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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Thermal Properties of Matter

Paper 2 — Theory / Structured Questions (topical compilation)

Fahad H. Ahmad

Contact: +92 323 509 4443

M.Eng NUS Singapore · B.Eng NUST · 15+ years of teaching experience in Singapore, UAE & Pakistan · 60,000+ subscribers and 20 million+ video lecture views.

1 Fig. 3.1 illustrates the arrangement of the molecules of a substance in its solid, liquid and gaseous states.

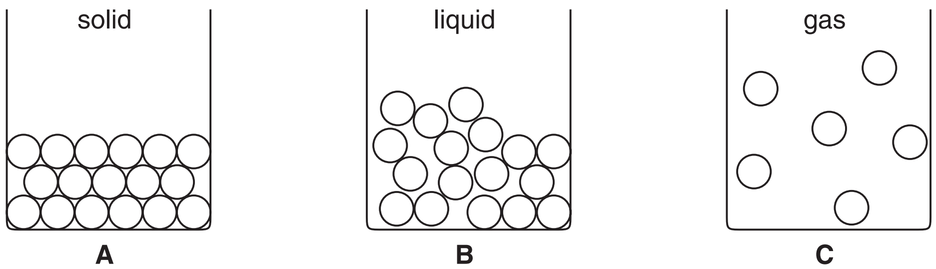


Fig. 3.1

(a) State which arrangement, **A**, **B** or **C**, contains molecules with the most energy.

....[1]

(c) Define the term *specific latent heat of fusion* of a substance.

....

....

....

....

....[2]

5054/02/M/J/03/Q3

2 A student compares the efficiency of two electric water heaters in the kitchen. Each heater consists of a tank to contain the water and an electrical heating element to heat the water.

The two tanks are different, but each tank contains the same amount of water and is heated by the same type of electrical heating element.

Fig. 10.1 shows part of the tank from the heater that is less efficient, and Fig. 10.2 shows the heater that is more efficient.

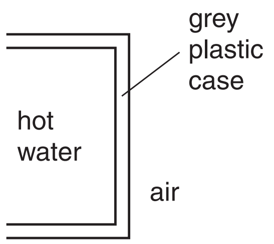


Fig. 10.1

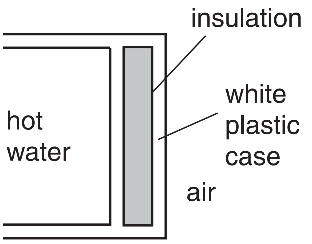


Fig. 10.2

(c) When one heater is switched on, 15 kg of cold water at 20 °C is heated to 56 °C in ten minutes. The electrical heater is rated 5000 W, 230 V. The specific heat capacity of water is 4200 J/(kg °C).

(i) Calculate the increase in the internal energy (heat) of the water in ten minutes.

(ii) Calculate the electrical energy input to the heater in ten minutes.

(iii) Calculate the efficiency of the heater.

[8]

5054/02/M/J/03/Q10

3 Thermal expansion can be a problem.

Fig. 3.1

Small gaps are left in railway lines and in bridges, as shown in Fig. 3.1.

(a) Explain in detail why the gaps are needed.

....

....

....

....

....[3]

(b) State one other problem caused by thermal expansion and explain how it can be solved.

....

....

....[1]

5054/02 M/J/04/Q3

4 Fig. 10.1 is a full-scale drawing of a small aluminium bar.

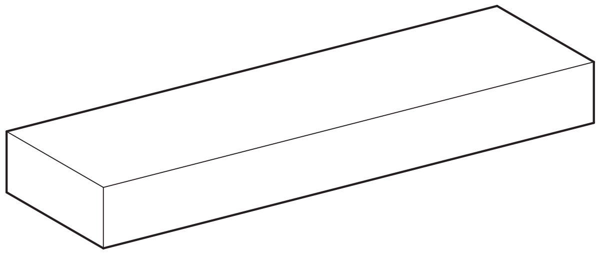


Fig. 10.1

(a) Describe how the density of aluminium may be determined using the bar. In your account

(i) describe the readings to be taken,

(ii) state the instruments used to make the readings,

(iii) describe how the density is calculated from the readings.

[6]

(b) The bar is placed in a small furnace.
Fig. 10.2 shows how the temperature of the bar varies with time *t*.

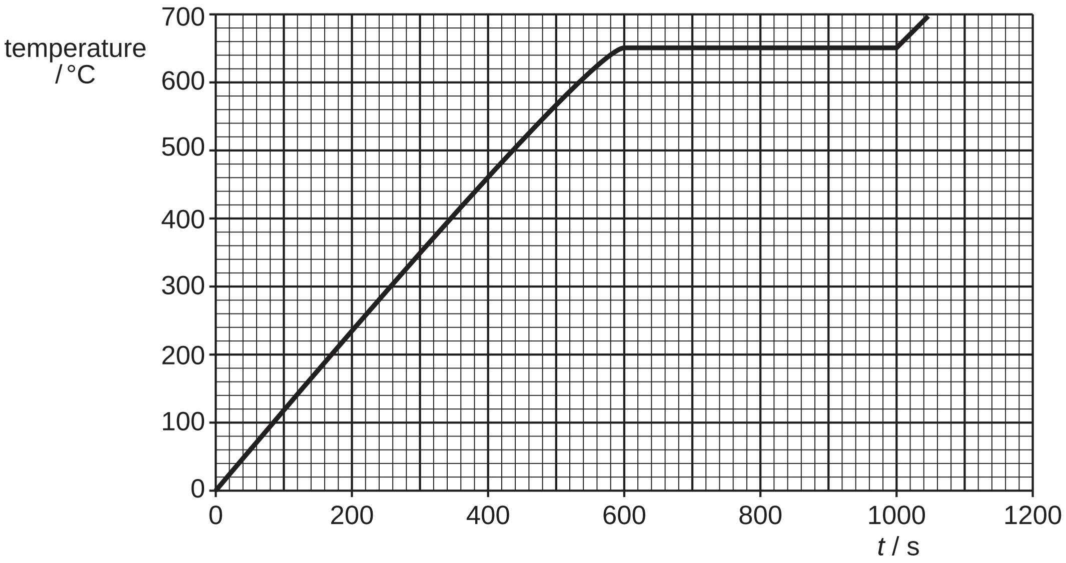


Fig. 10.2

(i) State what happens to the bar between t = 600 s and 1000 s.

(ii) Explain what effect the energy supplied to the bar has on its molecules between t = 0 and 1000 s.

(iii) The mass of the bar is 0.030 kg and the specific heat capacity of aluminium is 880 J/(kg °C). Calculate the energy supplied to the bar between t = 0 and 600 s.

5054/02 M/J/04/Q10

5 A student has an open tank for storing water outside her house. The tank is black and is in direct sunlight.

She notices that the level of water inside the tank slowly decreases as water evaporates.

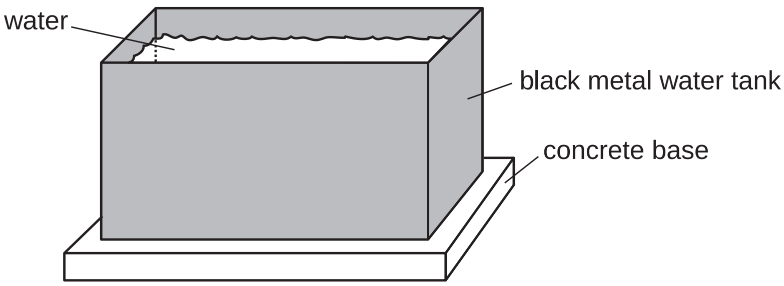


Fig. 9.1

She investigates whether some changes, shown in the table, will affect the amount of water evaporated each day.

change 1	a heater is used to increase the temperature of the water
change 2	a sheet of plastic is used to cover half the surface of the water
change 3	a fan is used to blow air over the top of the tank
change 4	the outside of the tank is painted white

Only one change is made at a time. All other factors are kept constant.

(a) State whether each change will increase, leave unchanged or decrease the amount of water evaporated each day. Explain each of your answers. [8]

(b) She notices that the water level in the tank falls by 0.005 m in 40 000 s.

The cross-sectional area of the tank is $3.0\,m^2$. The density of water is $1000\,kg/m^3$.

The specific latent heat of vaporisation of water is 2.2×10^6 J/kg.

Calculate

(i) the volume of water that evaporates, [1]

(ii) the mass of water that evaporates, [2]

(iii) the energy required to evaporate the water, [2]

(iv) the average rate at which energy is used to evaporate the water. [2]

5054/02/M/J/06/Q9

6 A student investigates the evaporation of water. He pours 100 cm^3 of water into measuring cylinder A and 100 cm^3 of water into measuring cylinder B. Measuring cylinder A is kept at 40 °C and B is kept at 80 °C in the same part of the laboratory. Fig. 2.1 shows the two measuring cylinders after 3 days.

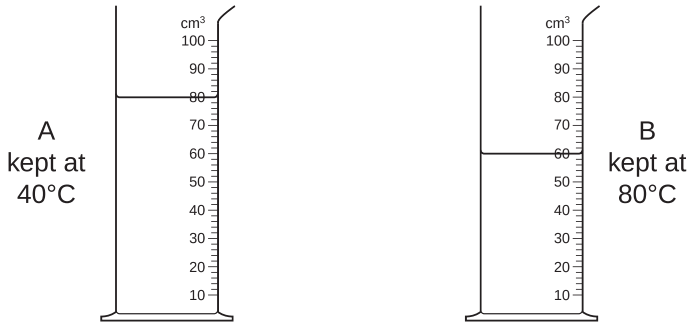


Fig. 2.1

(a) (i) Using ideas about molecules, explain why more water evaporates when the water is kept at 80 °C.

....

....

....

....

....

.... [2]

(ii) Apart from an increase in temperature, state one change that causes water to evaporate faster.

....

.... [1]

5054/02/M/J/07/Q2

7 Liquid air contains a mixture of oxygen and nitrogen.
The boiling point of nitrogen is –196 °C and the boiling point of oxygen is –183 °C.
A sample of liquid air in a beaker is allowed to warm up slowly.
Fig. 4.1 shows how the reading of a thermometer in the beaker varies with time *t*.

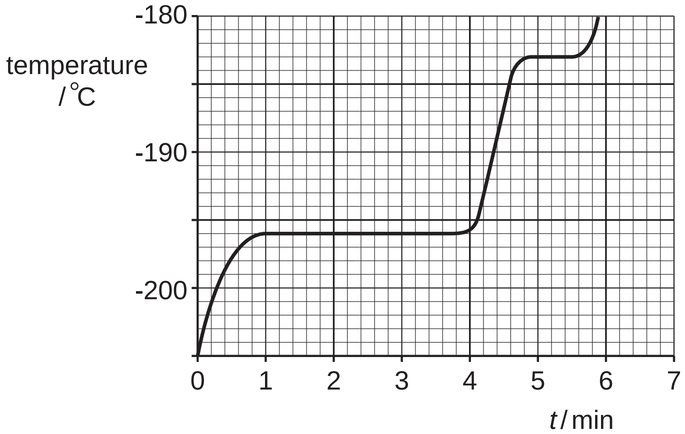


Fig. 4.1

(a) Describe the two changes of state that occur and state when they occur.

....

....

....

.... [3]

(b) The liquid air contains 200 g of liquid oxygen and 800 g of liquid nitrogen.
The specific heat capacity of liquid oxygen is 1.7 J / (g °C) and the specific heat capacity of liquid nitrogen is 2.0 J / (g °C).
Calculate the thermal energy needed to warm the liquid from –205 °C to −196 °C.
State the formula that you use in your calculation.

energy = ... [4]

5054/02/M/J/08/Q4

8 **(e)** Fig. 9.2 shows a copper block of mass 1.8 kg with two holes in the top. An 80 W heater is placed in one hole and a thermometer in the other.

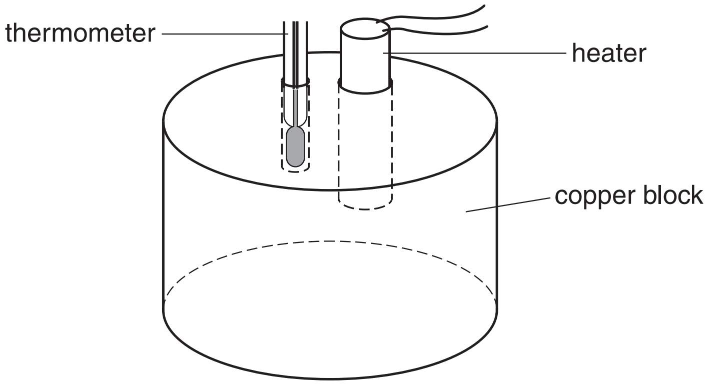


Fig. 9.2

The heater is switched on for 5.0 minutes. Assume that no energy is lost from the block.

(i) Calculate the energy supplied to the block.

energy supplied = ... [2]

(ii) The specific heat capacity of copper is 390 J / (kg °C). Calculate the rise in temperature of the block.

temperature rise = ... [2]

5054/21/M/J/10/Q9

9 Fig. 3.1 shows a metal roof. One side is facing the Sun.

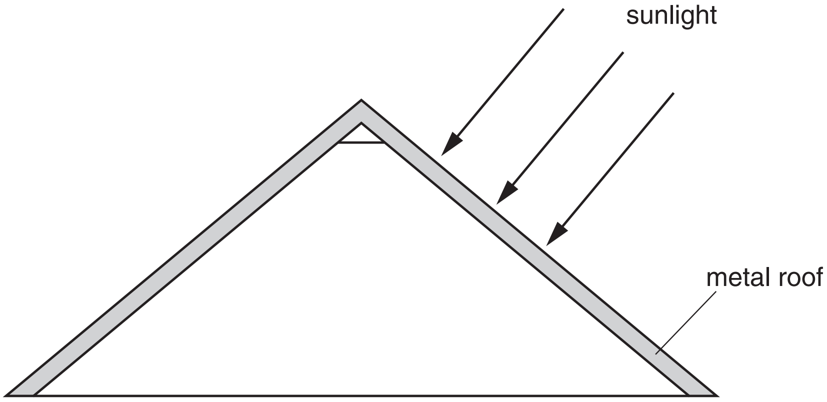


Fig. 3.1

(a) State the means by which thermal energy (heat) is transferred from the Sun to the Earth and explain why other means of thermal energy transfer are not involved.

....

....[2]

(b) Describe how thermal energy is transferred through the metal roof from the heated surface.

....

....

....[2]

(c) During the night, the metal roof loses 1.2×10^6 J of thermal energy and its temperature falls by 20 °C.

The specific heat capacity of the metal in the roof is 400 J / (kg °C).

Calculate the mass of metal in the roof.

mass = ...[2]

5054/22/M/J/10/Q3

10 A student notices puddles of water on a road, as shown in Fig. 4.1.

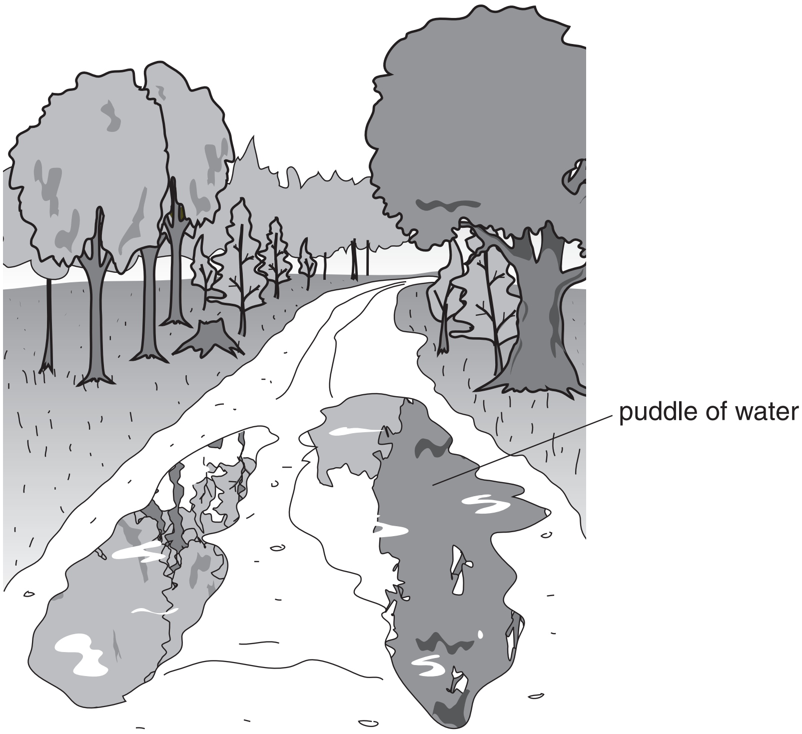


Fig. 4.1

Later in the day, he passes the puddles again and some of the water has evaporated.

(a) State two changes to the atmospheric conditions that would cause the water to evaporate faster.

1. ....

2. ....
[2]

(b) Explain, in terms of molecules, what happens during evaporation.

....

....

....

....

....[2]

5054/22/M/J/10/Q4

11 Water at a temperature of 16 °C enters an ice-making machine and emerges as ice cubes at a temperature of –5 °C. The melting point of ice is 0 °C.

(b) Using ideas about molecules,

(i) explain why energy is needed to change ice into water,

....

....

.... [1]

(ii) suggest why less energy is needed to change ice into water than to change the same mass of water into steam.

....

....

.... [1]

5054/21/M/J/11/Q4

12 **(a)** In an experiment to measure the specific heat capacity of water, an electric heater heats water in a glass beaker. The temperature of the water is measured at regular intervals of time. Fig. 11.1 shows how the temperature varies with time *t*.

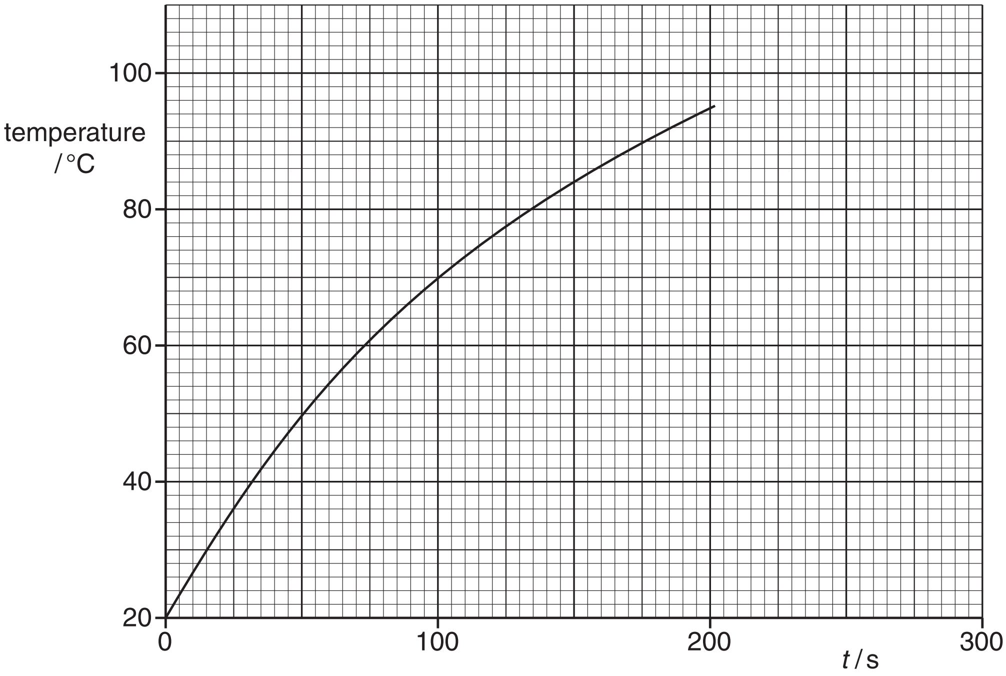


Fig. 11.1

(i) Use Fig. 11.1 to determine the change in temperature between

$t = 0$ and $t = 100\,s$,

change = ...

$t = 100\,s$ and $t = 200\,s$.

change = ...
[1]

(ii) State and explain why the values in **(i)** are different.

....

....

....[2]

(iii) Describe and explain what happens to the water if the heating is continued.

....

....

....[2]

(b) **(i)** The experiment in **(a)** is repeated using 72 g of water. The heater supplies 7400 J of thermal energy (heat) to the water and the temperature rise of the water is 23 °C.

Calculate the specific heat capacity of water.

specific heat capacity = ...[2]

(ii) A bullet of mass 72 g is fired from a gun at a speed of 450 m / s.

Calculate the kinetic energy of the bullet.

energy = ...[3]

(iii) The amount of internal energy gained by the water and the amount of kinetic energy gained by the bullet are approximately equal.

Describe the change in the motion of the molecules of the water and of the molecules of the bullet that this addition of energy has caused.

water: ....

....

bullet: ....

....

[3]

5054/22/M/J/11/Q11

13 A student slowly heats a sample of solid wax in a test-tube.
Fig. 4.1 shows how the temperature of the wax varies with time *t*.

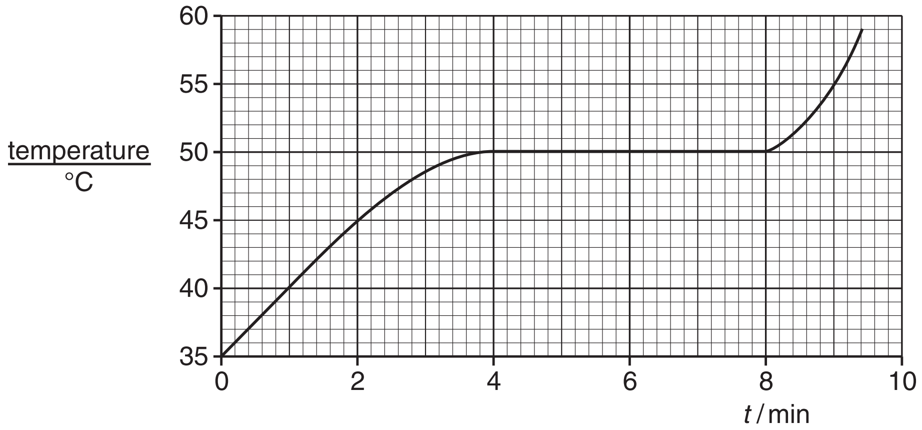


Fig. 4.1

(a) State what is meant by the *melting point* of a substance.

....

....[1]

(b) Thermal energy (heat) passes into the wax throughout the experiment.

(i) Describe what effect this energy has on the wax between $t = 0$ and $t = 4$ min.

....

....[1]

(ii) Describe and explain what effect this energy has on the wax between $t = 4$ min and $t = 8$ min.

....

....

....[2]

(c) The wax expands as the temperature rises. It expands more between $t = 8$ min and 9 min than between $t = 0$ and 1 min. Explain why.

....

....[1]

5054/21/M/J/12/Q4

14 A beaker contains 60 g of a hot substance, initially in the liquid state. Fig. 4.1 shows how the temperature of the substance changes with time t as it cools in a laboratory.

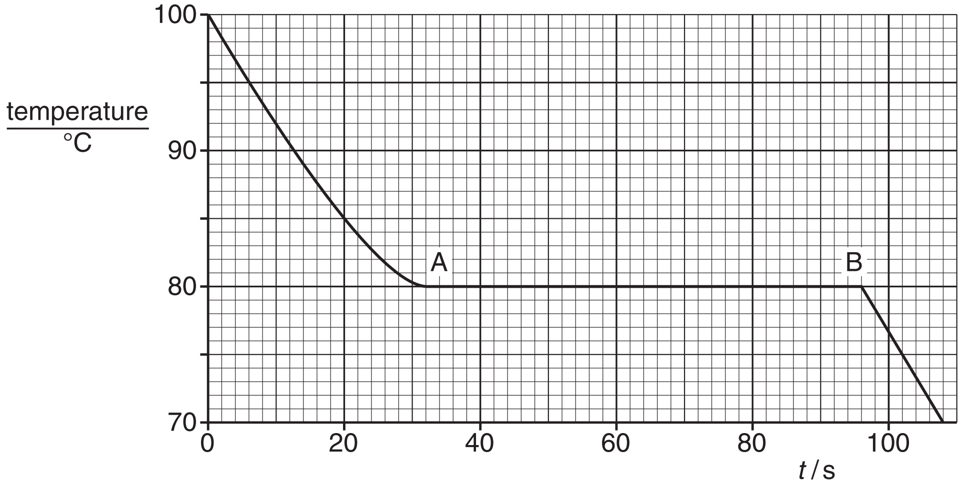


Fig. 4.1

(a) Use Fig. 4.1 to determine the melting point of the substance.

....[1]

(b) The specific heat capacity of the liquid is 1.7 J / (g °C). Calculate the loss of thermal energy (heat) from the liquid between $t = 0$ and $t = 20$ s.

loss of thermal energy = ...[2]

(c) Between points A and B on Fig. 4.1, the temperature is constant as the substance changes from liquid to solid.

(i) Explain why the temperature stays constant, even though thermal energy is lost by the substance.

....

....[2]

(ii) Describe the change in the arrangement of the molecules as the substance changes from a liquid to a solid.

....

....

.... [2]

5054/22/M/J/12/Q4

15 **(a)** The average input power to a freezer is 80 W. The cost of 1 kW h is 25 cents.

(i) Explain what is meant by the *kilowatt-hour* (kW h).

....

.... [2]

(ii) Calculate the cost of running the freezer for one week.

cost = ... [3]

(b) A large jug containing 1.5 kg of water is placed in the freezer.

(i) The water cools from 25 °C to 0 °C in a time of 60 minutes. The specific heat capacity of water is 4.2 J / (g °C).

Calculate the thermal energy (heat) removed from the water as it cools from 25 °C to 0 °C.

energy removed = ... [3]

5054/21/M/J/13/Q10

16 A student places a small electrical heater inside a cup of water, as shown in Fig. 11.1.

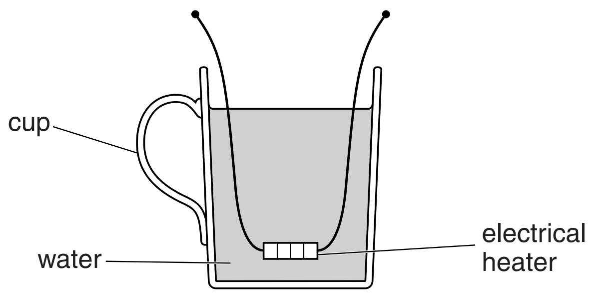


Fig. 11.1

The student determines the electrical power of the heater.

(a) In the space above the cup on Fig. 11.1, draw the electrical circuit that the student uses. Include an ammeter, a voltmeter and a power supply. [2]

(b) The voltage of the power supply is 12 V and the current is 4.2 A.

(i) Calculate the electrical power input to the heater.

power = ... [2]

(ii) Calculate the energy input to the heater in 8.0 minutes. Give your answer in kW h.

energy = ... kW h [3]

(c) During heating, the student notices that some of the water evaporates from the cup.

(i) Describe, using ideas about molecules of water, what happens during evaporation.

....

....

.... [2]

(ii) The student finds that the amount of evaporation increases when the temperature of the water is higher.

State and explain one other change that increases the amount of evaporation.

....

....

.... [2]

(iii) State two differences between evaporation and boiling.

1. ....

....

2. ....

....

[2]

5054/22/M/J/13/Q11

17 Fig. 2.1 shows apparatus used when determining the specific heat capacity of aluminium.

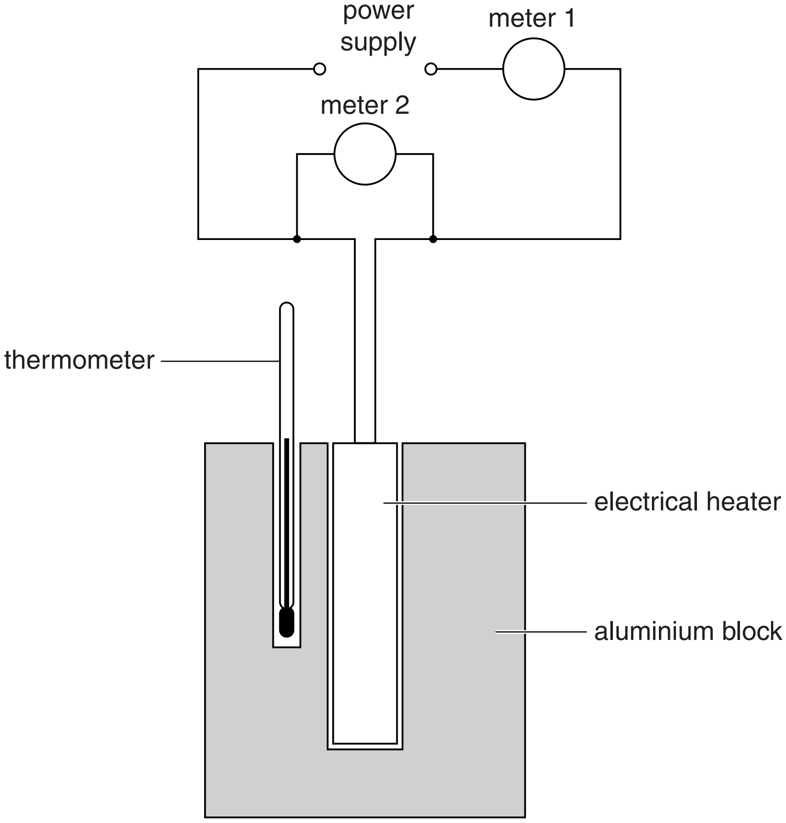


Fig. 2.1

Meter 1 and meter 2 are electrical meters.

(a) State the quantities measured by meter 1 and by meter 2.

meter 1: ....

meter 2: .... [1]

(b) The following results are obtained in the experiment:

initial temperature of block	= 18 °C
final temperature of block	= 40 °C
mass of block	= 0.85 kg
energy supplied to heater	= 17 000 J

Assuming that no heat is lost from the block during the experiment, calculate the specific heat capacity of aluminium.

specific heat capacity = ... [2]

(c) In practice, some heat is lost from the block and the air above it becomes hot.

(i) Describe and explain the process by which the hot air moves away from the block.

....

....

....

.... [2]

(ii) Suggest how to reduce the loss of heat from the block in the experiment.

....

.... [1]

5054/21/M/J/14/Q2

18 Most substances expand when they are heated.

(a) **(i)** State one example where expansion is useful.

.... [1]

(ii) State one example where expansion causes a problem.

.... [1]

(b) Explain, using ideas about molecules, why solids expand when heated.

....

....

....

....

.... [2]

(c) When equal volumes are heated through the same temperature rise, the expansions of solids, liquids and gases are different.

Complete each of the two sentences using one of these expressions:

much larger **slightly larger** **much smaller** **slightly smaller**

1. The expansion of a solid is .... than the expansion of a liquid.

2. The expansion of a gas is .... than the expansion of a liquid.

[2]

5054/22/M/J/14/Q3

19 Two metal saucepans contain the same mass of hot water at the same initial temperature.
Pan A is white and pan B is black, but otherwise the two saucepans are identical.
Both saucepans are uncovered and cool under the same conditions.
The cooling curves for the two saucepans are shown in Fig. 10.1.

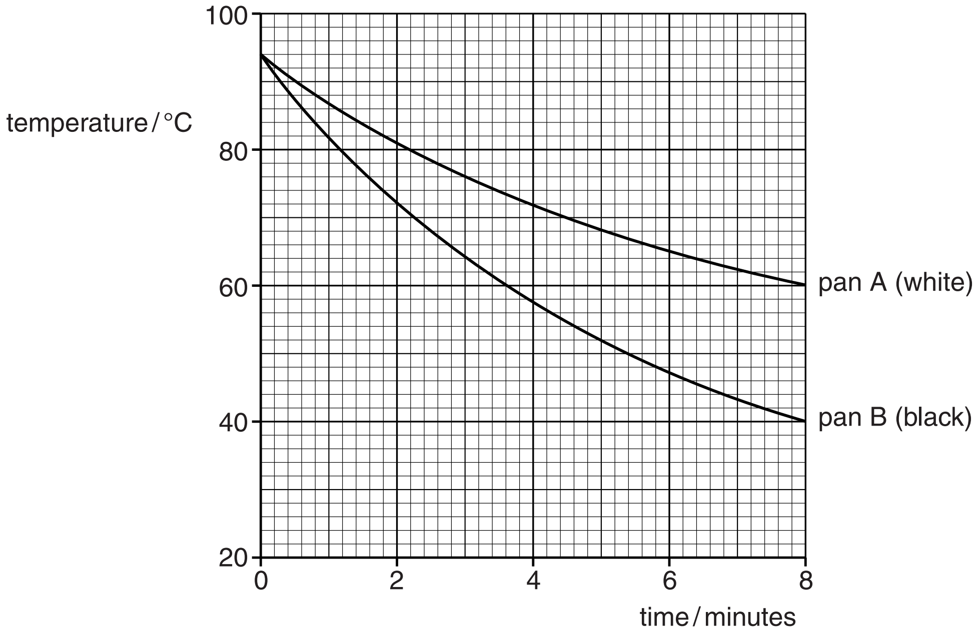


Fig. 10.1

(c) The specific heat capacity of water is 4200 J / (kg °C).

(i) Explain what is meant by *specific heat capacity*.

....

....

.... [2]

(ii) The specific heat capacity of water is very high. Suggest one disadvantage of this when water is used for cooking.

....

.... [1]

(iii) The water in pan A cools for 8 minutes, as shown in Fig. 10.1. During this time, the water loses an average of 9000 J of thermal energy per minute.

1. Calculate the mass of water in pan A.

mass = ... [3]

2. The mass of water in pan B is the same as that in pan A.

Calculate the thermal energy lost from the water in pan B during the 8 minutes.

loss of thermal energy = ... [2]

5054/22/M/J/14/Q10

20 **(b)** Some of the molecules of a liquid evaporate.

(i) Describe what happens during evaporation.

....

....[1]

(ii) Explain why evaporation has a cooling effect on the liquid.

....

....

....

....[2]

(c) The beaker shown in Fig. 10.2 contains pure water at a temperature of 80 °C. A thermometer, initially at room temperature, is placed in the air just above the water.
The reading on the thermometer starts to increase slowly.

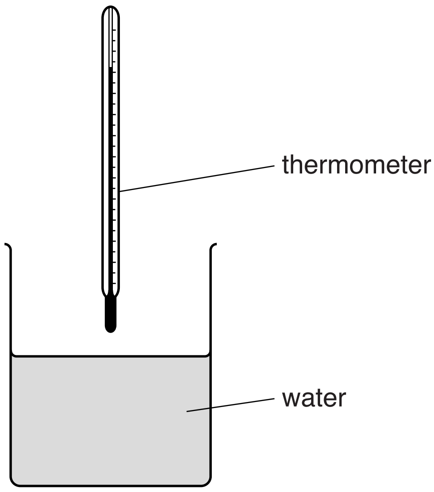


Fig. 10.2

(iii) The heater placed underneath the beaker has a power of 200 W.

The mass of water in the beaker is initially 100 g.

The water in the beaker is heated for a time of 120 s. During this time, the temperature of the water in the beaker rises from 80 °C to 100 °C.

The specific heat capacity of water is 4.2 J / (g °C).

Calculate the thermal energy (heat)

1. produced by the heater in 120 s,

thermal energy = ...[2]

2. used to warm the water from 80°C to 100°C,

thermal energy = ...[2]

5054/21/M/J/15/Q10

21 A metal can and a plastic bottle, both containing liquid, are cooled by placing them in a jug of melting ice, as shown in Fig. 4.1.

Fig. 4.1

The can and bottle each contain 330 g of the same liquid at 15 °C.

(a) The specific heat capacity of the liquid is 4.2 J / (g °C).

Calculate the thermal energy released when 330 g of the liquid at 15 °C cools to 2 °C.

energy = ... [2]

(b) When water at 0 °C is used in the jug, instead of the melting ice, the cooling is slower.

Explain why cooling is faster when using melting ice in the jug, rather than water at 0 °C.

....

....

....

.... [2]

(c) The liquid in the metal can cools down faster than the liquid in the plastic bottle.

Suggest why this happens.

....

....

.... [1]

5054/22/M/J/15/Q4

22 **(a)** Equal volumes of air, copper and water are heated from 20 °C to 80 °C. They expand by different amounts.

Draw a line from each box on the left-hand side to show which expands the most and which expands the least.

	air
expands the most	
	copper
expands the least	
	water

[1]

5054/21/M/J/16/Q4

23 A beaker is filled with water and placed on a hot-plate to boil, as shown in Fig. 4.1. The hot-plate is on top of a balance, which measures the mass of water in the beaker.

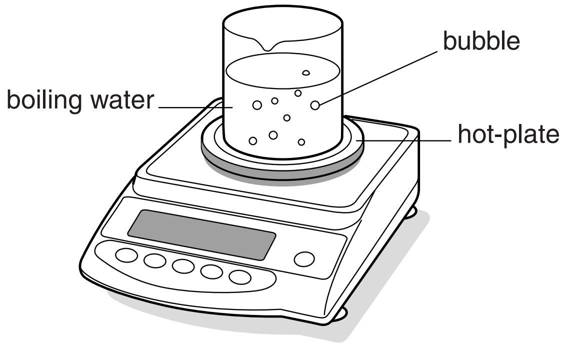


Fig. 4.1

The liquid boils for a long time. There are bubbles within the boiling water.

(a) State what is inside each bubble.

....[1]

(c) The beaker of water is taken off the hot-plate. The boiling stops but evaporation still continues and the water cools.

Explain, using ideas about molecules, how evaporation causes cooling.

....

....

....[2]

5054/22/M/J/16/Q4

24 Fig. 4.1 shows apparatus used to measure the specific heat capacity of a metal.

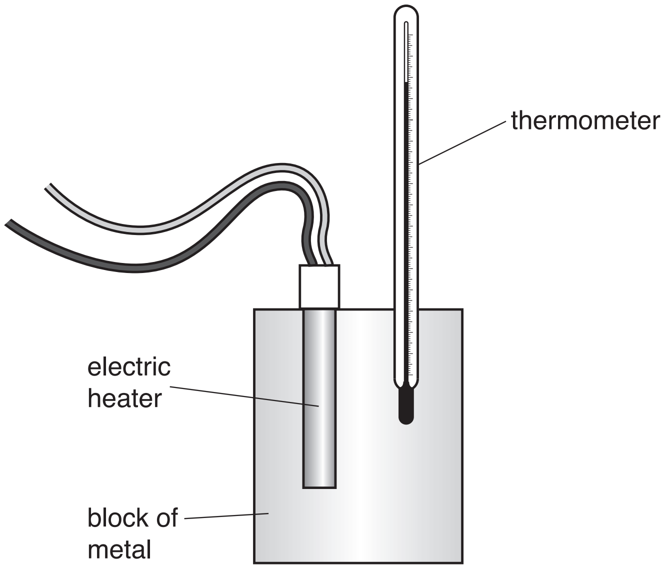


Fig. 4.1

The electric heater is switched on and supplies 17000 J of thermal energy (heat) to the block of metal. The temperature of the metal rises from 16 °C to 38 °C. The mass of the block of metal is 850 g. No energy is lost from the metal.

(a) Calculate the specific heat capacity of the metal.

specific heat capacity = ...[2]

(b) Calculate the heat capacity of the block of metal.

heat capacity = ...[1]

(c) Explain how thermal energy (heat) is conducted through the metal.

....

....

....[1]

5054/22/M/J/17/Q4

25 **(a)** **(i)** Describe two differences between boiling and evaporation.

1. ....

....

....

2. ....

....

....
[4]

(ii) Explain, using ideas about molecules, why thermal energy is needed to boil a liquid.

....

....

....

....[2]

(b) In one type of bathroom shower, cold water passes through a metal pipe which contains an electric heater.

The cold water is heated and emerges from the shower head.

The temperature of the cold water before heating is measured and the hot water emerging from the shower in 1.0 minute is collected in a container.

Measurements and other data are:

temperature of water before heating = 16 °C
temperature of water after heating = 37 °C
volume of water collected in 1.0 minute = $4.6 \times 10^{-3}\,m^3$
specific heat capacity of water = 4200 J / (kg °C)
density of water = $1000\,kg/m^3$

(i) Calculate the mass of water leaving the shower in 1.0 s.

mass = ...[2]

(ii) Calculate the thermal energy (heat) gained by the water in 1.0 s.

energy = ...[3]

(iii) To calculate the efficiency of the shower, the value in **(b)(ii)** and the value of one other quantity are needed.

1. State what other quantity is needed.

....

....

2. Describe how these two values are used to calculate the efficiency of the shower.

....

....

....
[2]

(iv) The metal pipe that contains the electric heater is earthed.

Explain why this is necessary.

....

....

....

....[2]

5054/21/M/J/18/Q10

26 **(a)** Some sources of energy, used to produce electricity, may run out in the future.

Underline the **two** sources of energy that are likely to run out first, before the others.

coal oil solar tides wave wind

[1]

(b) Fig. 2.1 is a simplified diagram of a geothermal power station.

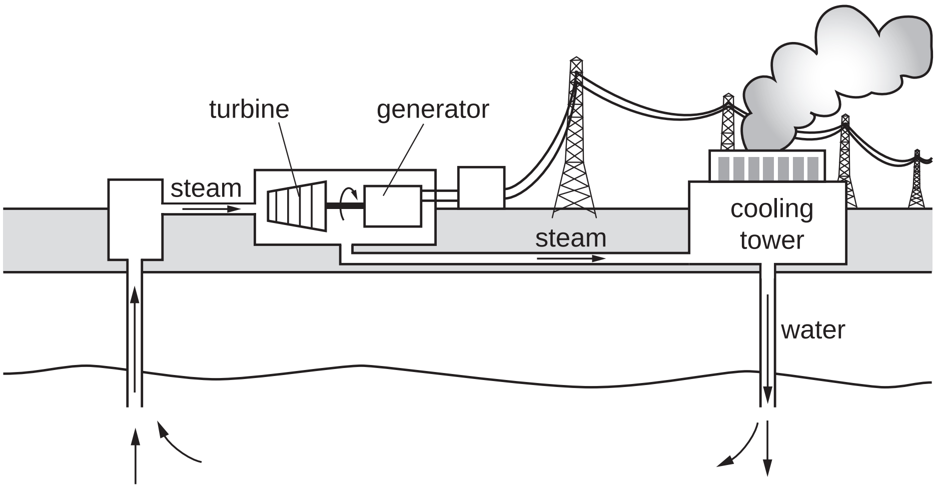


Fig. 2.1

(i) Thermal energy is given to the water as it passes through rocks underground.

Describe the process by which this thermal energy causes the turbine to turn.

....

....

....

.... [2]

(ii) Water from the cooling tower at 30 °C passes into the ground and is heated to 160 °C.

The specific heat capacity of water is 4200 J / (kg °C).

Calculate the thermal energy (heat) needed to heat 90 kg of water from 30 °C to 160 °C.

thermal energy = ... [2]

5054/21/M/J/19/Q2

27 Fig. 10.1 is a diagram of a soldering iron. Solder is a mixture of metals used to make a permanent contact between electrical wires.

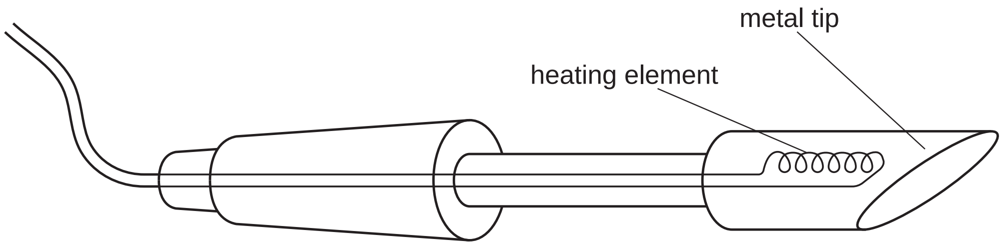


Fig. 10.1

The heating element raises the temperature of the metal tip. When solder is placed against the tip, the solder melts over the wires to be joined. When the solder cools, it solidifies and the permanent connection is made.

The working temperature of the metal tip is 380 °C.

(a) The boxes in Fig. 10.2 show two materials and some different melting points.

material	**melting point**
	1000 °C
metal of the metal tip	380 °C
	200 °C
	20 °C
solder	0 °C

Fig. 10.2

On Fig. 10.2, draw a line from the metal of the metal tip and a line from the solder to a suitable melting point for each. [2]

(b) The heating element is rated at 24 V, 3.3 A.

The heating element is switched on.

The temperature of the metal tip rises from 20 °C to 320 °C in the first 10 s.

(i) Calculate the electrical energy supplied to the heating element in the first 10 s.

energy = ... [2]

(ii) The metal tip is made of copper and has a mass of 2.3 g. The specific heat capacity of copper is 0.39 J / (g °C).

Calculate the thermal energy (heat) gained by the metal tip in the first 10 s.

thermal energy = ... [3]

5054/22/M/J/19/Q10

28 **(b)** Fig. 4.1 shows apparatus used to show expansion.

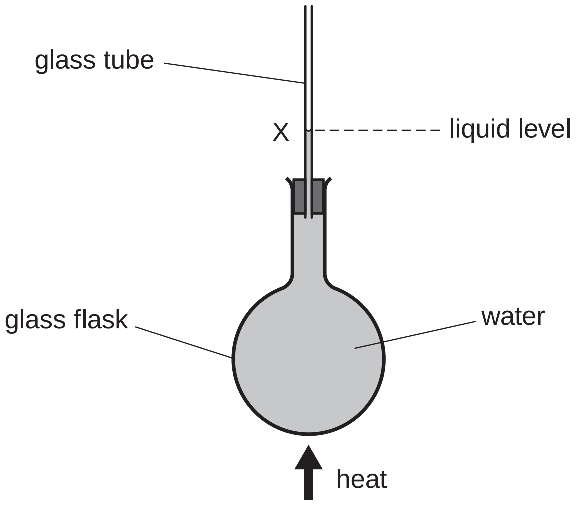


Fig. 4.1

The glass flask, full of water, is heated. A student is surprised when the liquid level X in the glass tube falls for a few seconds before it rises.

(i) Suggest why the liquid level falls and why it then rises.

....

....

....

....

.... [2]

5054/21/M/J/20/Q4

29 A hot steel rod is cooled by plunging it into cold water, as shown in Fig. 3.1.

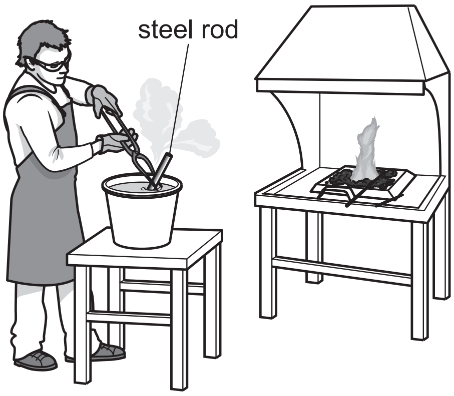


Fig. 3.1

(a) The steel rod has a mass of 2.0 kg and is initially at a temperature of 500 °C.
It cools to 50 °C when placed in the water.

The specific heat capacity of steel is 460 J / (kg °C).

Calculate the thermal energy (heat) lost by the steel rod as it cools to 50 °C.

thermal energy = ... [3]

(b) A small mass of water boils when the rod is placed in the water. The remaining water then cools to room temperature and some of it evaporates.

In both boiling and evaporation, water molecules escape into the air.

(i) State **one** way in which boiling is *different* from evaporation.

....

....

.... [1]

(ii) The rate of evaporation decreases as the water cools.

Explain why this happens, using ideas about molecules.

....

....

.... [2]

5054/21/M/J/21/Q3

30 **(a)** Define latent heat of fusion.

....

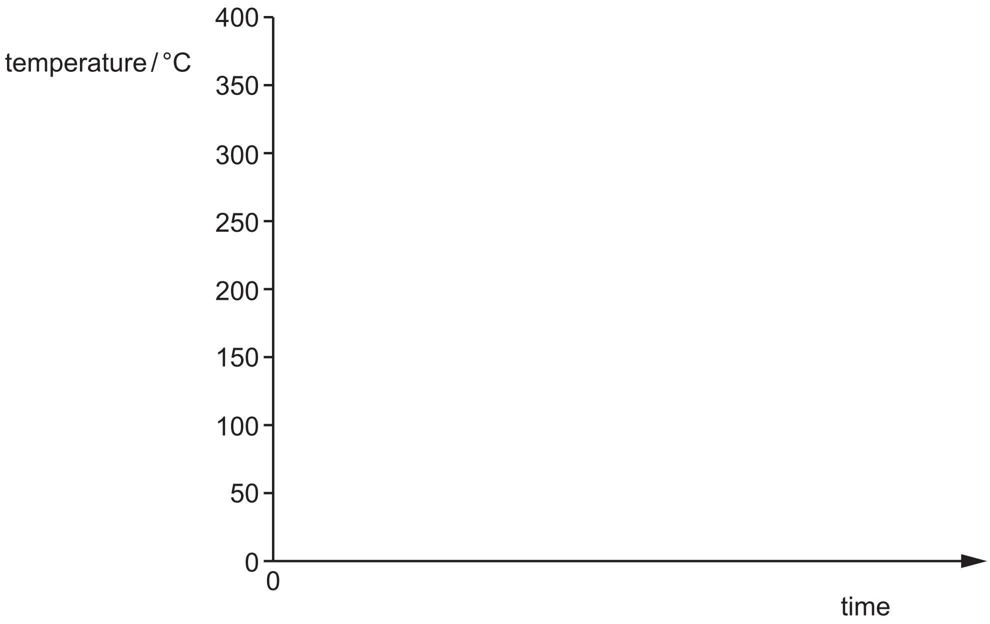
....

.... [2]

(b) A sample of metal P at 100 °C is heated steadily until its temperature reaches 400 °C.

The melting point of the metal is 250 °C.

(i) On Fig. 3.1, sketch a graph to show how the temperature of the metal changes with time.



[2]

Fig. 3.1

(ii) A sample of a different metal Q has a greater latent heat of fusion than the sample of P.

P and Q are metals with the same melting points and the samples have the same heat capacity.

The experiment is repeated with the sample of Q. This sample is supplied with the same amount of energy per second as is supplied to the sample of P.

Explain how the graph of temperature against time for Q differs from the graph in **(b)(i)**.

....

....

....

.... [2]

5054/21/M/J/22/Q3

31 **(a)** Fig. 9.1 represents the conversion of energy in a mobile phone.

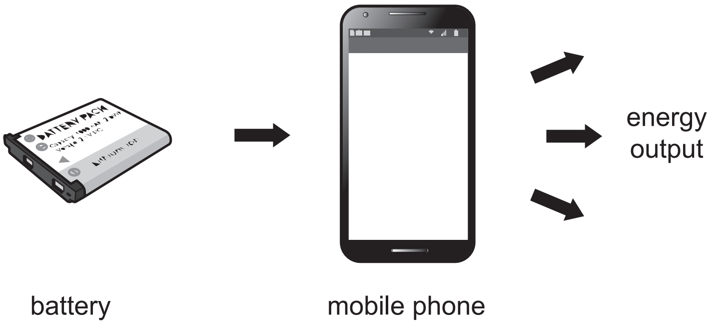


Fig. 9.1

(i) State the form of energy stored in the battery.

.... [1]

(ii) State the useful form of output energy from the battery.

.... [1]

(iii) State **two** useful forms of output energy from the mobile phone.

.... [2]

(b) When the battery is in use, the average current is 1.3 mA.

Determine the charge that passes through the battery in a time of 2.0 minutes.

charge = ... [2]

(c) A student estimates the thermal energy produced in the battery when the mobile phone is used and uses this value to estimate the efficiency of the battery.

He measures a temperature rise of 5.0 °C within the battery in a period of time when the useful energy output from the battery is 5200 J.

The mass of the battery is 110 g and its specific heat capacity is 830 J / (kg °C).

(i) Calculate the thermal energy (heat) needed to raise the temperature of the battery by 5.0 °C.

thermal energy = ... [3]

(ii) State what is meant by *efficiency*.

....

.... [2]

(iii) Calculate the efficiency of the battery.

efficiency = ... [2]

(iv) Suggest and explain **one** reason why the value for the efficiency calculated in **(iii)** is larger than the actual efficiency of the battery.

....

....

....

.... [2]

5054/22/M/J/21/Q9

32 Fig. 2.1 shows a long cardboard tube, sealed at both ends, which contains many small pieces of metal.

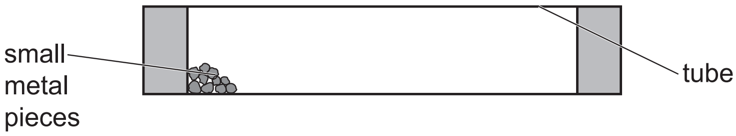


Fig. 2.1

The tube is turned vertically so that the pieces of metal fall from one end to the other.
The temperature of the pieces increases as a result of the fall.

During the fall, the gravitational potential energy of the metal pieces is transferred to other forms of energy.

(a) State **two** forms of energy to which the gravitational potential energy is transferred.

....

.... [2]

(b) The pieces fall an average distance of 1.2 m during one turn. The total mass of the metal pieces is 150 g.

(i) Calculate the loss in the gravitational potential energy of the pieces as they fall once.

The gravitational field strength g is 10 N / kg.

loss in gravitational potential energy = ... [2]

(ii) A student turns the tube quickly. After the small metal pieces have fallen from one end to the other 80 times, their temperature has increased by 7.0 °C.

Determine the specific heat capacity of the metal.

specific heat capacity = ... [3]

(iii) The student repeats the experiment, turning the tube more slowly.

Suggest why a different temperature increase is obtained.

....

.... [1]

5054/22/M/J/22/Q2

33 Fig. 9.1 shows a refrigerator.

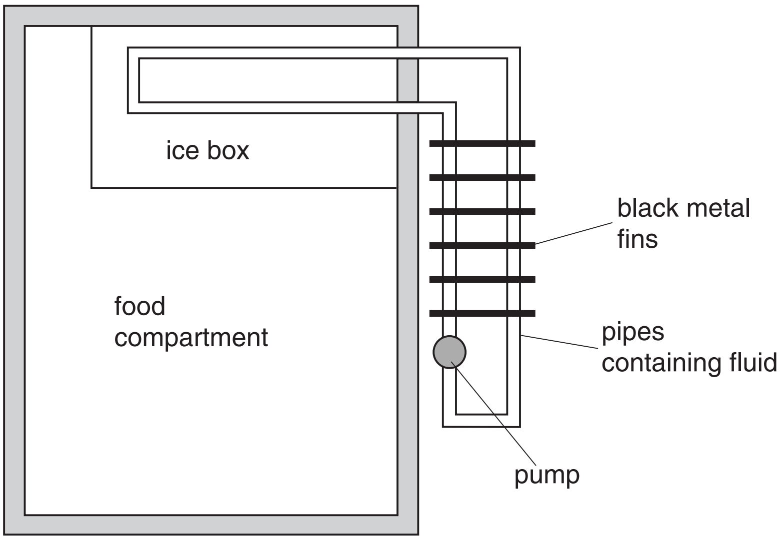


Fig. 9.1

Inside the pipes in the ice-box, a liquid boils and takes in latent heat. The gas condenses in the pipes at the back of the refrigerator and thermal energy (heat) leaves through the black metal fins.

(a) **(i)** State **one** similarity and **one** difference between boiling and evaporation.

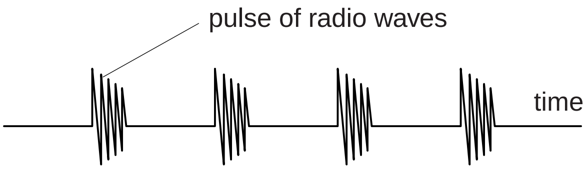
(ii) Explain, in terms of the molecules involved, why latent heat is needed to boil the liquid. [5]

5054/02/O/N/03/Q9

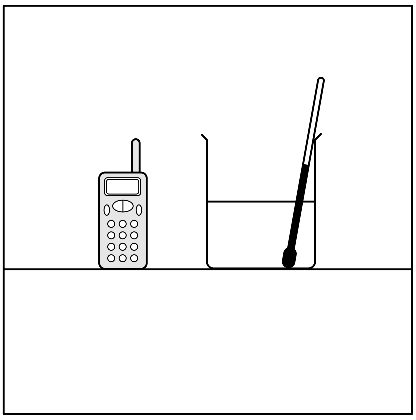
34 A student uses a mobile phone. He is concerned that the energy of the radio waves may cause a temperature rise in his brain. To investigate this effect, he calculates and tries to measure the heating effect of the phone on a nearby glass beaker of water.

Information from manufacturer

constant input power 0.20 W



The mobile phone emits pulses of radio waves.
Each pulse of waves has energy 0.00012 J.
There are 216 pulses of waves in 1.0 s



The phone is used for 360 s when next to a glass beaker containing 50 g of water.

(a) Calculate

(i) the number of pulses of radio waves produced during the phone call, [2]

(ii) the total energy of the radio waves emitted during the phone call, [2]

(iii) the maximum temperature rise produced in 50 g of water if all of the energy calculated in **(ii)** is absorbed by the water. The specific heat capacity of water is 4.2 J/(g °C). [3]

5054/02/O/N/05/Q10

35 One type of renewable energy source is shown in Fig. 3.1.

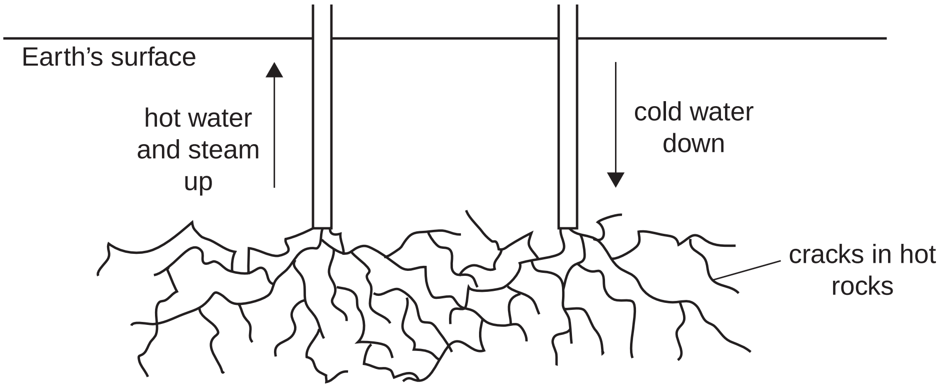


Fig. 3.1

(a) **(i)** State the name of the renewable energy source shown in Fig. 3.1.

.... [1]

(ii) State what is meant by a *renewable* energy source.

....

....

.... [1]

(b) 1000 kg of cold water at a temperature of 20 °C is pumped down to the hot rocks. 100 kg of water returns as steam and 900 kg as hot water, both at a temperature of 100 °C.

The specific heat capacity of water is 4200 J / (kg °C).

Calculate

(i) the energy needed to heat 1000 kg of water from 20 °C to 100 °C,

energy = ... [2]

5054/02/O/N/07/Q3

36 A river flows over a cliff, producing a waterfall. The water, at a temperature of 7.2 °C, falls 700 m into a pool. The gravitational field strength is 10 N / kg.

(a) Calculate the change in the gravitational potential energy of each kilogram of water due to its fall.

energy change = ... [2]

(b) Assume that all of this energy is converted into thermal energy (heat) in the water in the pool. Calculate the temperature of this water when it is in the pool. The specific heat capacity of water is 4200 J / (kg °C).

temperature = ... [3]

5054/02/O/N/08/Q3

37 Fig. 9.1 shows an electric boiler in a school kitchen.

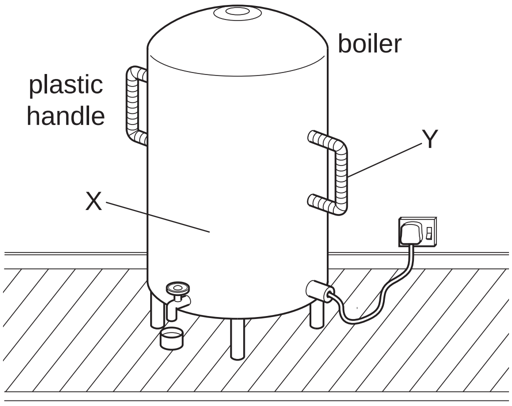


Fig. 9.1

The boiler contains 35 kg of water at 22 °C. The specific heat capacity of water is 4200 J / (kg °C).

(a) **(i)** Calculate the thermal energy (heat) needed to raise the temperature of the water from 22 °C to its boiling point. [3]

(ii) The water in the boiler is heated with a 2600 W immersion heater. Calculate the minimum time for the heater to bring the water to its boiling point. [2]

(iii) Suggest **one** reason why the actual time is greater than the time calculated in **(ii)**. [1]

(b) **(i)** The immersion heater is placed in the water at the bottom of the boiler. Explain in detail how this ensures that the thermal energy (heat) is transferred throughout the water. [4]

(ii) The boiler is made of steel and has two large plastic handles. When the water is boiling, the steel surface at X is hot while the plastic handle at Y is cool. Explain why. [2]

(c) Before the water reaches boiling point, water vapour is seen escaping from the boiler.

(i) State the name of the process that produces this water vapour. [1]

(ii) State **two** differences between this process and boiling. [2]

5054/02/O/N/09/Q9

38 Fig. 10.1 shows a domestic heater that is used to heat a room. It contains 16 large bricks each of mass 7.5 kg.

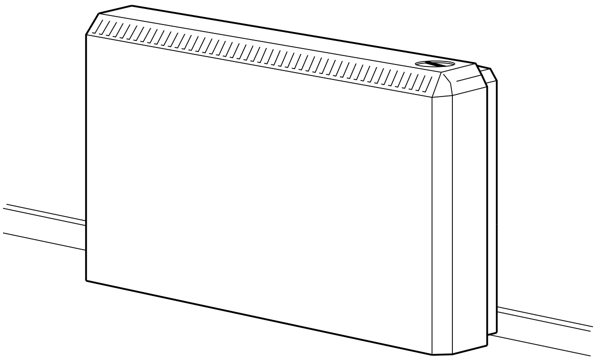


Fig. 10.1

During the night, the bricks are heated from a temperature of 17 °C to 96 °C. The bricks are made from a material that has a specific heat capacity of 2300 J / (kg °C).

(a) Calculate the thermal energy (heat) supplied to the bricks.

thermal energy = ... [3]

(b) During the day, the bricks gradually cool and the stored thermal energy is released to the room. After 7.0 hours, the bricks have cooled to 17 °C.

(i) Calculate the average rate of release of thermal energy to the room during these 7.0 hours.

rate = ... [2]

(ii) At the beginning of the day, the heater releases thermal energy at a greater rate than later in the day.

Suggest why.

....

....

.... [2]

5054/21/O/N/12/Q10

39 A swimming pool is filled with 450 m^3 of water at 12 °C.

The density of water is 1000 kg / m^3 and its specific heat capacity is 4.2 J / (g °C).

(a) Calculate the mass of water in the swimming pool.

mass = ... [2]

(b) (i) Calculate the thermal energy (heat) needed to raise the temperature of the water to 27 °C.

thermal energy = ... [3]

(ii) Suggest one reason why the thermal energy supplied to the water by the heating system, when raising the temperature of the water to 27 °C, differs from the value calculated in **(i)**.

....

.... [1]

5054/21/O/N/13/Q1

40 A large test-tube contains wax above its melting point. It is placed in a cool room.

Fig. 4.1 shows how the temperature *T* of the wax changes in a time of 30 minutes.

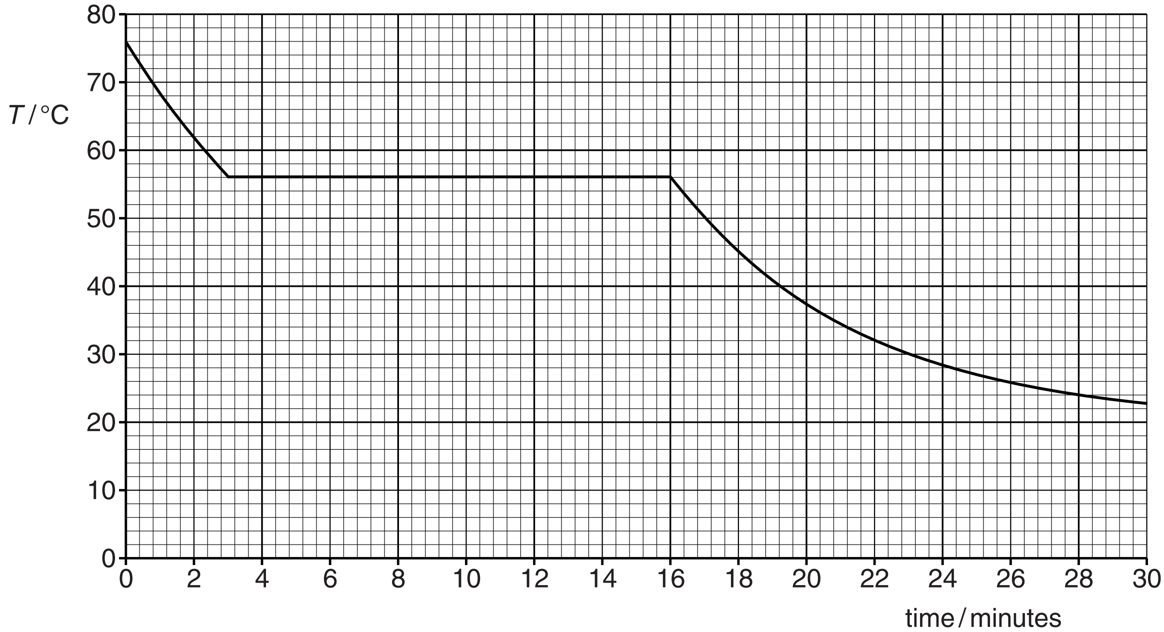


Fig. 4.1

(a) Determine the melting point of the wax.

melting point = ... [1]

(c) (i) State what happens to the wax between 3 and 16 minutes.

.... [1]

(ii) Between 3 and 16 minutes, the temperature of the wax is above room temperature and energy is lost to the room.

Explain, in terms of molecules, why the temperature of the wax remains constant.

....

....

.... [2]

5054/22/O/N/13/Q4

41 The casing of an electric kettle is made of white plastic. Fig. 10.1 shows the heating element positioned in the base of the kettle.

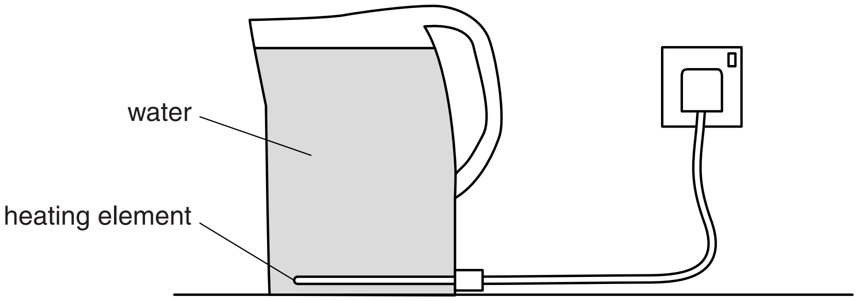


Fig. 10.1

(b) The kettle is powered by a 230 V supply. It is switched on for 3.5 minutes and there is a current of 9.6 A in the heating element.

(i) Calculate the thermal energy produced in the heating element in this time.

thermal energy = ... [2]

(ii) The kettle contains 1.6 kg of water that was at an initial temperature of 22 °C.
The specific heat capacity of water is 4200 J / (kg °C).

Calculate the maximum possible temperature of the water.

temperature = ... [3]

(iii) Suggest one reason why the temperature of the water, after 3.5 minutes, is less than the value calculated in **(b)(ii)**.

....

.... [1]

(d) The kettle is switched on again and the water reaches its boiling point. It starts to boil and the kettle remains switched on.

(i) State the meaning of *boiling point*.

....

....[1]

(ii) Explain, in terms of molecules, what happens to the thermal energy that is supplied when the water is boiling.

....

....

....[2]

5054/21/O/N/14/Q10

42 A test-tube contains solid wax. The melting point of the wax is 58 °C.

The test-tube is partially immersed in a beaker of boiling water and the wax melts. A thermometer is placed in the liquid wax.

At time t = 0, the thermometer reads 90 °C and the test-tube is immediately removed from the water. The test-tube then cools to room temperature of 23 °C.

(a) The temperature of the wax changes as it cools to room temperature.

On the axes of Fig. 5.1, sketch a graph to show how the temperature changes with time t. Mark on the temperature axis 90 °C, 58 °C and 23 °C. [3]

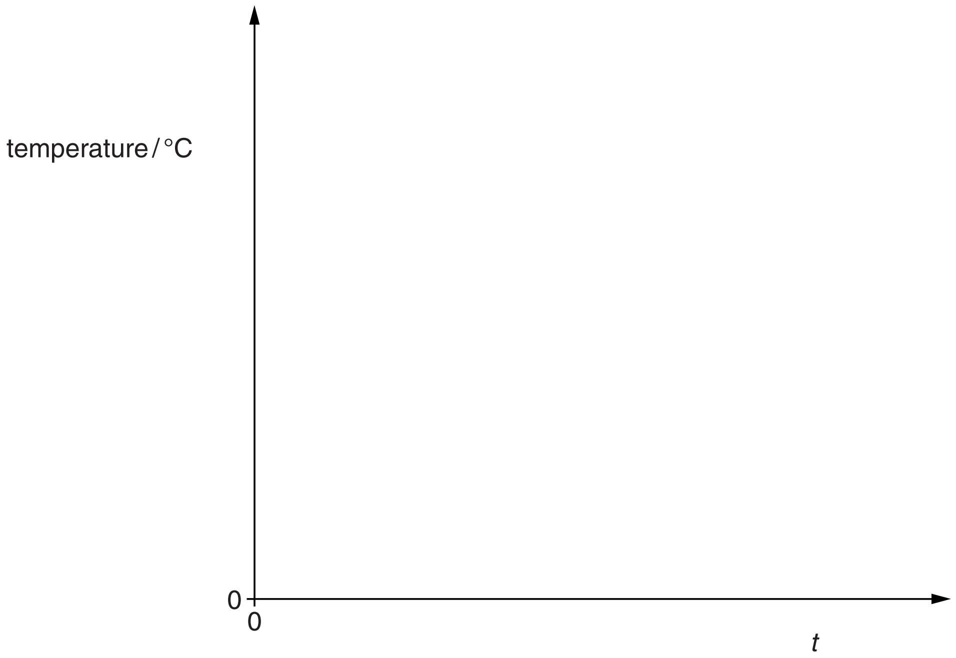


Fig. 5.1

(b) On the completed graph of Fig. 5.1, mark a point H, where half of the wax is solid and half is liquid. [1]

5054/22/O/N/14/Q5

43 In a steam cleaner, water is heated to its boiling point and is then turned into steam (water in the gas state).

(a) Define *boiling point*.

....

.... [1]

(b) (i) Describe the molecular structure of a liquid.

....

....

....

....

.... [2]

(ii) Explain, using ideas about molecules, why thermal energy (heat) must be supplied to the water as it boils.

....

....

....

....

.... [2]

5054/21/O/N/15/Q5

44 A particular type of cooking oil is a liquid at room temperature.

(b) Some of the oil is poured into a metal pan. The oil in the pan has a mass of 680 g.

(i) The density of the oil is 0.85 g / cm^3.

Calculate the volume of oil in the pan.

volume = ...[2]

(ii) The pan is placed on an electric hotplate, as shown in Fig. 10.1.

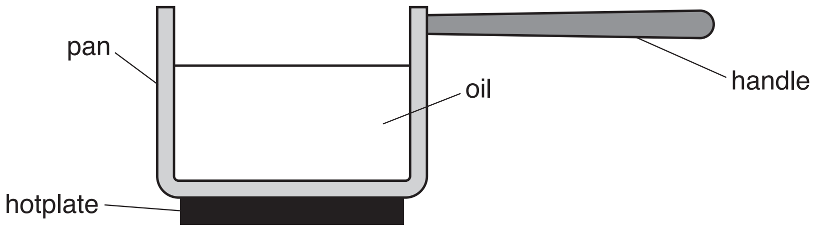


Fig. 10.1

(c) The specific heat capacity of the oil is 2.0 J / (g °C). The oil is heated from 20 °C to its boiling point of 260 °C.

(i) State what is meant by *boiling point*.

....

....[1]

(ii) Calculate the thermal energy needed to heat the 680 g of oil to its boiling point.

thermal energy = ...[2]

(iii) Suggest one reason why the energy output from the hotplate, when heating the oil, is larger than the value calculated in **(c)(ii)**.

....

....

....[1]

5054/21/O/N/16/Q10

45 Fig. 4.1 shows a kettle containing water placed on the burner of a gas cooker.

Fig. 4.1

The gas burner is lit at time $t = 0$. At $t = 250\,\text{s}$ the temperature of the water is 100 °C, the boiling point of water.

(a) State what is meant by *boiling point*.

....

....[1]

(b) Fig. 4.2 shows how the temperature of the water changes with time *t*.

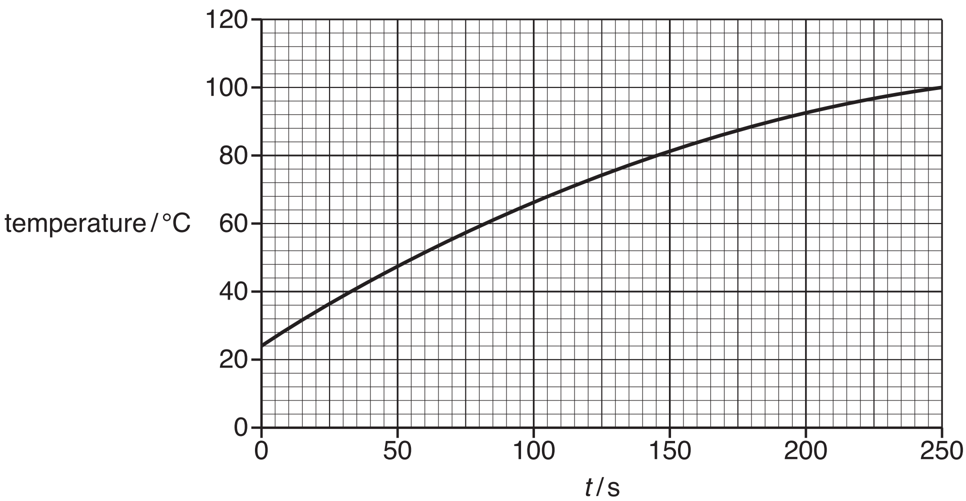


Fig. 4.2

(i) The kettle contains 1.5 kg of water which has a specific heat capacity of 4200 J / (kg °C).

Using Fig. 4.2, determine the increase in the internal energy of the water between $t = 0$ and $t = 250$ s.

increase in internal energy = ...[3]

(ii) Thermal energy (heat) is transferred to the water at a constant rate but the temperature of the water increases at a rate that is not constant, as shown in Fig. 4.2.

Explain why the temperature increases in this way.

....

....

....

....

....[2]

(c) When the temperature reaches 100 °C, the kettle is left on the burner. Thermal energy is still supplied to the water. The water boils as the molecules form bubbles and rise to the surface.

(i) State what happens to the temperature of the water.

....

....[1]

(ii) Explain, in terms of the molecules, why it is necessary to supply thermal energy in order to keep the water boiling.

....

....

....

....

....[2]

5054/22/O/N/16/Q4

46 Unwanted gold jewellery is heated in a furnace until it melts. Fig. 3.1 shows the liquid gold being poured into a mould to make a gold bar.

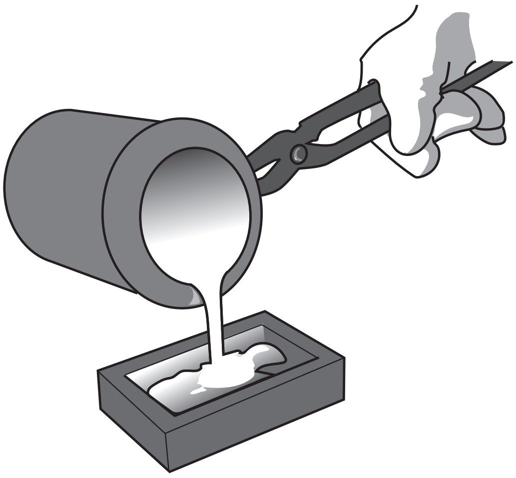


Fig. 3.1

The melting point of gold is 1100 °C.

(b) In the furnace, 0.84 kg of solid gold reaches its melting point.

The furnace continues to supply thermal energy and, after a short time, all the gold melts.

(i) Explain, in terms of the molecules, why thermal energy is needed to melt the gold.

....

....

....

.... [2]

5054/21/O/N/17/Q3

47 A boiler containing water is plugged into a 230 V mains supply. The heater in the boiler is operating at full power.

(a) The power used by the heater is 2.8 kW.

(i) Calculate the current in the heater.

current = ...[3]

(ii) The wiring in the cable from the socket and in the boiler remains safe and does not overheat provided that the current is less than 20 A.

Suggest a suitable fuse rating for the circuit.

....[1]

(b) The specific heat capacity of water is 4200 J / (kg °C). The heater is used to increase the temperature of 6.3 kg of water.

(i) In a certain time, the temperature of the water increases from 23 °C to 49 °C.

Calculate the change in the internal energy of the water.

change in internal energy = ...[2]

(ii) The heater supplies thermal energy to the water at a constant rate. It takes more time for the temperature of the water to increase from 49 °C to 75 °C than from 23 °C to 49 °C. In both cases, the increase in temperature is the same.

Suggest why it takes more time for the temperature to increase from 49 °C to 75 °C.

....

....

....[1]

(c) Fig. 10.1 shows the heater at the bottom of the water in the boiler.

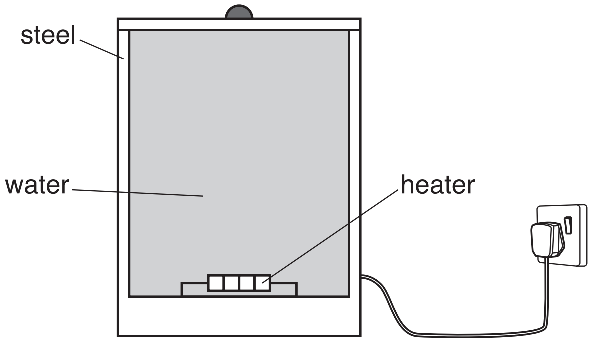


Fig. 10.1

(iii) State and explain, in terms of particles, what happens to the density of the steel as its temperature increases.

....

....

....

....[2]

5054/22/O/N/17/Q10

48 A nurse uses a mercury-in-glass, clinical thermometer to measure the temperature of a patient.

Fig. 5.1 shows the structure of a clinical thermometer.

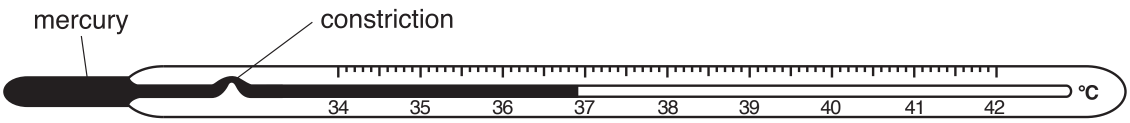


Fig. 5.1

(c) Explain, in terms of the mercury molecules, how an increase in temperature produces an increased reading on the thermometer.

....

....

....

....

.... [3]

5054/21/O/N/18/Q5

49 Fig. 3.1 shows a cylindrical copper kettle that contains cold water.

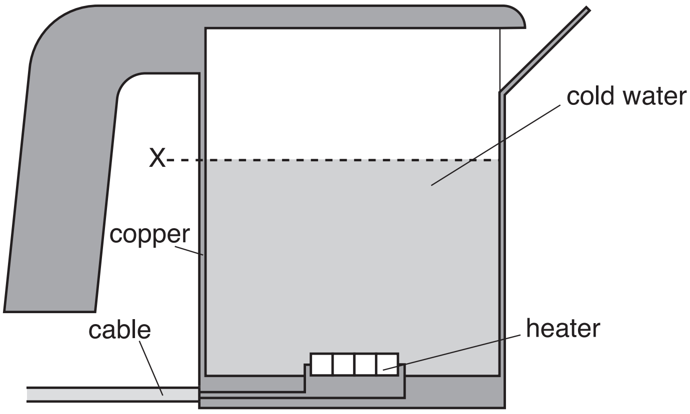


Fig. 3.1

The kettle is used to heat water and there is an electric heater at the base.

(b) As the water is heated, it expands.

(i) Explain, in terms of molecules, why water expands when it is heated.

....

....

....

.... [2]

(ii) Copper also expands when heated.

State what happens to level X of the water in the kettle. Explain your answer in terms of the expansion of the copper and the water.

....

....

.... [1]

5054/22/O/N/18/Q3

50 A house has several solar panels on the roof.

These panels use energy from the Sun both to generate electricity and to raise the temperature of water that passes through tubes inside the panels.

(a) The panels on the roof of the house have a black surface.

(i) State how energy from the Sun travels through space before it reaches the Earth.

....

.... [1]

(ii) Explain the advantage of using panels that have a black surface.

....

....

....

.... [2]

(b) On one occasion, the panels are supplying an electric current of 15 A at a voltage of 24 V.

(i) Calculate the electrical energy generated by the panels in one hour.

electrical energy = ... [2]

(ii) In the same time, 51 kg of cold water is pumped through the panels. The temperature of the water increases from 16 °C to 45 °C.

The specific heat capacity of water is 4200 J / (kg °C).

Calculate the increase in thermal energy of the water.

thermal energy increase = ... [3]

5054/22/O/N/18/Q4

51 Fig. 9.1 shows the structure of a water cooler that is used to supply cold water to the workers in a hot office.

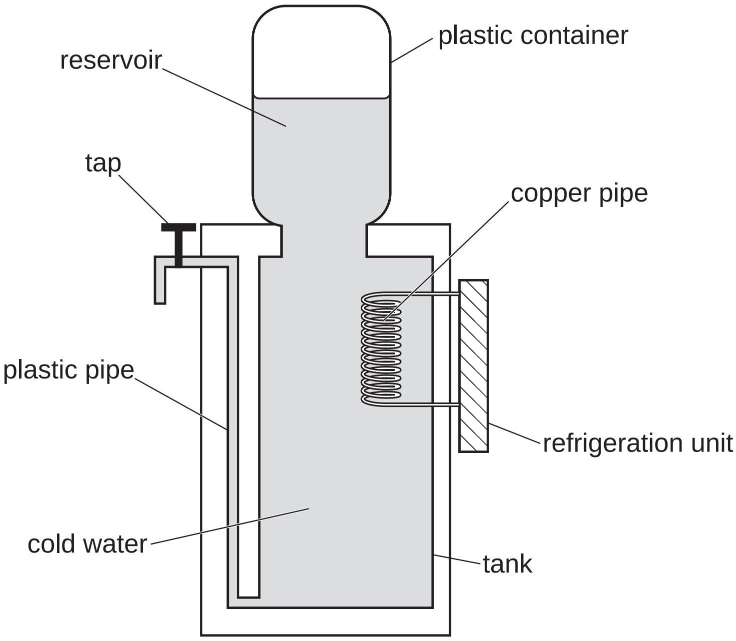


Fig 9.1

(c) The tap is opened and water at 21 °C flows from the reservoir into the tank.

The specific heat capacity of water is 4200 J / (kg °C).

Calculate the thermal energy that is removed from 250 g of this water to reduce its temperature to 7 °C.

energy = ... [3]

5054/21/O/N/19/Q9

52 In many countries, solid salt is produced by trapping sea-water in large, shallow ponds and letting the water evaporate.

Fig. 4.1 shows salt being produced in this way.

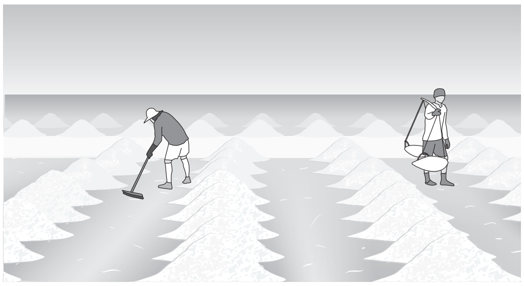


Fig. 4.1

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

1. ....

....

2. ....

.... [2]

(b) Describe, in terms of water molecules, what is happening as the water evaporates.

....

....

.... [2]

(c) **(i)** State why the ponds used in this process have large surface areas.

....

.... [1]

(ii) State why this method of salt production does not work well in a country with a cold climate.

....

.... [1]

5054/22/O/N/19/Q4

53 Fig. 9.1 shows a boiling liquid at its boiling point, trapped in a cylinder by a piston.

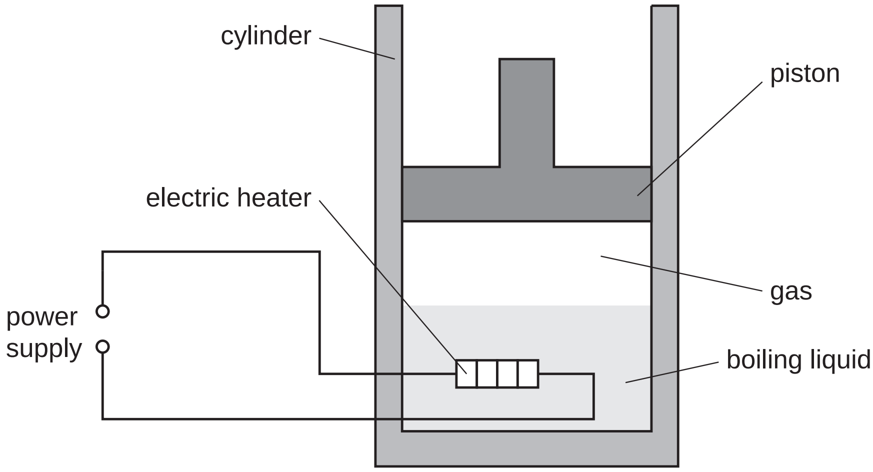


Fig. 9.1

There is an electric heater in the liquid which is connected to a power supply. The thermal energy produced by the heater gradually turns the boiling liquid into a gas.

(a) State what is meant by *boiling point*.

....

.... [2]

(b) Explain, in terms of molecules, why it is necessary to supply energy in order to turn a liquid at its boiling point into a gas.

....

....

....

.... [3]

(c) In order to determine the power of the electric heater, two meters are connected into the circuit. One meter measures the current in the heater and the other meter measures the potential difference (p.d.) across it.

On the circuit in Fig. 9.1, draw symbols to show the two meters used and where they are connected. [2]

(e) The piston is free to move in the cylinder. As the liquid boils, the piston is pushed upwards in the cylinder at a constant speed. The volume occupied by the gas just above the liquid increases.

Discuss whether the upward force on the piston changes as the piston moves upwards at constant speed.

....

....

....

.... [2]

5054/22/O/N/19/Q9

54 A small glass measuring cylinder of oil is placed inside a freezer where the temperature is –18 °C. Fig. 9.1 shows how the temperature of the oil varies with time *t*.

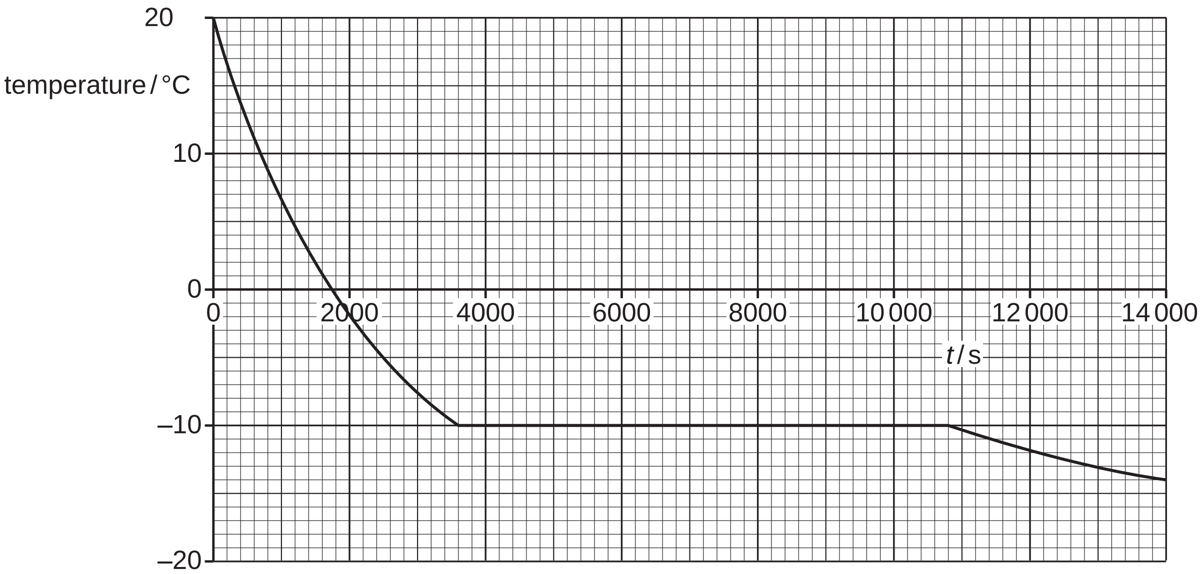


Fig. 9.1

Fig. 9.1 shows that it takes 700 s for the temperature to decrease from 20 °C to 10 °C but that it takes 1900 s to decrease from 0 °C to –10 °C.

(a) Suggest why these times are different.

....

....

....

.... [3]

(b) Explain what happens to the molecules of the oil and what happens to the level of the oil in the glass measuring cylinder as the temperature decreases from 20 °C to 0 °C.

....

....

....

.... [3]

(c) **(i)** Determine the melting point of the oil.

.... [1]

(ii) Explain, in terms of molecules, why the temperature of the oil does not change between t = 3600 s and t = 10 800 s.

....

....

....

.... [3]

(e) The graph in Fig. 9.1 is steeper before the horizontal section than it is after.

Use this observation to compare the specific heat capacity of oil in the liquid and solid states and explain your reasoning.

....

....

....

.... [2]

5054/21/O/N/20/Q9

55 **(b)** Fig. 4.1 shows a metal-worker heating a horseshoe to a high temperature before shaping it.

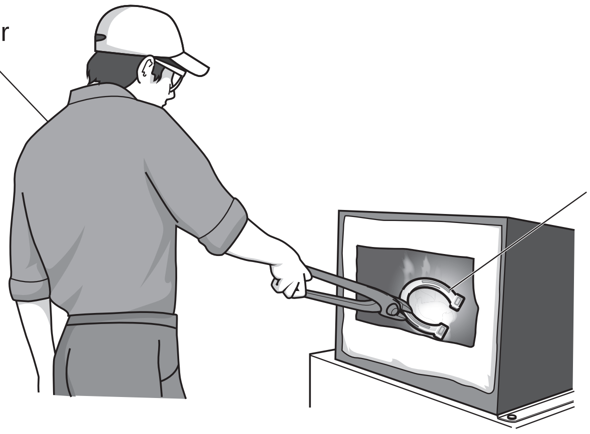


Fig. 4.1

The metal-worker then cools the horseshoe by dropping it into 8.0 kg of water at 18 °C. The final temperature of the water is 43 °C.

The specific heat capacity of water is 4200 J / (kg °C).

(i) Calculate the thermal energy transferred to the water as the horseshoe cools.

energy = ... [2]

(ii) The heat capacity of the horseshoe is 850 J / °C.

Calculate the temperature of the horseshoe immediately before it is dropped into the water.

temperature = ... [3]

5054/22/O/N/20/Q4