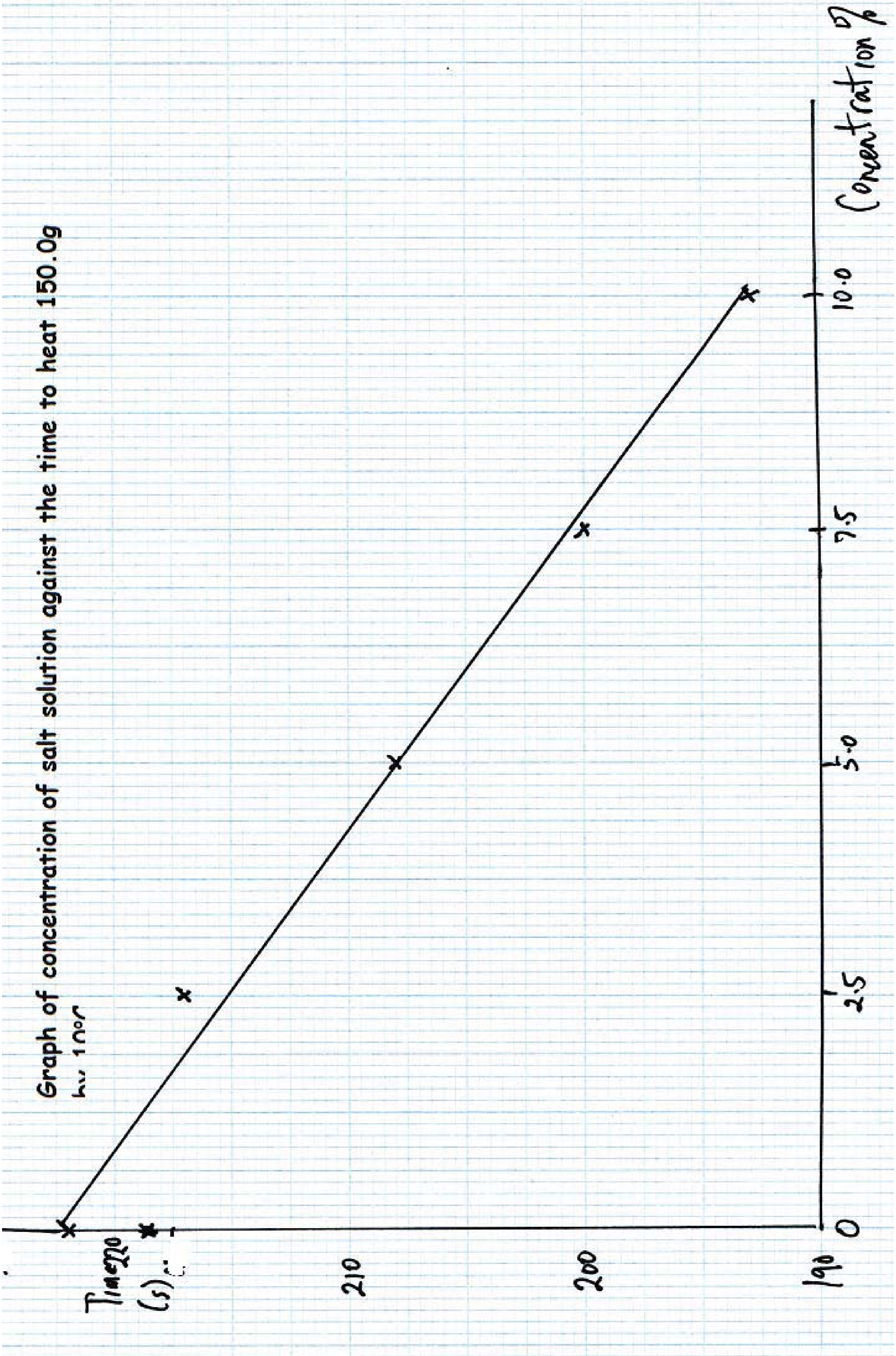
$$c = \frac{\text{energy supplied}}{m \times \Delta T}$$

c = specific heat capacity
m = mass of solution = 150.0g
ΔT = Temperature rise = 10°C

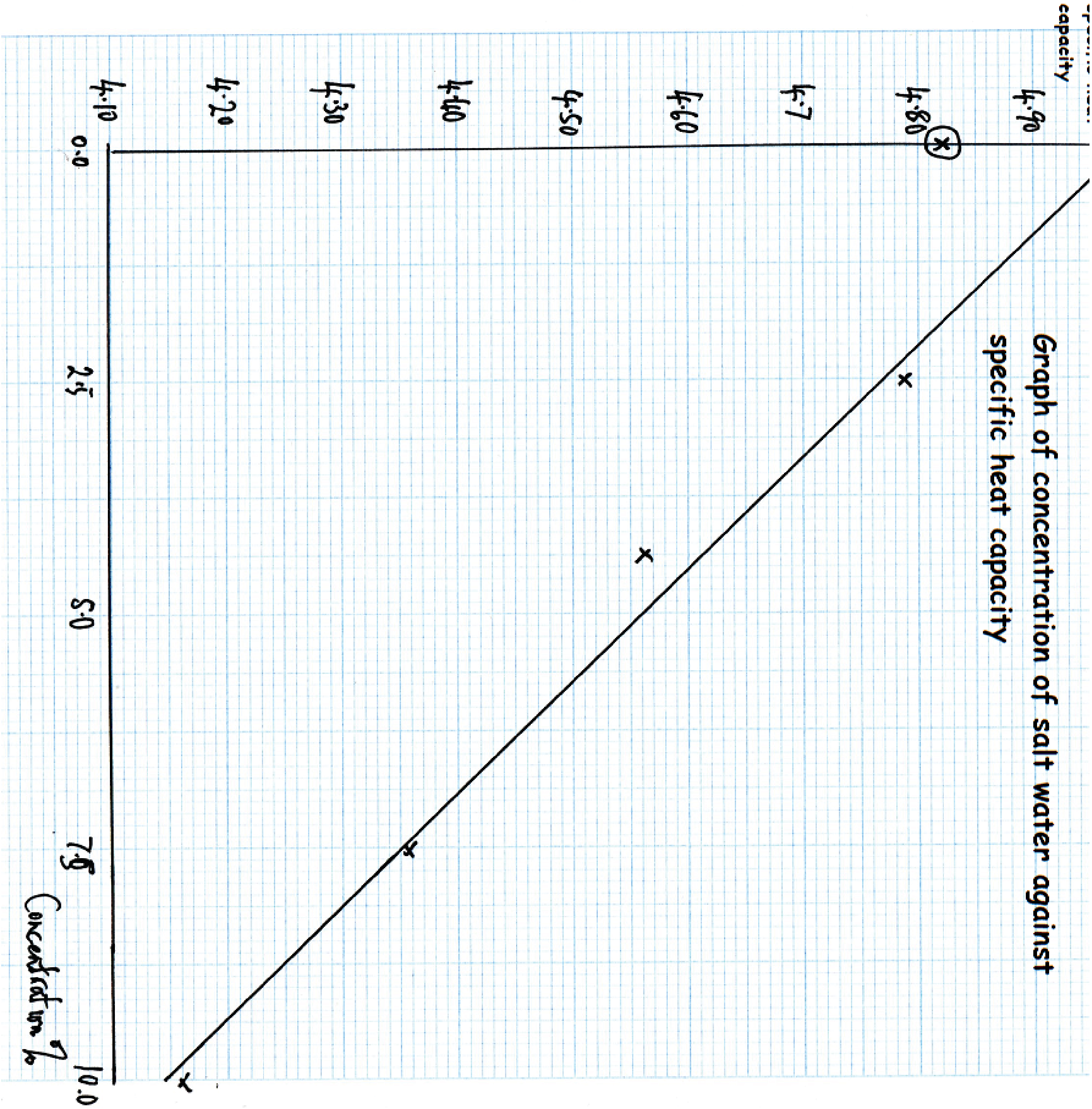
Results

Percentage concentration of sodium chloride%	Voltage V	Current I	Time s	Specific heat capacity J/g °C
0	9.70	3.30	222	4.82
2.5	9.75	3.36	217	4.79
5	9.82	3.36	208	4.56
7.5	9.79	3.33	200	4.36
10	9.70	3.34	193	4.16

Candidate A


Graph of concentration of salt solution against the time to heat 150.0g
Time (s)
220
210
200
190
0
2.5
5.0
7.5
10.0
Concentration %

Candidate A


Graph of concentration of salt water against specific heat capacity
capacity
4.90
4.80
4.7
4.60
4.50
4.40
4.30
4.20
4.10
0.0
2.5
5.0
7.5
10.0
Concentration %

2

Coolants

A scientist wants to find out why the amount of coolant used by nuclear power stations depends on the concentration of salt in the water.

1 Process the data you have collected and plot a graph to show the results of your investigation.

2 Describe any patterns or trends in your results. Comment on any unexpected results.

The higher the concentration of the salt, the less time it took to increase the temperature by 10°C. Also, the higher the concentration the lower the specific heat capacity. A lower specific heat capacity means it taks less energy to heat the water up by 1°C so the time taken to heat it up will be less, given the same amount of energy supplied .

3 Compare the data on specific heat capacities of sea water and fresh water from your research (Part 1) with the results of your own investigation (Part 2).

Comment on any similarities and differences. Suggest possible reasons for any differences.

The specific heat capacity for salt water in the research is 3.993J/g °C . The specific heat capacity for fresh water is 4.19J/g °C . The specific heat capacity from my data at 0% salt is 4.82J/g °C . Both of my results are higher than the published value, but follow a similar pattern in that the value for salt waster is lower that that for fresh water.
If I look at the graph on page 2 of my research it shows a similar shape to mine over the range 0 -10%.

4 ✎ Evaluate your results, the method you used and how well you managed the risks.

The salt solutions were made up using a volumetric flask which is a standard method of making solutions. The balance used to measure the salt has a precision of 0.01g which allowed for accurate masses to be added, and was also used to weigh out the 150g of solution used for each test. The largest source of error comes from the method of heating the immersion heater, while more efficient than spirit burners, still loses some of the energy supplied to heat the heater itself and energy is lost during heating to the surroundings, including the calorimeter. The effect of the heat loss is that it will lead to a higher value for the specific heat capacity, as the water will not heat up as quickly, than that published.

From my graph of average specific heat capacity, the value for 0% salt solution is lower than the line of best fit for the other values. This could be due to a greater proportion of heat loss because this solution had to be heated for longer than all the others.

I could try and improve the method by using a lid to prevent loss of heat through convection and insulating the calorimeter with felt to prevent heat loss by conduction.

The risks were manage well, taking care with using electricity near water, making sure there were no bare wires and any solutions spilt were cleaned up quickly. The solutions were only heated by 10°C to minimise the risk of burning through hot water.

Completed the practical without help and safely

4

5 Do your results from Part 2 support the hypothesis suggested by the scientist? Explain your answer.

My data does fit the hypothesis. The higher salt concentrations heated up more quickly and had a lower specific heat capacity eg 0% = 22s; 4.82J/g °C and 10% = 193s; 4.16J/g °C

6 Nuclear power stations use more coolant when the concentration of salt in the water is higher.

Explain why.

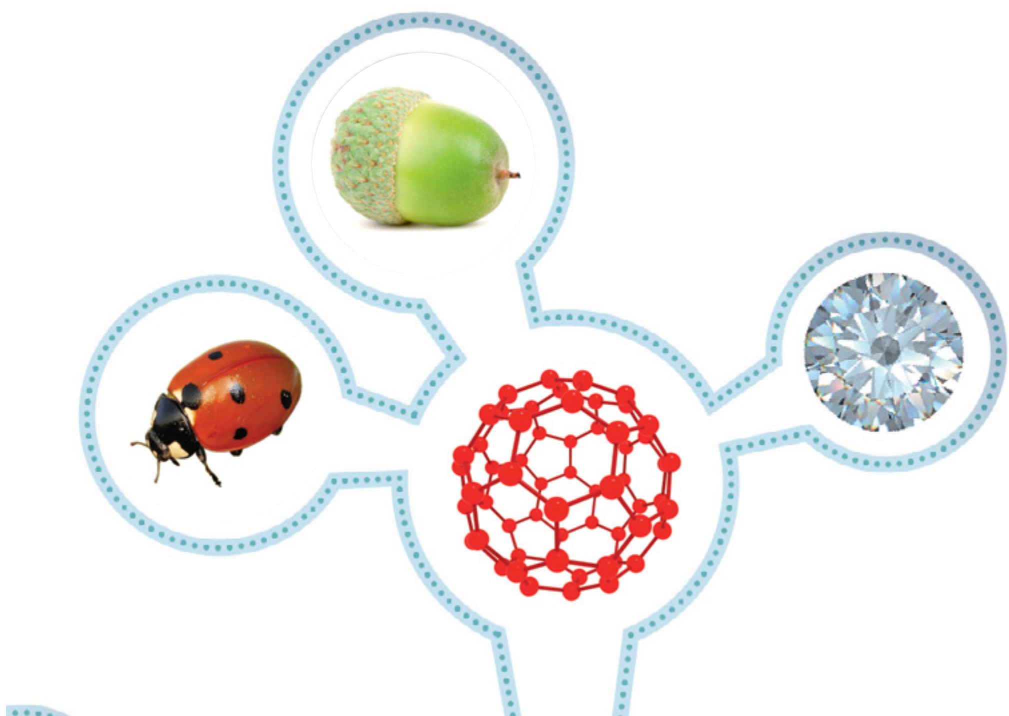
As higher salt concentrations have a lower specific heat capacity, the same mass of water absorbs less energy per gram than those that are lower, meaning you will need a larger volume of coolant to absorb the same amount of energy.

7 The Government is considering building more nuclear power stations. These will need access to water for cooling. From your research (Part 1) and investigation (Part 2), describe the advantages and disadvantages of building them by lakes or the sea.

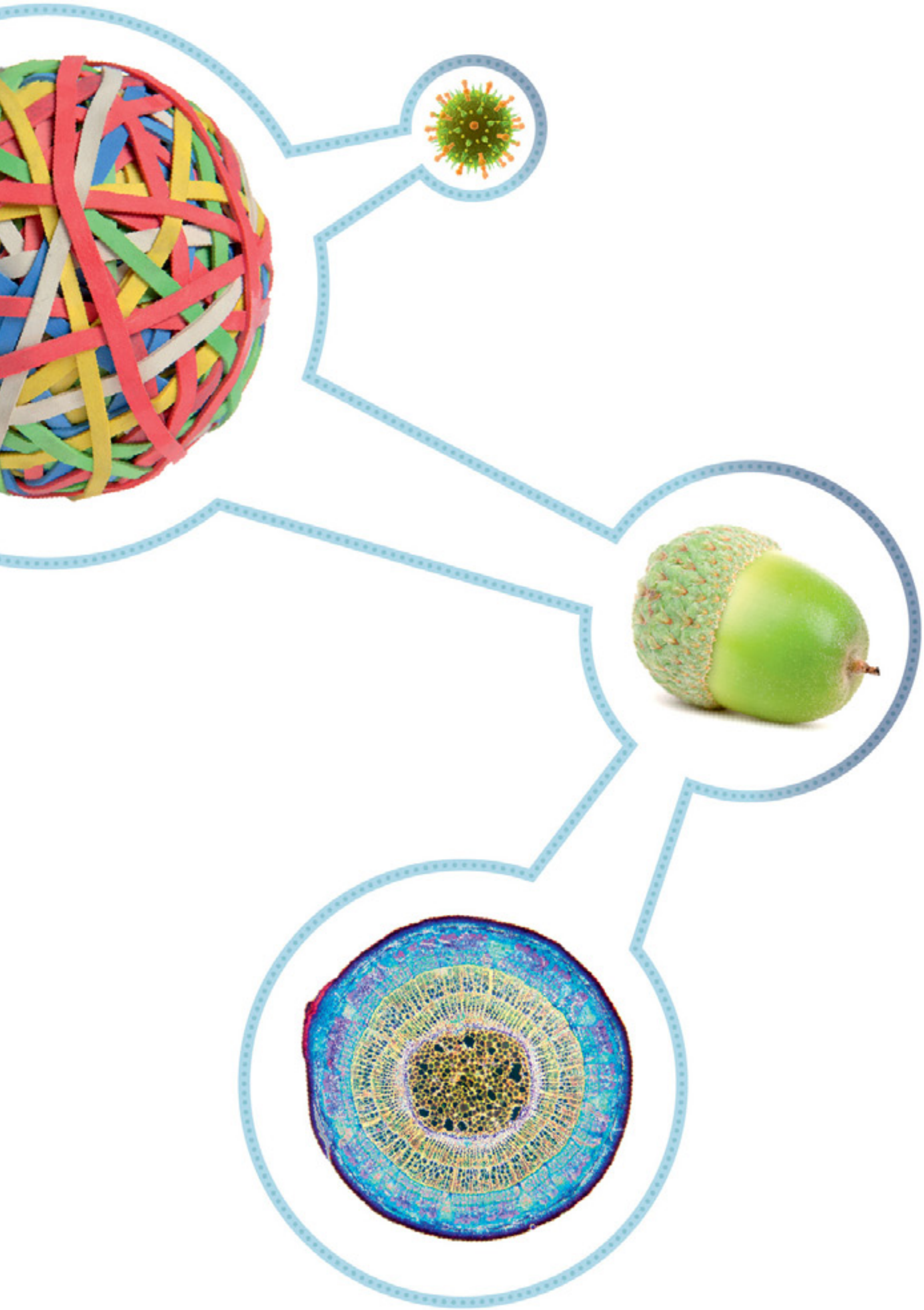
Power stations need large volumes of water, up to 7-8 GL/day is needed. Being near to the sea means an unlimited supply of water, but you would need to be able to pump water through at a higher rate to have the same cooling effect which would be more expensive than if they were built by a lake. However, with a lake if it wasn't large enough the returning water may be too warm, and there may not be enough water to achieve the necessary flow rate and cooling towers would be required.

COMMENTARY FOR CANDIDATE A

Quality	**Level L, M or H**	**Mark**	**Comments**
Researching	H	6	Good research used adequately in Part 3
Planning	H	6	Sufficient detail, with variable considered with reasoning given. does consider minimising errors (eg cooling and using the same calorimeter)
Collecting data	H	6	Units correct and table clear
Managing risk	H	6	Risk assessment, teacher annotation and used in Part 3
Processing data	H	5	No reference to uncertainty of data
Analysing & interpreting	M	4	No reasoning for differences, no detailed references to her own values
Evaluating	H	5	Weakness in evaluation of data limits to 5
Conclusion	H	6	Use of information from elsewhere in response to support mark
	Total	**44**	



CANDIDATE B



Candidate B

Coolants research

A nuclear reactor uses a collant to cool the reactor core. This can be water but can be other things. It can be sea water or river water.

Approximately one litre of seawater has roughly 35grams (1.2oz) of dissolved salts.
The specific heat capacity of water is 4200 J/kg per degree and sea water 3900 J/kg per degree

Plan

Salty water heats up more quickly because concentrated salt solutions have lower specific heat capacities.
Independent variable – amount of salt
Dependent varaiable Heat and time
Constant variable Amount of water

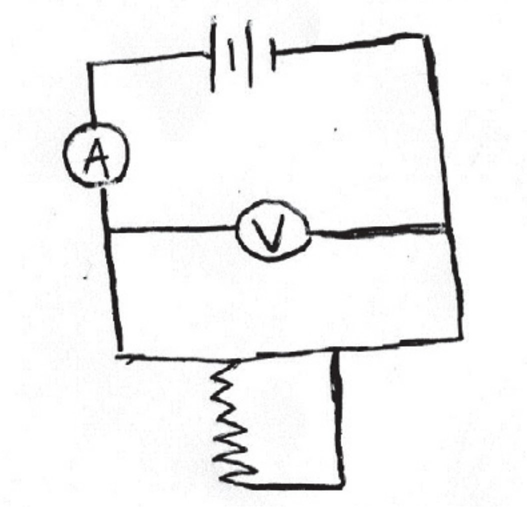
Heat different concentrations of salt solutions and measure the time taken for the temperature to rise by 10°.

Equipment
Immesion heater, power pack, ammeter, voltameter, metal can, stopclock, thermometer, beaker, spatula, distilled water, sodium chloride , balance, measuring cylinder, heatproof mat.

Risk assessment

Hazard Identified	Who is at risk	How is it controlled?
Boiling water	Me	goggles
Electrical	everyone	me

Candidate B



Method

Weigh different amounts of salt and dissolve each one in 100 cm^3 of water
Then put each solution into a calorimeter and heat with immersion heater measuring the temperature until it has gone up 10°.

Table

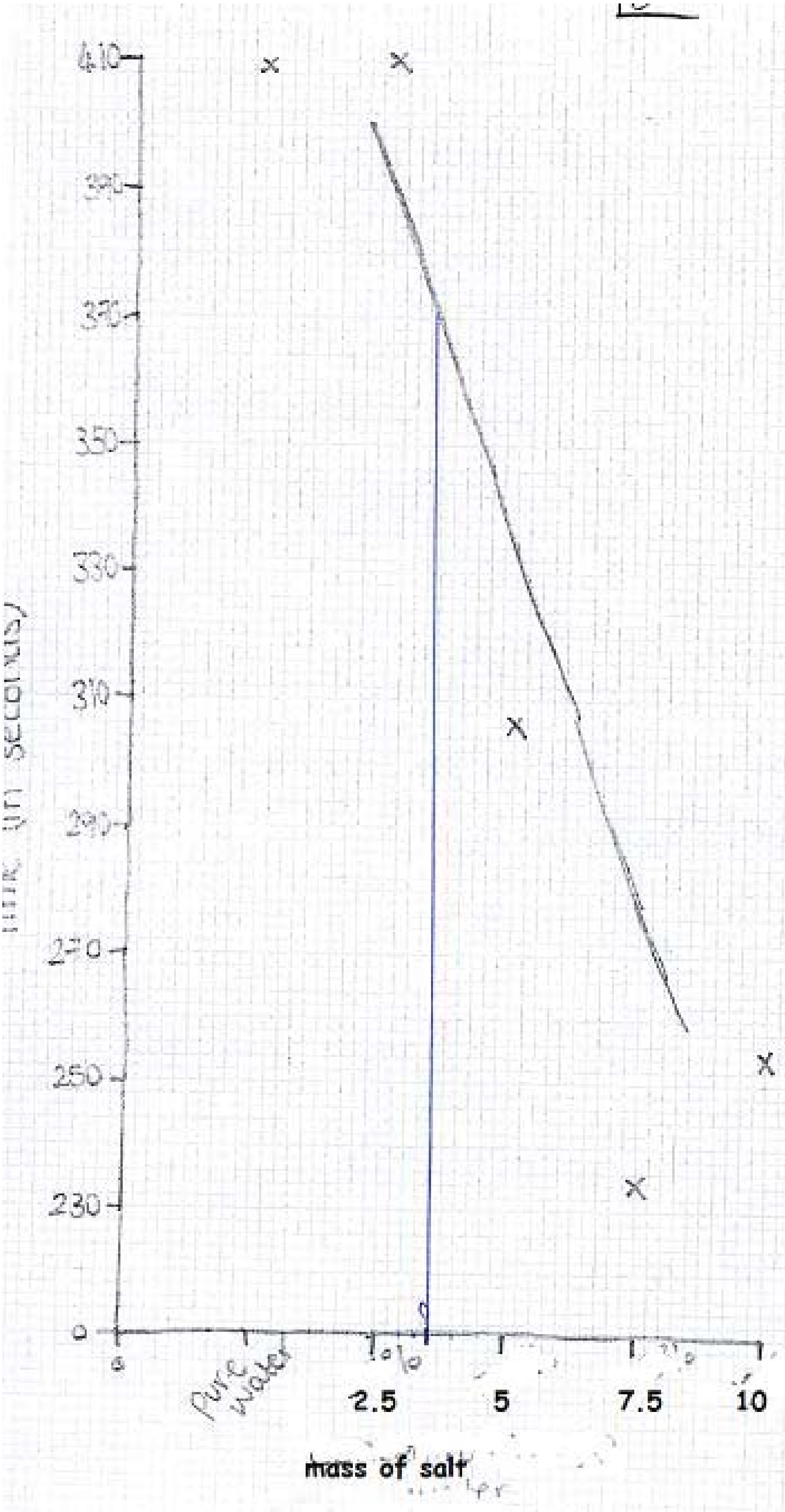
Weight of salt in g	Time in seconds
0 (water)	
2.5	
5	
7.5	
10	

Results

Weight of salt in g	Time in seconds
0 (water)	409
2.5	410
5	306
7.5	234
10	254

Completed the practical without safety problems but needed some help in connecting circuit.

Candidate B



6

2

Coolants

A scientist wants to find out why the amount of coolant used by nuclear power stations depends on the concentration of salt in the water.

1 Process the data you have collected and plot a graph to show the results of your investigation.

2 Describe any patterns or trends in your results. Comment on any unexpected results.

I can see in my data that 0% salt solution took longer to heay up by 10° than other concentrations.

∴

3 Compare the data on specific heat capacities of sea water and fresh water from your research (Part 1) with the results of your own investigation (Part 2).

Comment on any similarities and differences. Suggest possible reasons for any differences.

I noticed that the specific heat capacity of water is more than that of sea water. This means that water should heat up faster than sea water. We found this was true- water took 409 seconds and sea water about 370s,

4 ✎ Evaluate your results, the method you used and how well you managed the risks.

We might have the wrong salt solutions.
We might have used the balance wrongly.
We might miss read the metres.
We might not have stirred the water enough.
My data sn't very good as I did it only once. It would be better if I did it more times.

The risks are water and electricity being in the same place. There was burning hazzard from the immersion heater.

4

5 Do your results from Part 2 support the hypothesis suggested by the scientist? Explain your answer.

My graph supports the hypothsis.

6 Nuclear power stations use more coolant when the concentration of salt in the water is higher.

Explain why.

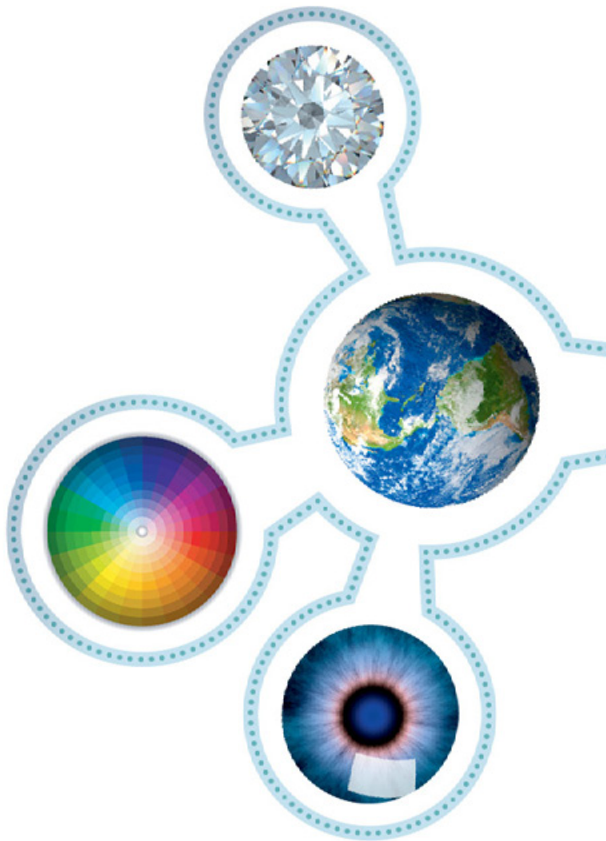
....

7 The Government is considering building more nuclear power stations. These will need access to water for cooling. From your research (Part 1) and investigation (Part 2), describe the advantages and disadvantages of building them by lakes or the sea.

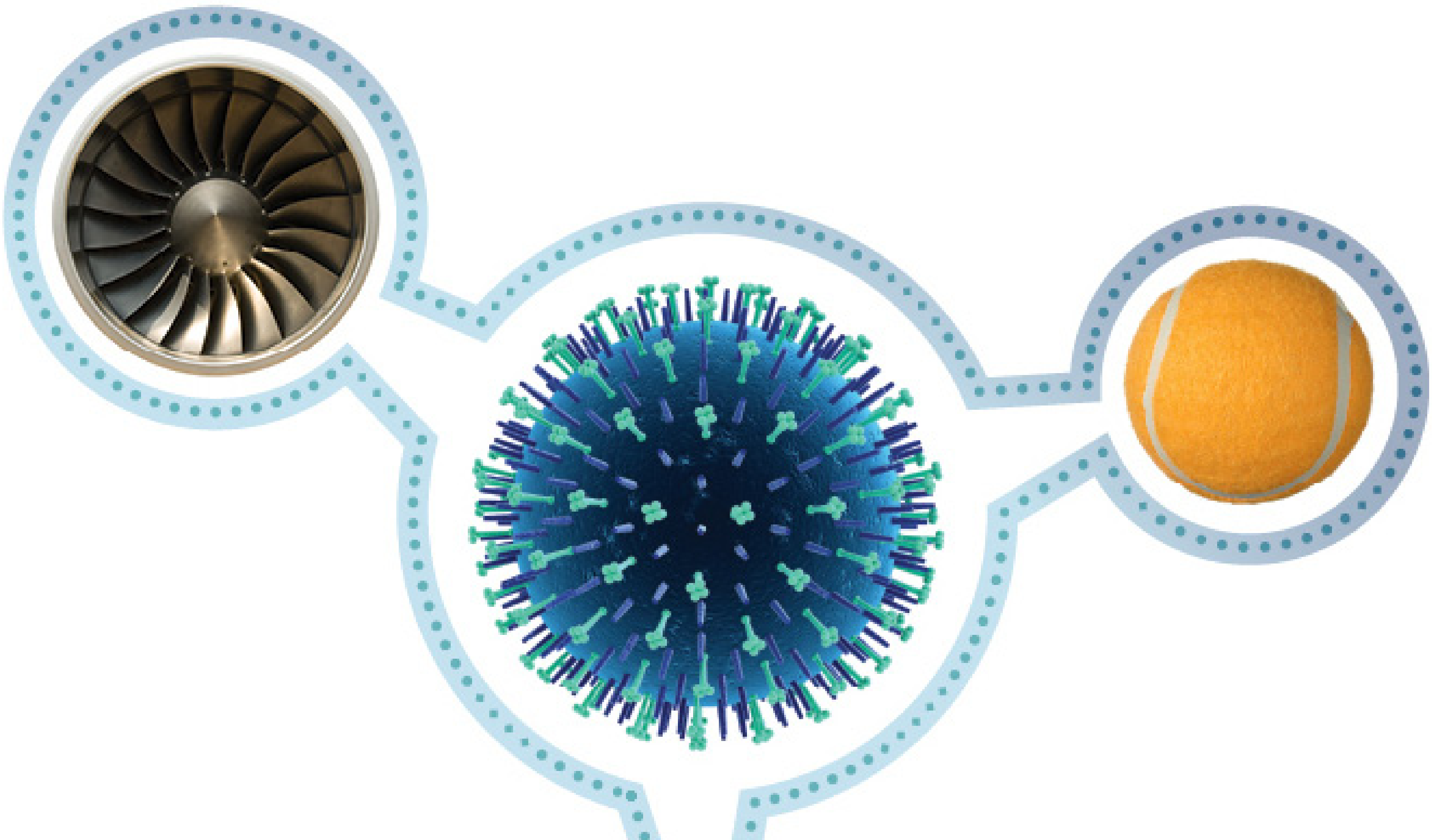
The advantage of building a nuclear power station by the sea is that you have plenty of sea water to keep the reactor cool. There is much less water in a lake. Also if nuclear waste escapes into the sea it will be mixed with lots of waer making it less dangerous.

COMMENTARY FOR CANDIDATE B

Quality	**Level L, M or H**	**Mark**	**Comments**
Researching	L	2	Assumption that the two pieces of information are from different sources (annotation to support this would be helpful)
Planning	L	2	An outline plan
Collecting data	M	4	Results in table, mass rather than concentration recorded and units incorrect
Managing risk	L	2	Understands that there are risks but no attempt to analyse
Processing data	M	3	Plotting and interpolation as mathematical techniques but graph contains sufficient errors to limit to 3
Analysing & interpreting	L	2	Idea of pattern just, some attempt to link primary and secondary
Evaluating	L	1	Some reference to the method made
Conclusion	L	1	No use of the data or information
	Total	**17**	



CANDIDATE C



Candidate C

Research

The coolant which passes through the nuclear reactors is used to transport the reactor heat either to a boiler where steam is raised to run a conventional turbine or it is used as a thermodynamic heat engine fluid and passes directly into the turbine and back to the reactor.

Seawater has 35g of salt per 1000g of water.

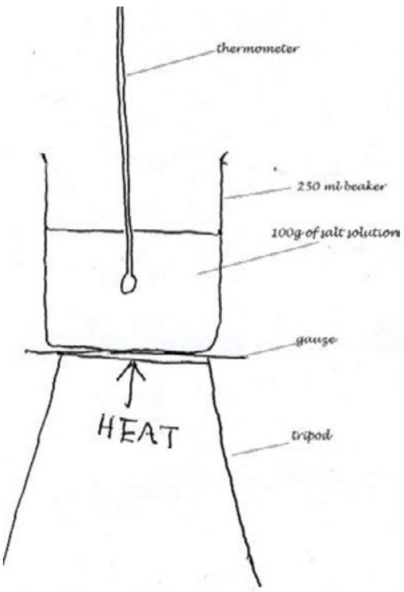
The specific heat capacities of pure water and sea water are 4.19 and 3.93

Planning

I am going to heat up 100 cm^3 samples of water with different salt concentrations and time how long it takes to raise the temperature $20^{O}C$.

Equipment needed

Beaker (250 ml), thermometer, Bunsen burner, tripod, gauze, 2 measuring cylinders , stopwatch, 100% salt solution, distilled water.



Method

1. Measure 100g of salt solution into a beaker using a measuring cylinder.

2. Light the Bunsen burner and adjust to give a small blue flame. I am going to not adjust the flame during the experiment. Set up the apparatus (see diagram)

Candidate C

3. Take the temperature of the salt solution and stand on the tripod. Stir the solution with the thermometer and stop timing when the salt solution has gone up 20 degrees.

4. Mix 50 cm^3 of distilled water with 50cm^3 of 100% salt solution to make 50% and repeat.

5. Keep diluting 50-50 and repeating.

Salt concentration	Time to heat up (s)			
	1	2	3	Average
100%				
50%				
25%				
12.5%				
Distilled water				

Risk assessment

I am only using salt and water. I should wear googles to stop salt solution getting in my eyes and wash my hands thoroughly. The water is never going to get too hot to burn me but the tripod and gauze might. So I must let them cool down at the end before touching them.

Results

Salt concentration	Time to heat up (s)
100%	70
50%	80.5
25%	84
12.5%	87
Distilled water	90

Annotation

Completed the practical without any safety problems.

No need to make modifcations

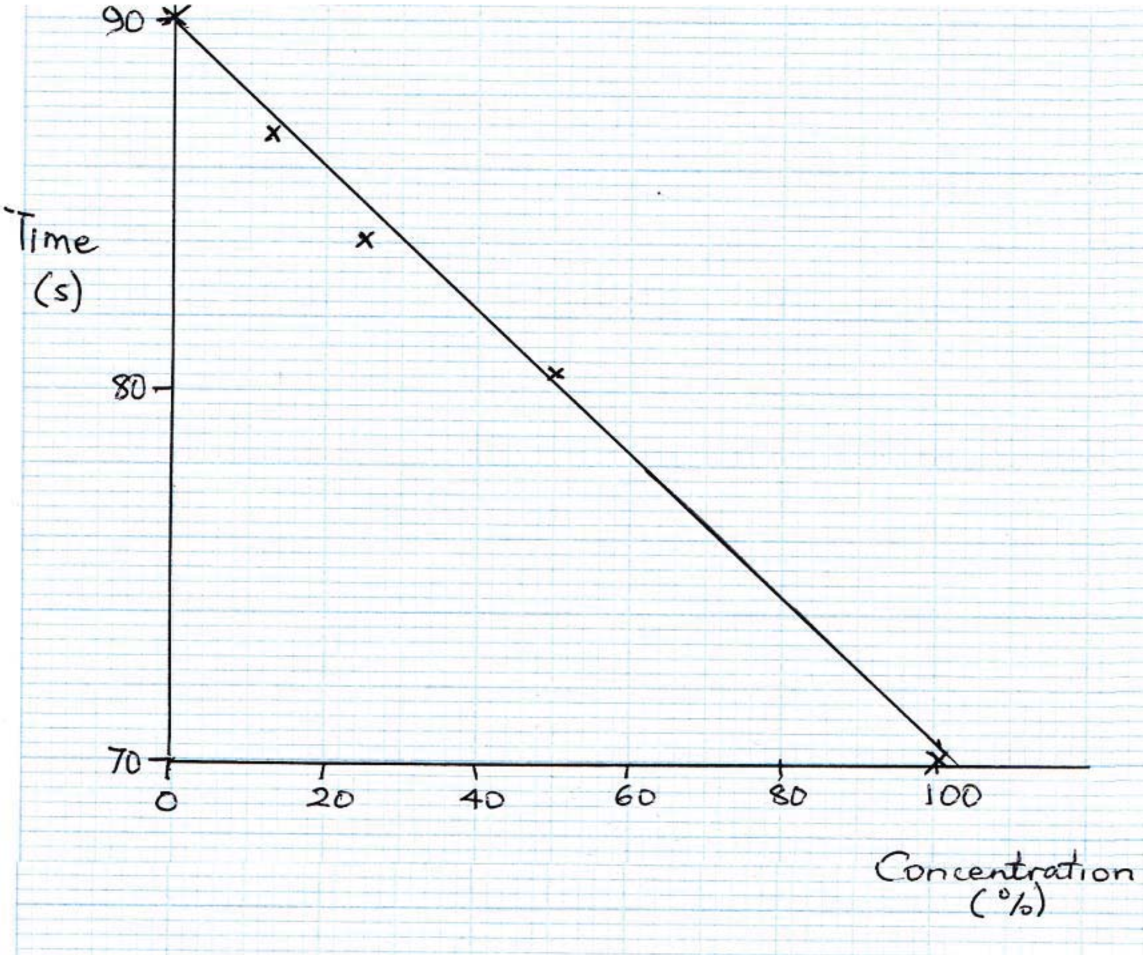
I did not have time to repeat my experiments.

Candidate C

Coolants

A scientist wants to find out why the amount of coolant used by nuclear power stations depends on the concentration of salt in the water.

1 Process the data you have collected and plot a graph to show the results of your investigation.



2 Describe any patterns or trends in your results. Comment on any unexpected results.

There is a negative correlation

As the concentration of salt solution increases the time taken to heat the solution decreases.

Salt solution heats up faster than fresh water.

There were no unexpected results.

Candidate C

3 Compare the data on specific heat capacities of sea water and fresh water from your research (Part 1) with the results of your own investigation (Part 2).

Comment on any similarities and differences. Suggest possible reasons for any differences.

I notice in my research that sea water has a lower specific heat capacity than pure water (4.19 and 3.89)

Since

Energy = mass x specific heat capacity x temperature rise

The same amount of energy will heat a mass of sea water more than the same mass of pure water. That is what I found.

I could not calculate the specific heat capacity because I did not know how much energy the Bunsen burner was giving out.

The energy taken in by the distilled water (using value) from my research

= 100 x 4.19 x 20 = 8380 J

The energy taken in by sea water (using value from research)

= 100 x 3.89 x 20 = 7780 J

4. Evaluate your results, the method you used and how well you managed the risks.

I collected 5 results but did not have the chance to repeat them. I think my data is good because all of the points are close to the line of best fit and there are no unexpected results.

In this experiment I am working on the fact that the Bunsen burner is giving out the same energy all the time. Also I am assuming that the energy losses are the same each time.

As the temperature does not go too high I will not loose to much energy. I could reduce energy losses by laging the beaker and putting a lid on the beaker. I could use an electrical heated that supplied the same energy each minute.

I managed the risks well making sure the apparatus had cooled before I took it apart.

Candidate C

5 Do your results from Part 2 support the hypothesis suggested by the scientist? Explain your answer.

I think my results fit the hypothesis. The more concentrated the salt solution, the faster it heats up. Water has a higher specific heat capacity than water so that fits in.

6 Nuclear power stations use more coolant when the concentration of salt in the water is higher.

Explain why.

More coolant is needed if sea water is used because sea water boils at a higher temperature than pure water.

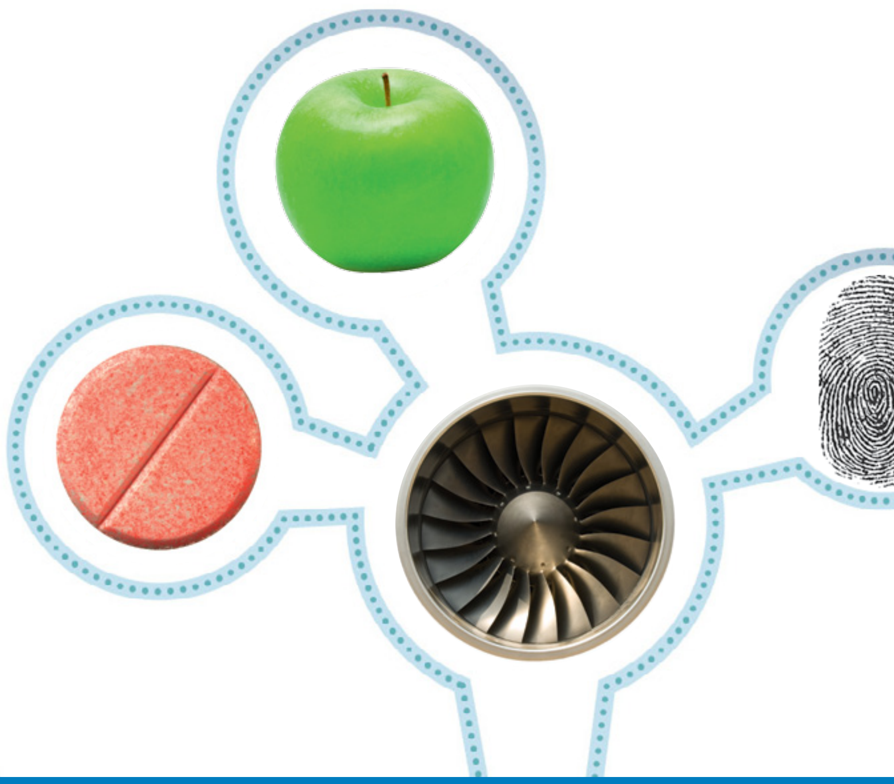
7 The Government is considering building more nuclear power stations. These will need access to water for cooling. From your research (Part 1) and investigation (Part 2), describe the advantages and disadvantages of building them by lakes or the sea.

Nuclear power stations need a lot of water for cooling. There is more water in the ocean than there is in a lake and in very dry conditions the water level in the lake might get too low. Salt water might make more rust in the pipes.

Also the water returning to the lake may be at a slightly higher temperature than the water being taken from the lake. This could affect plants and animals living in the lake.

COMMENTARY FOR CANDIDATE C

Quality	Level L, M or H	Mark	Comments
Researching	L	2	No referencing, annotation helpful to support use of more than one source
Planning	M	4	Sufficient information for it to be repeated, table shows number of replicates
Collecting data	M	4	
Managing risk	M	4	Risks identified and suggestions to reduce risks given
Processing data	M	4	More than one simple mathematical technique
Analysing & interpreting	M	3	Trend identified and references to secondary data made, but no comparison
Evaluating	M	4	
Conclusion	M	3	
	Total	**28**	



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