Topical Practice

IGCSE PHYSICS

Paper 4

Chapter 8

EDITION • Volum • STUDENT

CONTENTS

Chapter 8: Thermal Properties and Processes

1 (a) Suggest

(i) an example of a change of state resulting from the removal of thermal energy from a quantity of material,

.... [1]

(ii) the effect of this change of state on the temperature of the material.

.... [1]

(b) Define the *thermal capacity* of a body.

....

....

.... [2]

(c) A polystyrene cup holds 250 g of water at 20 °C. In order to cool the water to make a cold drink, small pieces of ice at 0 °C are added until the water reaches 0 °C and no unmelted ice is present.

[specific heat capacity of water = 4.2 J / (g °C), specific latent heat of fusion of ice = 330 J / g]

Assume no thermal energy is lost or gained by the cup.

(i) Calculate the thermal energy lost by the water in cooling to 0 °C.

thermal energy lost = ... [2]

(ii) State the thermal energy gained by the ice in melting.

thermal energy gained = ... [1]

(iii) Calculate the mass of ice added.

mass of ice = ... [2]

[Total: 9]

2 Fig. 6.1 shows a glass flask full of water at 10 °C and sealed with a bung. A long glass tube passes through the bung into the water. The water level in the tube is at X.

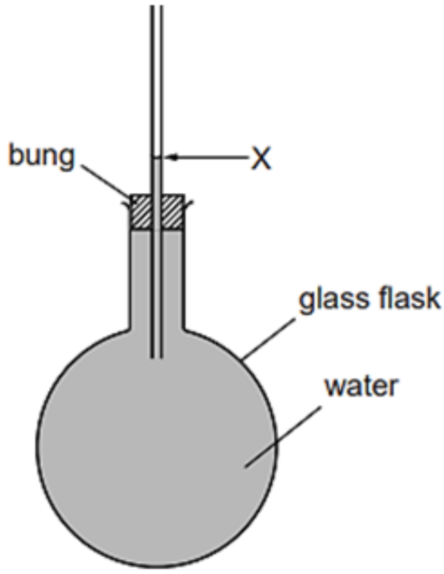

Fig. 6.1

When the flask is placed in hot water, the water level initially falls a little below X, and then rises some way above X.

(a) Suggest why

(i) the water level initially falls,

....

.... [2]

(ii) the water level then rises,

....

.... [2]

(iii) the rise is greater than the fall.

....

.... [1]

(b) Suggest a change to the apparatus that would make the fall and rise of the water level greater.

....

.... [1]

[Total: 6]

3 The water in a copper hot-water tank is heated during the night. During the day, the water cools as thermal energy (heat) passes from the water to the air surrounding the tank.

(a) **(i)** Describe the process by which the thermal energy is transferred from the hot water to the air.

....

....

....

....

.... [3]

(ii) State why the rate at which thermal energy passes into the air decreases as the water temperature falls.

....

.... [1]

(b) The manufacturer of the hot-water tank says that when the outside surface is polished regularly and kept bright and shiny, the hot water will cool more slowly.

Describe, with the aid of a diagram, an experiment that shows whether a container with a bright and shiny surface is better at keeping its contents warm than one with a dull and dark surface.

....

....

....

....

....

.... [4]

[Total: 8]

4 A thermometer uses the value of a physical property to indicate the temperature.

(a) A particular thermometer is sensitive, linear and has a wide range.

Draw a straight line from each characteristic of this thermometer to the appropriate feature.

characteristic of thermometer	feature of thermometer
	reacts quickly to change of temperature
sensitive	
	large difference between highest and lowest measurable temperatures
linear	same change of physical property for same change of temperature
	fixed points at 0°C and 100°C
wide range	
	large change of physical property for small change of temperature

[3]

(b) (i) In the space below, draw a diagram to show the structure of a thermocouple thermometer.

[2]

(ii) Explain why a thermocouple thermometer is particularly well suited to measure

1. high temperatures,

....

....

2. very rapidly changing temperatures.

....

....

[2]

[Total: 7]

5 Fig. 5.1 shows a thin plastic cup containing hot coffee, which an IGCSE Physics student gets from a machine.

Fig. 5.2 shows how another student, who finds an empty second cup, has placed his identical cup of coffee inside this second cup.

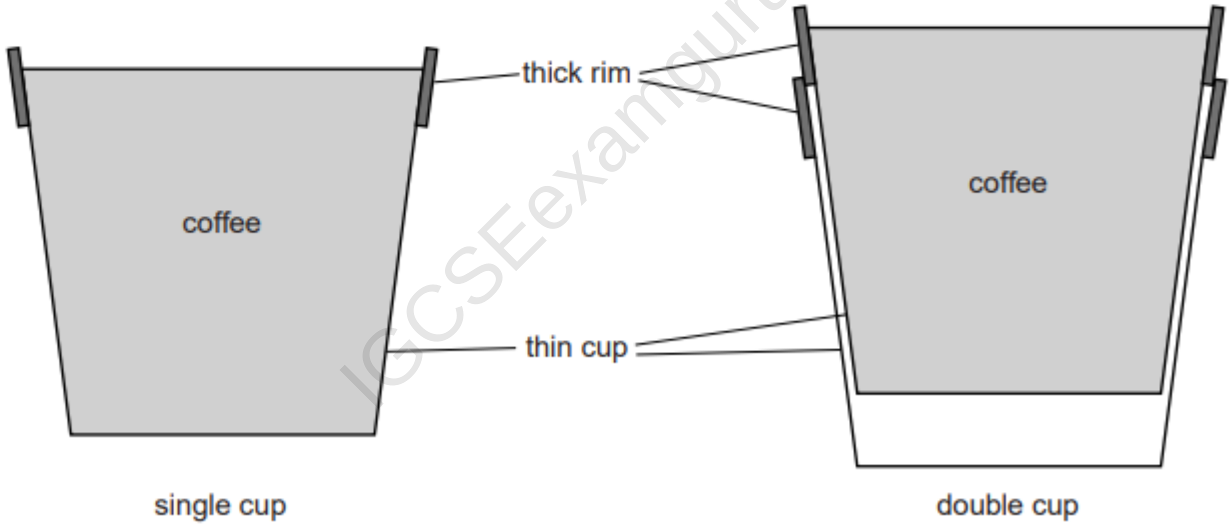

Fig. 5.1 **Fig. 5.2**

(a) Suggest and explain a difference that the students will feel when holding the cups.

....

....

....

.... [2]

(b) The students discuss this experience with their teacher, who makes hot drinks the subject of an experiment.

The same volume of hot water at the same temperature is placed in the single cup and in the double cup.

The temperature of the water in each cup is recorded for 10 minutes.

Fig. 5.3 shows the cooling curve for the water in the single cup.

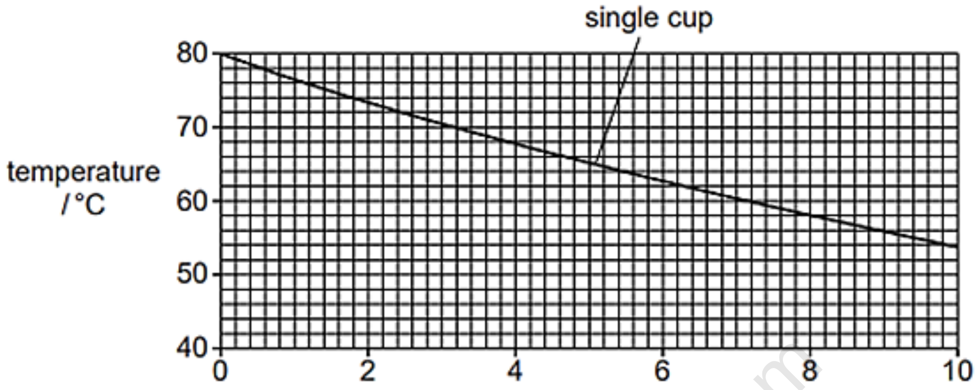

Fig. 5.3

On Fig. 5.3, sketch and label a possible cooling curve for the water in the double cup. [2]

(c) Explain why a cup of coffee cools more slowly when a lid is placed over the cup.

....

....

....

....

.... [2]

[Total: 6]

6 Cold water flows to the panels at 15 °C. During the day, the panels supply 3.8 kg of hot water at 65 °C every hour.

(a) Calculate the average energy that the solar panels deliver to the water in one hour. Specific heat capacity of water = 4200 J / (kg °C).

energy = ... [3]

7 **(a)** Define *specific latent heat of fusion*.

....

....

.... [1]

(b) **(i)** A tray of area 0.25 m^2, filled with ice to a depth of 12 mm, is removed from a refrigerator.

Calculate the mass of ice on the tray. The density of ice is 920 kg/m^3.

mass = ... [2]

(ii) Thermal energy from the Sun is falling on the ice at a rate of 250 W/m^2. The ice absorbs 60 % of this energy.

Calculate the energy absorbed in 1.0 s by the 0.25 m^2 area of ice on the tray.

energy = ... [2]

(iii) The ice is at its melting temperature.

Calculate the time taken for all the ice to melt. The specific latent heat of fusion of ice is 3.3×10^5 J/kg.

time = ... [3]

[Total: 8]

8 **(b)** Fig. 7.1 shows five vessels each made of the same metal and containing water.

Vessels A, B, C and D are identical in size and shape. Vessel E is shallower and wider. The temperature of the air surrounding each vessel is 20 °C.

Fig. 7.1

The table shows details about each vessel and their contents.

vessel	outer surface	volume of water / cm^3	initial temperature of water / °C
A	dull	200	80
B	shiny	200	80
C	dull	200	95
D	dull	100	80
E	dull	200	80

The following questions are about the time taken for the temperature of the water in the vessels to fall by 10 °C from the initial temperature.

(i) Explain why the water in B takes longer to cool than the water in A.

....

.... [1]

(ii) Explain why the water in C cools more quickly than the water in A.

....

.... [1]

(iii) Explain why the water in D cools more quickly than the water in A.

....

.... [1]

(iv) Suggest **two** reasons why the water in E cools more quickly than the water in A.

1. ....

....

2. ....

.... [2]

[Total: 7]

9 Fig. 5.1 shows a saucepan of boiling water on an electric hotplate.

Fig. 5.1

As time passes, thermal energy (heat) is constantly supplied to the water but its temperature remains at 100 °C.

(a) State two ways in which boiling differs from evaporation.

1. ....

....

2. ....

.... [2]

(b) Explain, in terms of the water molecules, what happens to the thermal energy supplied to the water as it boils.

....

....

....

.... [2]

(c) Describe an experiment to measure the specific latent heat of steam. You may include a diagram.

....

....

....

....

....

.... [4]

[Total: 8]

10 Water molecules evaporate from a puddle and escape to the atmosphere. Water molecules also escape to the atmosphere from water boiling in a kettle.

(a) State two ways in which *evaporation* differs from *boiling*.

1. ....

....

2. ....

....

[2]

(b) This part of the question is about an experiment to determine the specific latent heat of vaporisation of water.

(i) Suggest apparatus that will provide thermal energy (heat) and state the readings needed to determine the amount of thermal energy provided.

apparatus ....

....

readings ....

....

.... [2]

(ii) Suggest apparatus required for determining the mass of liquid vaporised and state the readings needed to determine that mass.

apparatus ....

....

readings ....

....

.... [2]

[Total: 6]

11 Fig. 4.1 shows a cross-section of a double-walled glass vacuum flask, containing a hot liquid. The surfaces of the two glass walls of the flask have shiny silvered coatings.

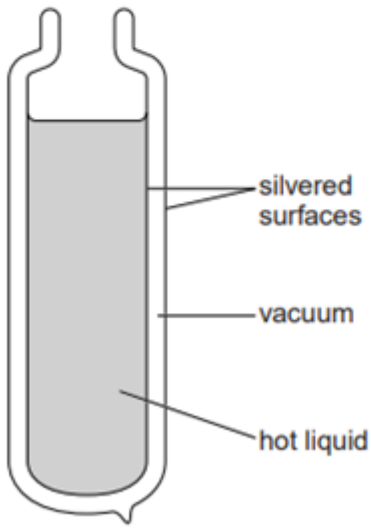

Fig. 4.1

(a) Explain

(i) why the rate of loss of thermal energy through the walls of the flask **by conduction** is very low,

....

....

....

....

(ii) why the rate of loss of thermal energy through the walls of the flask **by radiation** is very low.

....

....

....

....
[3]

(b) Suggest, with reasons, what must be added to the flask shown in Fig. 4.1 in order to keep the liquid hot.

....

....

....

....

....[3]

[Total: 6]

12 (b) The temperature of a person of mass 60 kg falls from 37.2 °C to 36.7 °C.

(i) Calculate the thermal energy lost from the body. The average specific heat capacity of the body is 4000 J / (kg °C).

thermal energy lost = ...[2]

(ii) The cooling of the body was entirely due to the evaporation of sweat.

Calculate the mass of sweat which evaporated. The specific latent heat of vaporisation of sweat is 2.4×10^6 J / kg.

mass = ... [2]

[Total: 7]

13 An archaeologist digging at an ancient site discovers a spoon. The spoon is made from an unidentified material.

(a) The archaeologist suspects that the spoon is made of metal. She places it above a flame, as shown in Fig. 1.1.

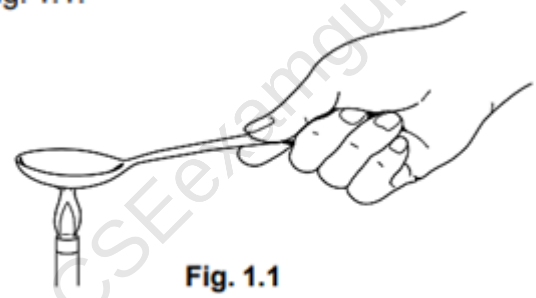

Fig. 1.1

(i) She notices that the handle of the spoon quickly becomes very hot.

State why this observation supports the suggestion that the spoon is made of metal.

....

.... [1]

(ii) Describe, in terms of its atoms, how thermal energy is transferred through a metal.

....

....

....

....

.... [3]

14 The Sun is a large sphere of high temperature gas. An extremely large quantity of energy radiates from the Sun into space every second.

(a) A process releases energy inside the Sun and its temperature stays high.

State the name of this process.

.... [1]

(b) A gardener stores water in a large, cylindrical metal drum. The drum is painted black and has no lid. On a bright, sunny day, the water evaporates quickly and the water level in the drum falls.

(i) Suggest how, by using a drum of a different shape, the gardener can reduce the quantity of water lost by evaporation.

....

.... [1]

(ii) The gardener is told that, by painting the drum white, he can reduce the quantity of radiation absorbed and so reduce the rate of evaporation.

Describe an experiment to show that black surfaces are better absorbers of radiation than white surfaces. You may include a diagram.

....

....

....

....

.... [4]

[Total: 6]

15 A student uses a 2400 W electric kettle to obtain a value for the specific heat capacity of sunflower oil.

Fig. 6.1 shows the apparatus.

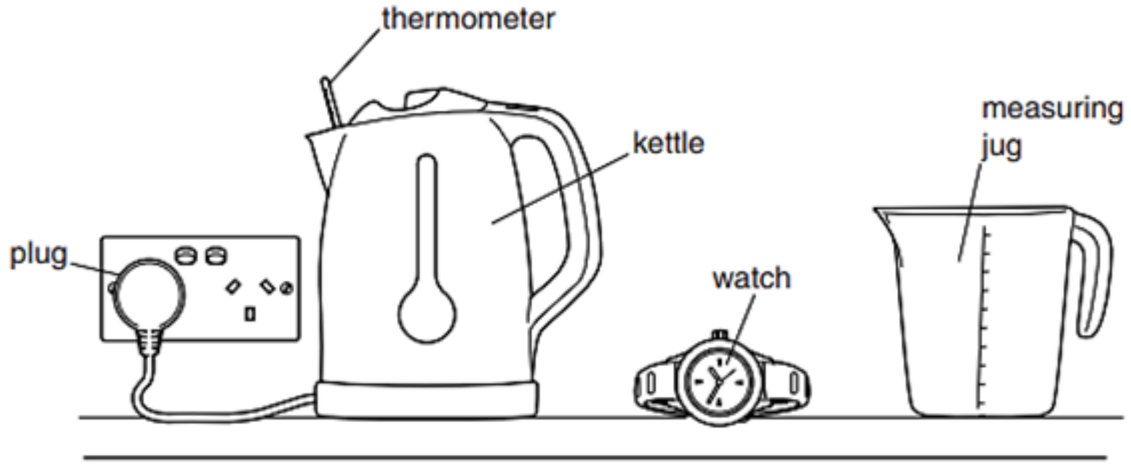

Fig. 6.1

The student uses a measuring jug and pours 1.5 kg of sunflower oil into the empty kettle. He uses a thermometer to measure the temperature of the oil.

The kettle is switched on and left on for 50 s. The temperature of the oil increases by 32 °C.

The student assumes that all the electrical energy is transferred as thermal energy to the oil.

(a) Calculate the value for the specific heat capacity of sunflower oil obtained by the student.

specific heat capacity = ... [4]

(b) State and explain whether the value for the specific heat capacity obtained by the student is too large or too small.

....

.... [1]

[Total: 5]

16 Fig. 5.1 shows two identical metal cans, open at the top, used in an experiment on thermal energy. The outside of can A is polished and the outside of can B is painted black.

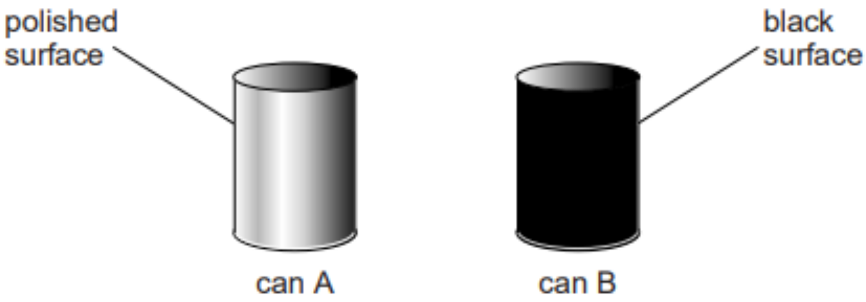

Fig. 5.1

(a) The cans are heated to the same temperature. Predict and explain the relative rates of loss of thermal energy by infra-red radiation from the two cans.

....

....

....

....[2]

(b) **(i)** A student is provided with the two cans, a supply of hot water and two thermometers.

Describe the experiment he should carry out to test your answer to **(a)**.

....

....

....

....

....

....

....

....

....

....[4]

(ii) Another student is given the same equipment but finds two polystyrene tiles. Fig. 5.2 shows the tiles alongside the cans.

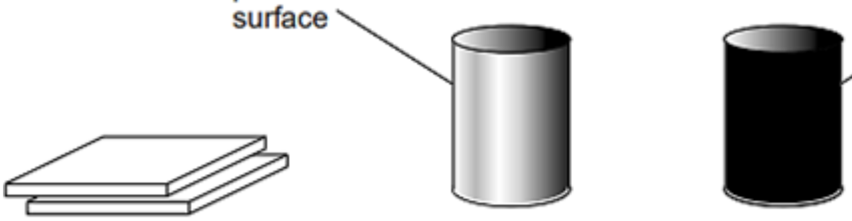

Fig. 5.2

State how she could use the tiles to improve the experiment, and explain why this is effective.

....

....

....

.... [2]

(c) The two cans are now filled with cold water and placed equal distances from a strong source of infra-red radiation.

State and explain which can of water heats up more quickly.

....

....

....

.... [2]

[Total: 10]

17 (b) A car of mass 940 kg is travelling at 16 m/s.

(i) Calculate the kinetic energy of the car.

kinetic energy = ... [2]

(ii) The car is brought to rest by applying the brakes.

The total mass of the brakes is 4.5 kg. The average specific heat capacity of the brake material is 520 J / (kg °C).

Calculate the rise in temperature of the brakes. Assume there is no loss of thermal energy from the brakes.

rise in temperature = ... [3]

[Total: 8]

18 One side of a copper sheet is highly polished and the other side is painted matt black.

The copper sheet is very hot and placed in a vertical position, as shown as in Fig. 5.1.

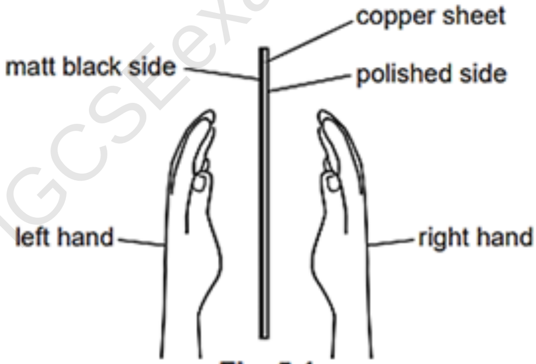

Fig. 5.1

A student places her hands at equal distances from the sheet, as shown in Fig. 5.1.

(a) Explain

(i) why her hands are not heated by **convection**,

....

.... [1]

(ii) why her hands are not heated by **conduction**.

....

.... [1]

(b) State and explain which hand gets hotter.

....

....

.... [2]

(c) It is suggested that one side of the copper sheet cools to a lower temperature than the other side.

Explain why this does not happen.

....

....

.... [2]

[Total: 6]

19 During both boiling and evaporation, liquid water is converted into water vapour.

The rate at which the mass of **boiling** water decreases depends only on the rate at which the water is gaining thermal energy.

(a) The specific latent heat of vaporisation of water is 2.3×10^6 J/kg. Thermal energy is supplied to boiling water in a kettle at a rate of 460 W.

Calculate the mass of water that is boiled away in 180 s.

mass = ... [2]

20 The liquids in five liquid-in-glass thermometers A, B, C, D and E expand linearly with temperature. All the thermometers have scales marked in °C. Fig. 6.1 accurately represents the scales of these five thermometers.

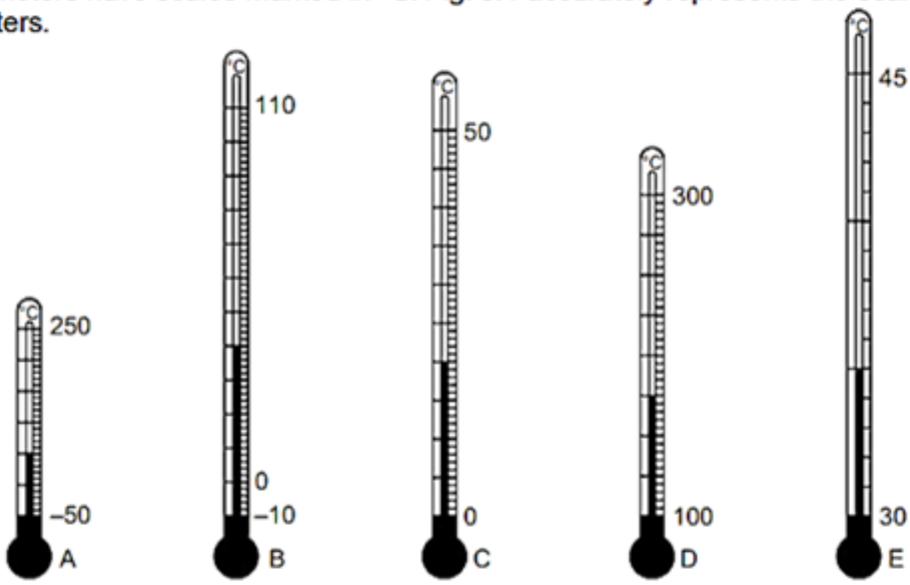

Fig. 6.1

(a) **(i)** Use information from the scales of the thermometers in Fig. 6.1 to state which thermometer has the greatest range.

.... [1]

(ii) State and explain which thermometer has the greatest sensitivity.

....

.... [1]

(b) Suggest two design features that would cause a liquid-in-glass thermometer to have a large sensitivity.

1. ....

2. ....
[2]

(c) The distance on thermometer B between the 110 °C mark and the −10 °C mark is 18 cm.

Calculate the length of the liquid thread above the −10 °C mark when the temperature recorded by B is 70 °C.

length = ... [2]

[Total: 6]

21 **(a)** Define the *specific heat capacity* of a substance.

....

.... [2]

(b) Fig. 4.1 shows a cylinder of aluminium heated by an electric heater.

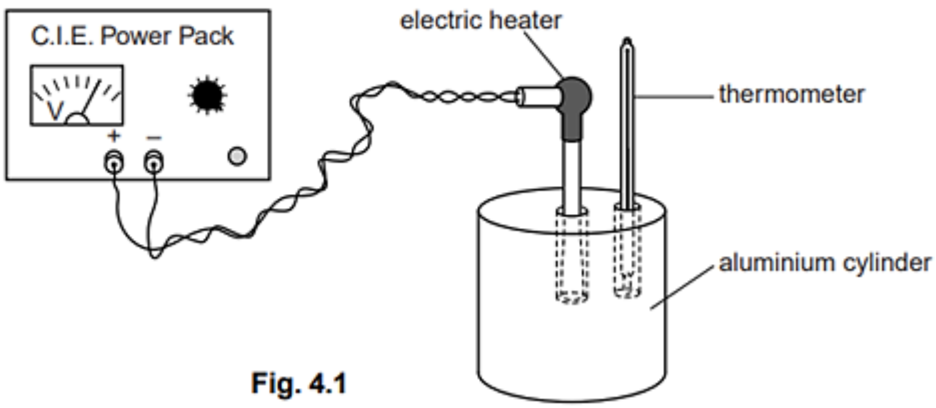

Fig. 4.1

The mass of the cylinder is 800 g. The heater delivers 8700 J of thermal energy to the cylinder and the temperature of the cylinder increases by 12 °C.

(i) Calculate a value for the specific heat capacity of aluminium.

specific heat capacity = ... [2]

(ii) Calculate the thermal capacity (heat capacity) of the aluminium cylinder.

thermal capacity = ... [2]

(c) State and explain a method of improving the accuracy of the experiment.

....

....

.... [2]

[Total: 8]

22 (c) Describe an experiment to demonstrate the difference between good and bad emitters of infra-red radiation. You may include a diagram to help your description. State what readings should be taken.

....

....

....

....

....

....[3]

[Total: 9]

23 (a) Fig. 1.1 shows a liquid-in-glass thermometer.

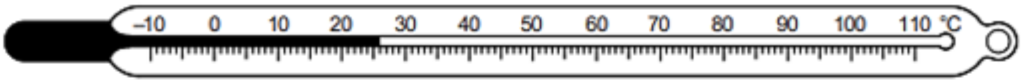

Fig. 1.1

(i) In the process of making the thermometer, the scale divisions were spaced equally.

What assumption was made about the liquid?

....

.... [1]

(ii) Suggest **two** changes to the thermometer that would require the spacing of the scale divisions to be larger.

1. ....

2. ....

[2]

(iii) As a result of the changes in **(ii)**, what other change is needed to enable the thermometer to be used for the same temperature range?

.... [1]

(b) The expansion of a liquid is an example of a physical property that may be used to measure temperature.

State **two** other physical properties that may also be used to measure temperature.

1. the .... of ....

2. the .... of ....

[2]

[Total: 6]

24 (a) The following are three statements about boiling.

- A liquid boils at a fixed temperature.
- During boiling, vapour can form at any point within the liquid.
- Without a supply of thermal energy, boiling stops.

Complete the following equivalent statements about evaporation.

- A liquid evaporates at ....

  ....

- During evaporation ....

  ....

- Without a supply of thermal energy, evaporation ....

[3]

(b) A pan containing water boiling at 100 °C is standing on an electrically heated hot-plate. In 20 minutes, 0.075 kg of water is lost as steam. The specific latent heat of vaporisation of water is 2.25×10^6 J / kg.

(i) Calculate the energy used in converting 0.075 kg of boiling water to steam.

energy = ... [2]

(ii) The hot-plate operates at 240 V, 0.65 A.

Calculate the energy supplied to the hot-plate in 20 minutes.

energy = ... [2]

(iii) Suggest why the answers to **(b)(i)** and **(b)(ii)** are not the same.

....

.... [1]

[Total: 8]

25 (b) (iii) The specific latent heat of vaporisation of ethanol is 850 J / g.

Calculate the thermal energy required to evaporate 3.4 g of ethanol.

thermal energy = ... [2]

26 A technician is designing a liquid-in-glass thermometer. The following is a list of properties of the thermometer that she is considering.

sensitivity　　range　　speed of response　　linearity

(a) (i) 1. Which one of these properties is affected by the length of the stem of the thermometer?

....

2. Explain your answer.

....

....

[2]

(ii) **1.** Which property is affected by the diameter of the capillary?

....

2. Explain your answer.

....

....
[2]

(b) The thermometer is to be used to measure temperatures between −10 °C and 50 °C. The technician considers using water or red-coloured alcohol as the liquid in the thermometer.

(i) Write down which liquid would be suitable.

....

(ii) Give **two** reasons for your answer.

1. ....

....

2. ....

....
[2]

[Total: 6]

27 Fig. 4.1 shows some of the apparatus that a student uses to determine the specific heat capacity of aluminium.

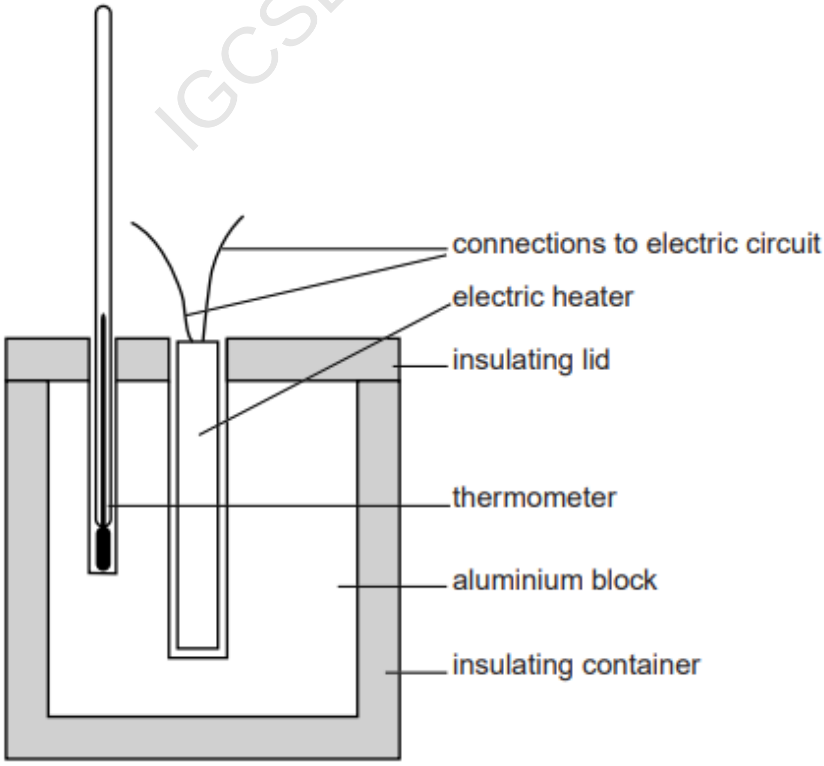

Fig. 4.1

(a) State the measurements the student needs to make, including those from the electric circuit. For each quantity measured, state a symbol.

....

....

....

....

....

....

....[4]

(b) Use your symbols from **(a)** to complete the formula used to determine the specific heat capacity *c*.

specific heat capacity *c* =

....[2]

(c) Another student performs the experiment without using insulation. He obtains a higher value for *c*.

Explain why this student's measurements lead to this higher value.

....

.... [1]

[Total: 7]

28 (b) (ii) Later, the temperature increases and some of the balloons burst.

Suggest and explain why this happens.

....

....

....[2]

[Total: 9]

29 A liquid-in-glass thermometer has a linear scale and a range of 120 °C.

(a) State what is meant by a *linear scale*.

....

....[1]

(b) The highest temperature that this thermometer can measure is 110 °C.

State the lowest temperature that it can measure.

lowest temperature = ...[1]

(c) A second liquid-in-glass thermometer has the same range but it has a greater sensitivity.

Suggest **two** ways in which the second thermometer might differ from the first.

1. ....

2. ....

[2]

(d) A thermometer has a bulb that is painted white and is shiny.

It is placed in boiling water for several minutes. It is then removed from the water and is held in air.

Fig. 4.1 shows how the thermometer reading changes during the next 8 minutes.

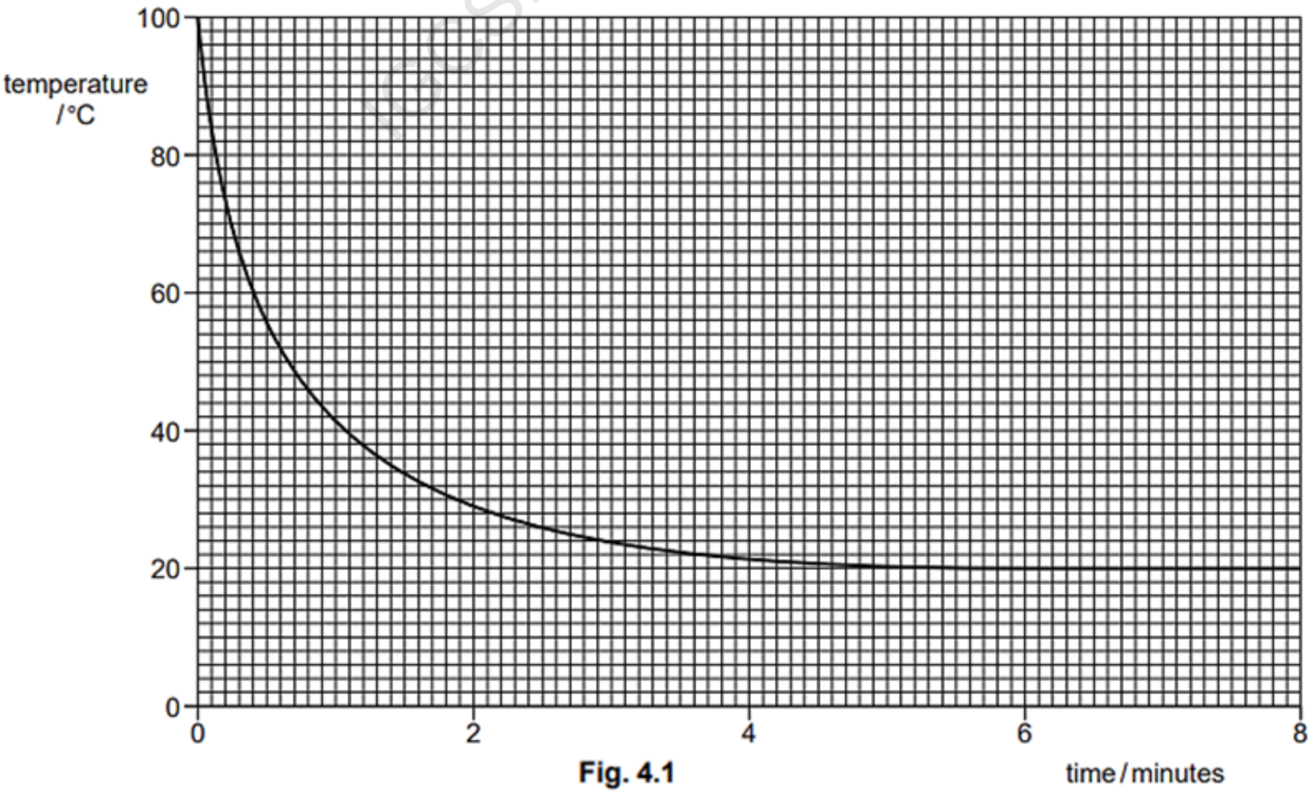

Fig. 4.1

The bulb of this thermometer is now re-painted so that it has a matt, black surface.

The procedure is repeated.

(i) On Fig. 4.1, sketch a second line to suggest how the reading of the re-painted thermometer changes during the 8 minutes. [2]

(ii) Tick **one** of the boxes to show how painting the bulb black affects the linearity of the scale, the range and the sensitivity of the thermometer.

☐ The linearity, the range and the sensitivity all change.

☐ Only the linearity and the range change.

☐ Only the linearity and the sensitivity change.

☐ Only the range and the sensitivity change.

☐ Only the linearity changes.

☐ Only the range changes.

☐ Only the sensitivity changes.

☐ None of these properties changes.

[1]

[Total: 7]

30 **(a)** State what is meant by the *specific latent heat of fusion* (*melting*) of a substance.

....

....[2]

(b) Ice cubes of total mass 70 g, and at 0 °C, are put into a drink of lemonade of mass 300 g.

All the ice melts as 23 500 J of thermal energy transfers from the lemonade to the ice. The final temperature of the drink is 0 °C.

(i) Calculate the specific latent heat of fusion for ice.

specific latent heat of fusion = ...[2]

(ii) The thermal energy that causes the ice to melt is transferred from the lemonade as it cools. The loss of this thermal energy causes the temperature of the 300 g of the lemonade to fall by 19 °C.

Calculate the specific heat capacity of the lemonade.

specific heat capacity = ...[2]

(iii) The melting ice floats on top of the lemonade.

Explain the process by which the lemonade at the bottom of the drink becomes cold.

....

....

....[2]

[Total: 8]

31 (a) Fig. 4.1 shows a device used as a thermocouple thermometer.

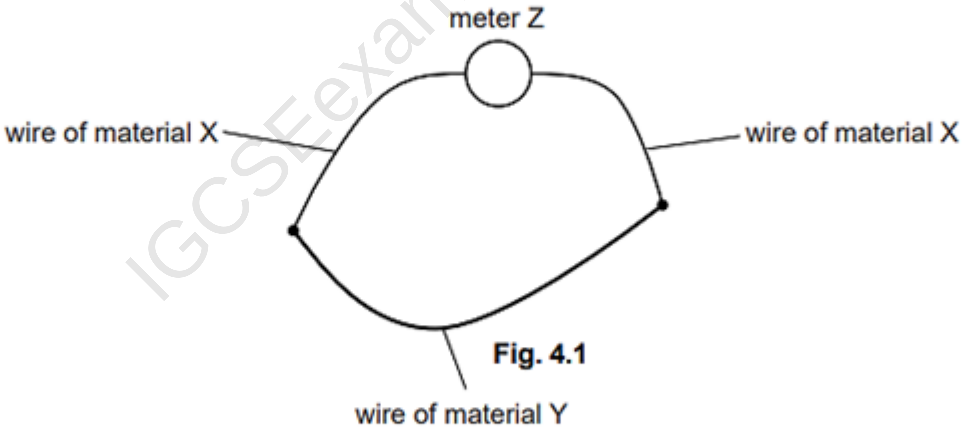

Fig. 4.1

In the table put **three** ticks against the correct statements about the thermocouple thermometer.

Meter Z measures energy.	
Meter Z measures potential difference.	
Meter Z measures power.	
Materials X and Y are different materials.	
Materials X and Y are the same material.	
Materials X and Y are electrical conductors.	
Materials X and Y are electrical insulators.	

[3]

(b) A liquid-in-glass thermometer is replaced by a similar thermometer with a larger bulb. No other change is made.

State and explain the effect on the sensitivity.

....

....

....[2]

(c) The capillary of a liquid-in-glass thermometer should have a constant diameter.

Fig. 4.2 shows the capillary of a thermometer made with a manufacturing fault.

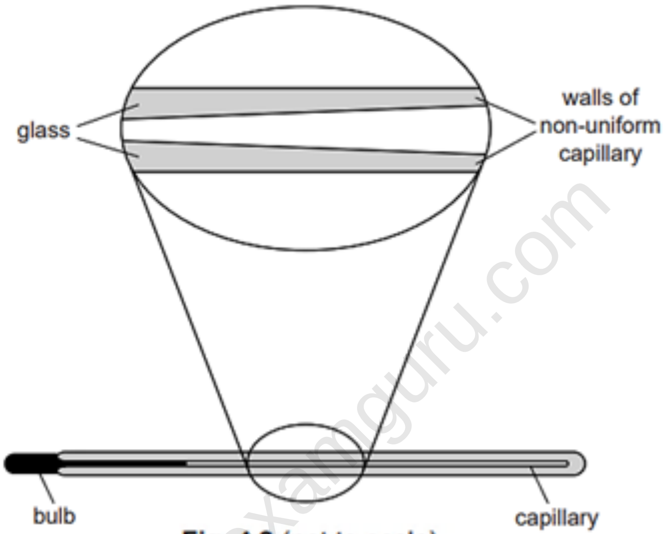

Fig. 4.2 (not to scale)

State and explain the effect of this fault on the linearity of the thermometer.

....

....

....[2]

[Total: 7]

32 (a) (ii) Explain, in terms of energy, the process which takes place as a solid at its melting point changes into a liquid at the same temperature.

....

....

.... [1]

(b) During a severe snowstorm, a layer of snow (ice crystals) forms on the body of an animal in a field. The snow and the surrounding air are at 0 °C. The snow begins to melt.

(i) The mass of snow that falls on the animal is 1.65 kg. The specific latent heat of fusion of snow is 330 000 J / kg.

Calculate the thermal energy needed to melt this snow.

thermal energy = ... [2]

(ii) The animal derives energy from its food to maintain its body temperature.

State the energy change that takes place.

.... [1]

[Total: 6]

33 **(a)** State what is meant by the *specific heat capacity* of a substance.

....

....

.... [2]

(b) A student carries out an experiment to find the specific heat capacity of aluminium. He uses an electric heater and a thermometer, inserted into separate holes in an aluminium block.

The following data are obtained.

mass of aluminium block = 2.0 kg
power of heating element = 420 W
time of heating = 95 s
initial temperature of block = 19.5 °C
final temperature of block = 40.5 °C

Calculate the value of the specific heat capacity of aluminium given by this experiment.

specific heat capacity = ... [4]

(c) In the experiment in **(b)**, no attempt is made to prevent loss of thermal energy from the surfaces of the block.

Suggest two actions the student could take to reduce the loss of thermal energy from the surfaces of the block.

1. ....

2. .... [2]

[Total: 8]

34 (a) State two examples of physical properties that vary with temperature and that may be used for the measurement of temperature.

1. ....

2. .... [2]

(b) When first manufactured, a liquid-in-glass thermometer has no scale markings.

(i) Describe the procedure needed to determine

1. the position on the thermometer of the lower fixed point,

....

....

....

2. the position on the thermometer of the upper fixed point.

....

....

.... [3]

(ii) Explain why

1. the graduations marked on the thermometer between the fixed points are spaced equally,

....

....[1]

2. the expansion of the glass of the thermometer is ignored.

....

....[1]

[Total: 7]

35 **(a)** X and Y are liquid-in-glass thermometers. The scale of each thermometer starts at 0 °C.

X has a large range, good linearity and high sensitivity.
Y has a small range, poor linearity and low sensitivity.

Explain what is meant by

(i) the difference in their *ranges*,

....

....

(ii) the difference in their *linearities*,

....

....

(iii) the difference in their *sensitivities*.

....

....
[3]

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....

....

[3]

(b) A thermocouple is used to measure the temperature of a small volume of liquid.

(i) Draw and label a sketch of the arrangement.

[3]

(ii) The temperature of the liquid is changing rapidly.

Explain why the thermocouple is able to respond quickly to this rapid change.

....

....

....[2]

[Total: 8]