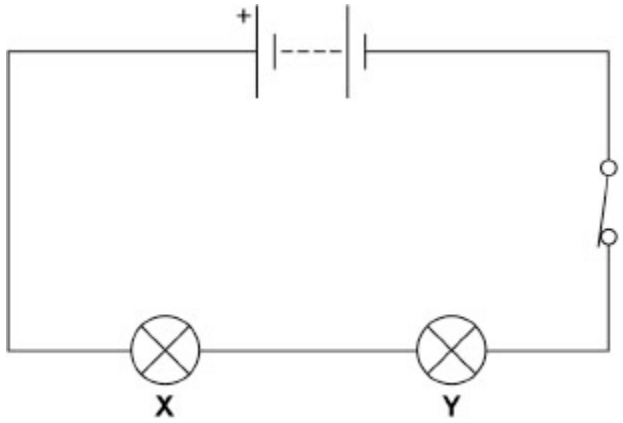
1. The figure below shows a circuit diagram. The circuit contains a battery and two lamps, **X** and **Y**.



(a) How does the current in lamp **X** compare with the current in lamp **Y**?

Tick (✓) **one** box.

The current in lamp **X** is smaller. ☐

The current in both lamps is the same. ☐

The current in lamp **X** is greater. ☐

(1)

(b) Lamp **X** and lamp **Y** are **not** identical.

The potential difference across the battery is 4.5 V.

The potential difference across lamp **X** is 1.5 V.

Calculate the potential difference across lamp **Y**.

_____

_____

Potential difference across lamp **Y** = _____ V

(1)

The current in lamp **X** is 1.2 A.

The potential difference across lamp **X** is 1.5 V.

(c) Calculate the power of lamp **X**.

Use the equation:

power = potential difference × current

Power = _____ W

(2)

(d) Calculate the resistance of lamp **X**.

Use the equation:

$$\text{resistance} = \frac{\text{potential difference}}{\text{current}}$$

Resistance = _____ Ω

(2)

(e) The current in lamp **X** is 1.2 A.

Calculate the charge flow through lamp **X** in 40 seconds.

Use the equation:

charge flow = current × time

Charge flow = _____ C

(2)

(f) The switch can be used to turn the lamps on and off.

Immediately after the lamps are switched on, the resistance of each lamp increases.

Why does the resistance of each lamp increase?

Tick (✓) **one** box.

The current in the battery decreases. ☐

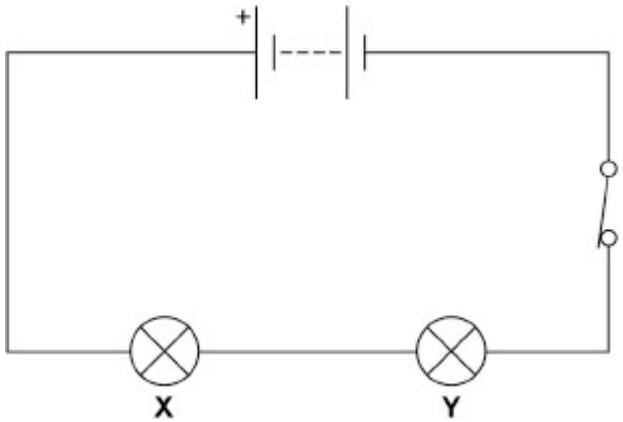
The potential difference across each lamp decreases. ☐

The power of the battery increases. ☐

The temperature of each lamp increases. ☐

(1)

The figure above is repeated below.



(g) Lamp **Y** breaks.

What happens to lamp **X**?

Give a reason for your answer.

Tick (✓) **one** box.

Lamp **X** gets brighter. ☐

Lamp **X** stays the same brightness. ☐

Lamp **X** no longer emits light. ☐

Reason _____

_____

(2)

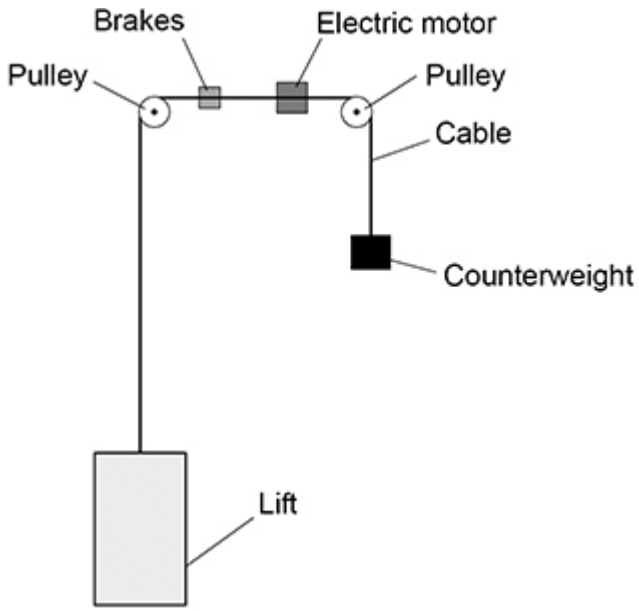
(Total 11 marks)

2. The diagram below shows a lift near the bottom of a building.

The lift is attached by a cable to a counterweight.

An electric motor moves the lift.

The lift is moving up.



(a) As the lift moves up, how far does the counterweight move down?

Tick (✓) **one** box.

A shorter distance than the lift. ☐

The same distance as the lift. ☐

A longer distance than the lift. ☐

(1)

(b) What happens to the gravitational potential energy of the counterweight as it moves down?

Tick (✓) **one** box.

It decreases ☐

It stays the same ☐

It increases ☐

(1)

(c) Calculate the change in gravitational potential energy of the lift when it moves up 4.0 m

The mass of the lift is 1300 kg

gravitational field strength = 9.8 N/kg

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

_____

_____

_____

_____

Change in gravitational potential energy = _____ J

(2)

(d) Complete the sentences.

Choose answers from the box.

chemical	**elastic potential**	**gravitational potential**
internal	**kinetic**	

Friction between the brakes and the cable causes the speed of the lift to decrease.

As the speed decreases, there is a decrease in the _____

energy of the lift.

As the speed decreases, there is an increase in the _____

energy of the brakes.

(2)

(e) The motor transfers different amounts of energy each time people use the lift.

Which factors affect the amount of energy transferred by the motor as the lift moves?

Tick (✓) **two** boxes.

- The distance moved by the lift ☐
- The height of the building ☐
- The length of the steel cable ☐
- The maximum power of the motor ☐
- The weight of the people in the lift ☐

(2)

(f) The weight of the lift and the counterweight stretch the cable by 0.015 m

The cable acts like a spring with a spring constant of 880 000 N/m

Calculate the elastic potential energy of the stretched cable.

Use the equation:

$$\text{elastic potential energy} = 0.5 \times \text{spring constant} \times (\text{extension})^2$$

Elastic potential energy = _____ J

(2)

(g) A lift system using a counterweight is more efficient than a lift system that does not use a counterweight.

How does having a more efficient system affect the energy transferred by the motor?

Tick (✓) **one** box.

Less energy is transferred. ☐

The same amount of energy is transferred. ☐

More energy is transferred. ☐

(1)

(Total 11 marks)

3. The figure below shows an outdoor swimming pool.

The water in the swimming pool comes from the sea.

The water in the pool is heated using a geothermal energy resource.

(a) Which of the following describes a geothermal energy resource?

Tick (✓) **one** box.

A non-renewable energy resource with high carbon emissions. ☐

A non-renewable energy resource with low running costs. ☐

A renewable energy resource that uses hot rocks underground. ☐

A renewable energy resource that uses the tides. ☐

(1)

(b) 15 kg of seawater is heated before it is added to the pool.

specific heat capacity of seawater = 3800 J/kg °C

Calculate the change in thermal energy of 15 kg of seawater when its temperature is increased by 9.0 °C.

Use the equation:

change in thermal energy = mass × specific heat capacity × temperature change

_____

_____

_____

Change in thermal energy = _____ J

(2)

(c) The energy transferred from 1.0 m^2 of the surface of the pool to the air is 80 J each second.

The surface area of the pool is 120 m^2.

Calculate the energy transferred from the whole surface of the pool to the air each second.

_____

_____

Energy transferred each second = _____ J

(1)

(d) Which of the following units is the same as 1 J/s?

Tick (✓) **one** box.

1 N ☐

1 Pa ☐

1 W ☐

(1)

(e) The pool is above sea level.

5.0 kg of water is pumped from sea level into the pool.

The water gains 196 J of gravitational potential energy.

gravitational field strength = 9.8 N/kg

Calculate the height of the pool above sea level.

Use the equation:

$$\text{height} = \frac{\text{gravitational potential energy}}{\text{mass} \times \text{gravitational field strength}}$$

_____

_____

_____

Height = _____ m

(2)

(f) The water in some swimming pools is heated by burning fossil fuels.

Explain **one** environmental **disadvantage** of burning fossil fuels.

_____

_____

_____

_____

(2)

(Total 9 marks)

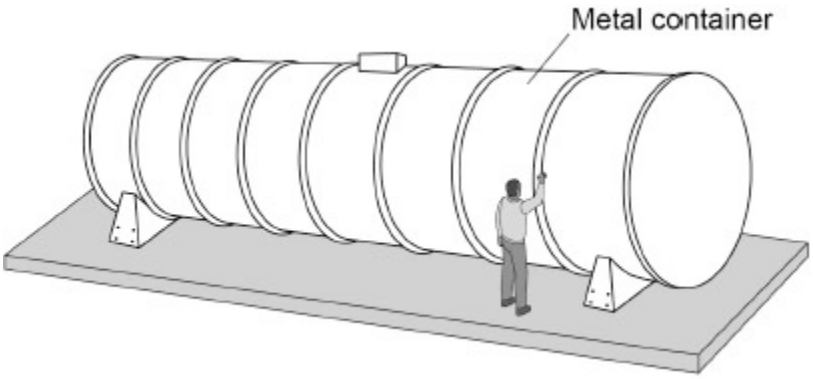
4. Data-storage computers get very hot.

Scientists investigated using the sea to cool data-storage computers.

The computers were set up inside a large metal container.

Figure 1 shows the metal container before it was lowered into the sea.

Figure 1



(a) Why is the container made of metal?

Tick (✓) **one** box.

Metal has a high thermal conductivity. ☐

Metal is a good thermal insulator. ☐

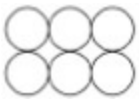
Metal is a poor conductor of thermal energy. ☐

(1)

(b) The walls of the container are solid.

Figure 2 shows an arrangement of six particles in a solid.

Figure 2



The air inside the container is a gas.

Draw an arrangement of six particles in a gas in the box below.

(1)

(c) How does the air in the container exert pressure on the container?

Tick (✓) **one** box.

Air particles absorb energy from the container. ☐

Air particles collide with the walls of the container. ☐

Air particles expand to fill the container. ☐

(1)

(d) As the container is lowered into the sea, the temperature of the air in the container decreases.

Complete the sentence.

Choose the answer from the box.

decreases	**stays the same**	**increases**

When the temperature of the air in the container decreases, the average speed of the air particles _____ .

(1)

(e) After the temperature of the air in the container had decreased, the computers were switched on.

The computers caused the temperature of the air to then increase.

Describe how the air pressure in the container changed as the temperature decreased and then increased.

_____

_____

_____

_____

(2)

(f) The container has a length of 12 m.

The container has a cross-sectional area of 7.5 m^2.

Calculate the volume of the container.

Use the equation:

volume = length × cross-sectional area

_____

_____

_____

Volume = _____ m^3

(1)

Use the Physics Equations Sheet to answer parts (g) and (h).

(g) Write down the equation that links density (ρ), mass (m) and volume (V).

_____

_____

(1)

(h) The average density of the container and its contents is 1100 kg/m^3.

Calculate the mass of the container and its contents.

Use your answer to part (f)

_____

_____

_____

_____

_____

Mass = _____ kg

(3)

(Total 11 marks)

5. **Figure 1** shows a swimmer wearing a wetsuit.

The wetsuit helps to keep the swimmer warm.

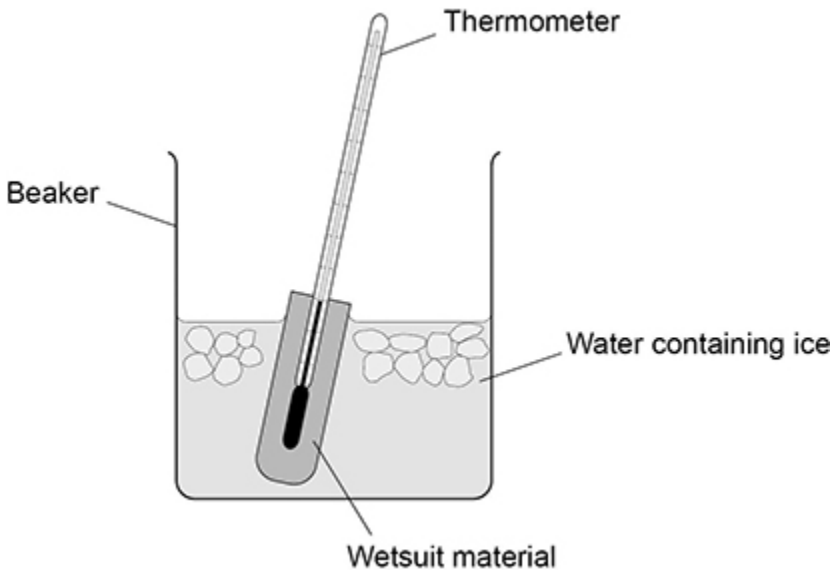
Figure 1

A swimmer wearing a wetsuit © OSTILL / iStock

A student wrapped a thermometer in a piece of wetsuit material and placed the thermometer in water containing ice.

Figure 2 shows the apparatus.

Figure 2



(a) After 30 seconds in the water the temperature of the thermometer had decreased by 7.5 °C

Calculate the average decrease in temperature each second.

_____

_____

_____

Average decrease in temperature each second = _____ °C

(2)

The student recorded the temperature of the thermometer after 30 seconds for four materials. Each piece of material was the same size and thickness.

In each test the starting temperature of the thermometer was 21.0 °C

Table 1 shows the results.

Table 1

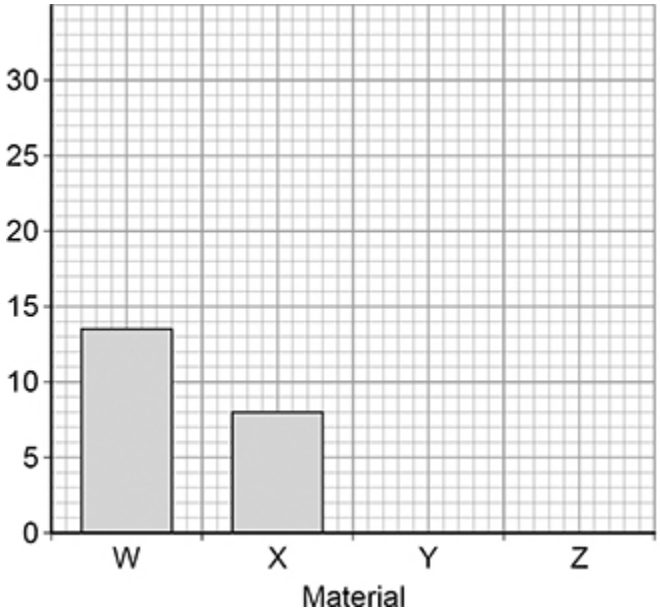
Material	W	X	Y	Z
Temperature in °C	13.5	8.0	16.0	12.0

(b) Complete **Figure 3** using the data in **Table 1**.

You should:

- label the *y*-axis
- draw the bars for materials Y and Z.

Figure 3



(2)

(c) Which material is the best thermal insulator?

Give a reason for your answer.

Tick (✓) **one** box.

W ☐ **X** ☐ **Y** ☐ **Z** ☐

Reason _____

_____

(2)

(d) The student tested a new material with a greater thermal conductivity than material Z.

The piece of new material was the same size and thickness as the piece of material Z.

What was the temperature of the thermometer after 30 seconds?

Tick (✓) **one** box.

Less than 12.0 °C ☐

Exactly 12.0 °C ☐

Greater than 12.0 °C ☐

(1)

(e) During the investigation 0.0150 kg of the ice melted. The temperature of the water and ice did not change.

specific latent heat of fusion of ice = 334 000 J/kg

Calculate the energy needed to melt the ice.

Use the equation:

energy to melt the ice = mass × specific latent heat

_____

_____

_____

_____

Energy needed to melt the ice = _____ J

(2)

The student wanted to determine the density of a wetsuit material.

The student measured the length of one side of a cube of wetsuit material with:

- a micrometer
- a ruler.

Table 2 shows the results.

Table 2

Equipment	**Length in cm**		
	Measurement 1	**Measurement 2**	**Measurement 3**
Micrometer	0.581	0.557	0.576
Ruler	0.6	0.6	0.6

(f) Complete the sentence.

Choose the answer from the box.

calibration	**precision**	**reproducibility**	**resolution**

The results show that compared to the ruler the micrometer has a higher

_____.

(1)

Use the Physics Equations Sheet to answer parts (g) and (h).

(g) Write down the equation that links density (ρ), mass (m) and volume (V).

_____

_____

(1)

(h) The student calculated the volume of the cube of wetsuit material to be 0.186 cm^3

The density of the cube was 0.300 g/cm^3

Calculate the mass of the cube.

Give your answer in grams.

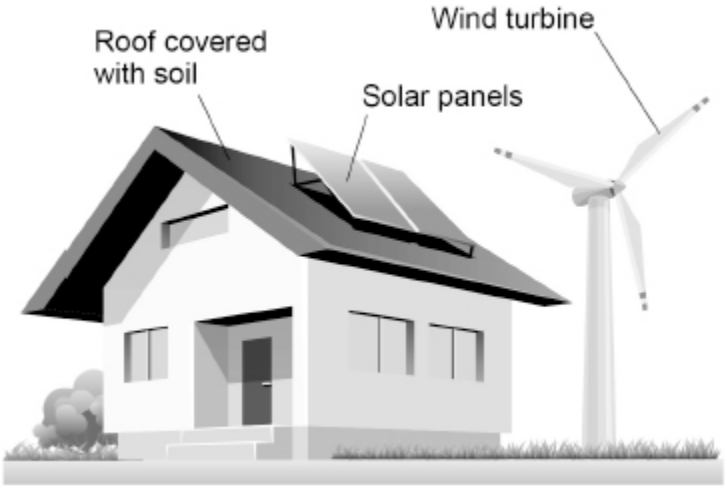
Mass = _____ g

(3)

(Total 14 marks)

6. An eco-house is designed to be environmentally friendly.

The diagram below shows a picture of an eco-house.



(a) The solar panels and a wind turbine are used to generate electricity for the eco-house.

Solar and wind are both renewable energy resources.

What does renewable energy resource mean?

Tick (✓) **one** box.

It can be replenished as it is used. ☐

It is unreliable. ☐

It has no fuel costs. ☐

It produces no greenhouse gases. ☐

(1)

(b) Biomass, nuclear and natural gas are three other energy resources.

Complete the table to show whether each energy resource is renewable or non-renewable.

Tick (✓) **one** box for **each** energy resource.

Energy resource	**Renewable**	**Non-renewable**
Biomass		
Nuclear		
Natural gas		

(2)

(c) Moving air makes the wind turbine spin.

The wind turbine generates electricity which is used to charge a battery.

Complete the sentences.

Choose answers from the box.

chemical	**electrical**	**gravitational**	**kinetic**

When the wind turbine spins faster there is an increase in its _____ energy.

Charging the battery increases the _____ store of energy of the battery.

(2)

(d) The roof of the eco-house is covered with soil.

Covering the roof with soil decreases the thermal conductivity of the roof.

What are the advantages of having a roof with a lower thermal conductivity?

Tick (✓) **two** boxes.

Less energy is needed to heat the house. ☐

The rate of energy transfer by conduction is greater. ☐

The roof is a better insulator. ☐

The roof is less likely to leak. ☐

Weather will have a greater effect on the temperature of the house. ☐

(2)

(e) The average power transferred to the solar panels by sunlight is 26 000 W

Calculate the average energy transferred to the solar panels in 30 seconds.

Use the equation:

energy transferred = power × time

_____

_____

_____

_____

Average energy transferred to solar panels = _____ J

(2)

(f) Write down the equation that links efficiency, total power input and useful power output.

_____

_____

(1)

(g) The solar panels on the roof of the eco-house have an efficiency of 0.15

The average power input to the solar panels is 26 000 W

Calculate the average useful power output from the solar panels.

_____

_____

_____

_____

_____

_____

Average useful power output = _____ W

(3)

(h) Explain why it is a good idea for the eco-house to have both a wind turbine and solar panels.

_____

_____

_____

_____

(2)

(Total 15 marks)

7. A scientist investigated the radiation emitted by different radioactive isotopes.

The scientist had a sample of polonium-210.

The radiation emitted by polonium-210 can be represented by the symbol $^{4}_{2}$He.

(a) Which type of radiation can be represented by the symbol $^{4}_{2}$He?

Tick (✓) **one** box.

Alpha ☐

Beta ☐

Gamma ☐

(1)

(b) How many protons are there in a particle of radiation represented by $^{4}_{2}$He?

Tick (✓) **one** box.

2 ☐ 4 ☐ 6 ☐ 8 ☐

(1)

(c) A polonium-210 (Po) nucleus changes into a lead (Pb) nucleus by emitting a $^{4}_{2}$He particle. This is shown by the following nuclear equation.

$$^{210}_{84}\text{Po} \rightarrow {}^{206}_{\mathbf{X}}\text{Pb} + {}^{4}_{2}\text{He}$$

What is the value of **X**?

Tick (✓) **one** box.

80 ☐ 82 ☐ 84 ☐ 86 ☐

(1)

(d) The sample of polonium-210 had an activity of 100 Bq.

Complete the sentence.

Choose the answer from the box.

25	**50**	**100**	**200**

After one half-life, the activity of polonium-210 in the sample

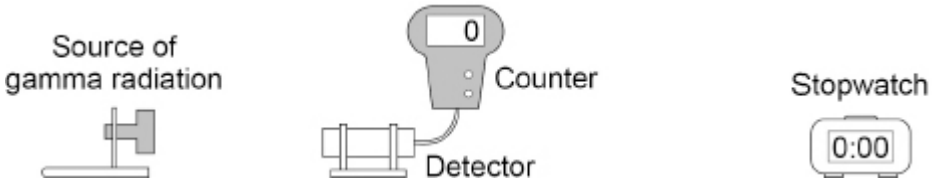
was _____ Bq.

(1)

The scientist investigated another radioactive isotope that is a source of gamma radiation.

Figure 1 shows the equipment used.

Figure 1



(e) The count-rate is the number of counts detected each second.

In 30 seconds the number of counts detected was 1500.

Calculate the count-rate.

_____

_____

_____

Count-rate = _____ counts per second

(2)

The scientist placed a thick sheet of lead between the source of gamma radiation and the detector.

(f) What was the effect of the sheet of lead on the count-rate?

Give a reason for your answer.

Effect _____

_____

Reason _____

_____

(2)

(g) The lead was irradiated by the gamma radiation.

What happened to the lead when it was irradiated by the gamma radiation?

Tick (✓) **one** box.

The lead atoms became radioactive. ☐

The lead gained atoms from the radioactive source. ☐

The lead was exposed to gamma radiation. ☐

(1)

(h) Gamma radiation is emitted from the nucleus of an atom.

Complete the sentence.

Choose the answer from the box.

electromagnetic waves	**high speed electrons**
neutrons	**positively charged ions**

Gamma radiation consists of _____.

(1)

(i) **Figure 2** shows the scientist holding the radioactive source using tongs.

Figure 2

Suggest **one** reason why using long tongs rather than short tongs was safer for the scientist.

_____

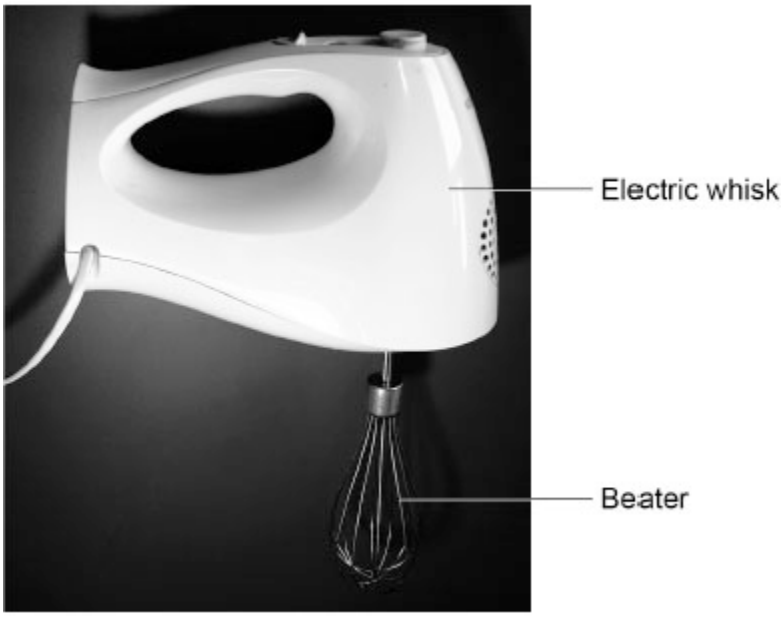
_____

(1)

(Total 11 marks)

8. The figure below shows an electric whisk that plugs into the mains electricity supply.

The whisk can mix food by spinning a beater.



(a) Give **two** energy stores that increase when the whisk is switched on.

1 _____

_____

2 _____

_____

(2)

Use the Physics Equations Sheet to answer parts (b) and (c).

(b) Work is done by the whisk when it is used to mix food.

Write down the equation that links power (*P*), time (*t*) and work done (*W*).

_____

(1)

(c) The power output of the whisk is 92 W.

Calculate the time for the whisk to do 23 000 J of work.

_____

_____

_____

_____

_____

Time = _____ s

(3)

Use the Physics Equations Sheet to answer parts (d) and (e).

(d) Which equation links current (*I*), power (*P*) and resistance (*R*)?

Tick (✓) **one** box.

$P = \frac{I}{R^2}$ ☐

$P = I R^2$ ☐

$P = \frac{I^2}{R}$ ☐

$P = I^2 R$ ☐

(1)

(e) The current in the whisk is 500 mA.

The resistance of the whisk is 640 Ω.

Calculate the power of the whisk.

_____

_____

_____

_____

_____

Power = _____ W

(3)

The whisk has several settings that allow the beater to spin at different speeds.

A faster beater speed needs a greater power input from the mains electricity supply.

(f) What is the potential difference between the live wire and neutral wire in the mains electricity supply?

_____ V

(1)

(g) Changing the beater speed does **not** change the potential difference between the live wire and neutral wire.

The power input to the whisk changes because the current in the whisk changes.

Complete the sentence.

When the beater speed increases, the current in the whisk increases because the

resistance of the whisk _____ .

(1)

(Total 12 marks)

9. Body analysis scales use the electrical resistance of a person's legs to estimate the percentage of water in the person's body.

Figure 1 shows body analysis scales.

Figure 1

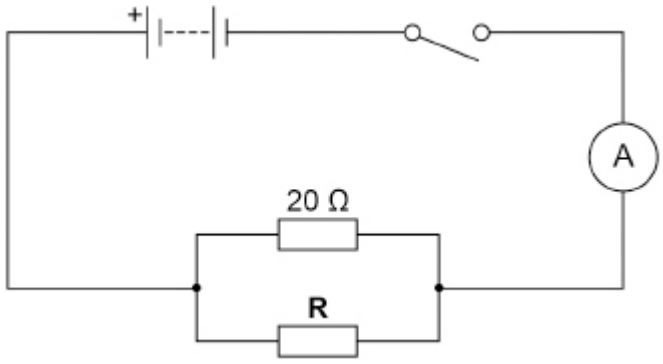
The person's legs contain both solid tissue and water.

A student used resistors to model the solid tissue and water.

The student connected a 20 Ω resistor in parallel with a resistor, **R**.

Figure 2 shows the circuit diagram.

Figure 2



(a) To determine the total resistance of both resistors, a voltmeter must be connected into the circuit.

Complete **Figure 2** to show where the voltmeter should be connected.

(1)

(b) The student calculated the total resistance of the two resistors.

The student's answer was 26 Ω.

Explain why the student's answer **cannot** be correct.

_____

_____

_____

_____

(2)

Use the Physics Equations Sheet to answer parts (c) and (d).

(c) Write down the equation that links current (*I*), resistance (*R*) and potential difference (*V*).

_____

_____

(1)

(d) When the total resistance of the resistors was 7.5 Ω the current in the circuit was 480 mA.

Calculate the potential difference across the two resistors.

_____

_____

_____

_____

_____

Potential difference = _____ V

(3)

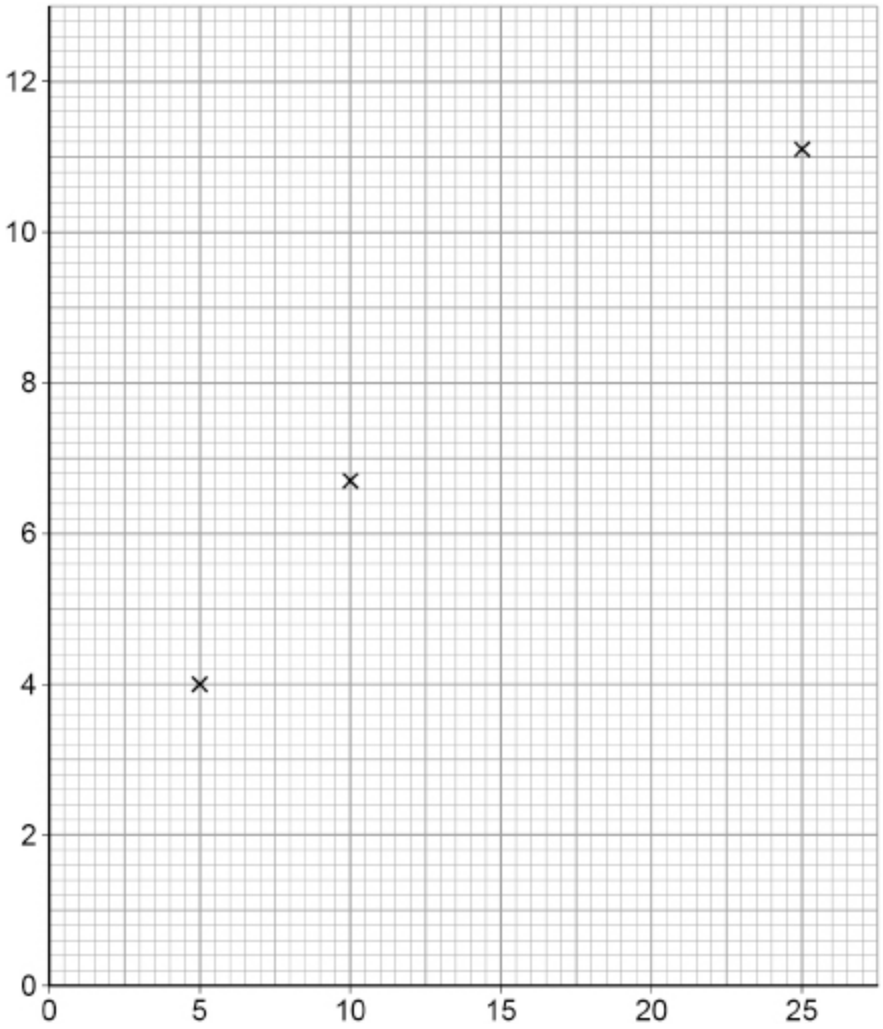
The student investigated how the resistance of **R** affected the total resistance of the circuit.

The table below shows the results.

Resistance of R in ohms	Total resistance of the circuit in ohms
5.0	4.0
10.0	6.7
15.0	8.6
20.0	10.0
25.0	11.1

Some of the results are plotted in **Figure 3**.

Figure 3



(e) Complete **Figure 3**.

You should:

- label both axes
- plot the two remaining values from the table above
- draw the line of best fit.

(3)

(f) What resistance of **R** would give a total resistance of 4.4 Ω?

Use **Figure 3**.

Resistance of **R** = _____ Ω

(1)

The body analysis scales initially show a reading of 0.0 kg.

When the student steps onto the scales the reading is 64.8 kg.

The student steps off the scales and then immediately steps back on.

The scales now show a reading of 64.1 kg.

(g) Complete the sentence.

The difference between the two values given by the scales is due

to a _____ error.

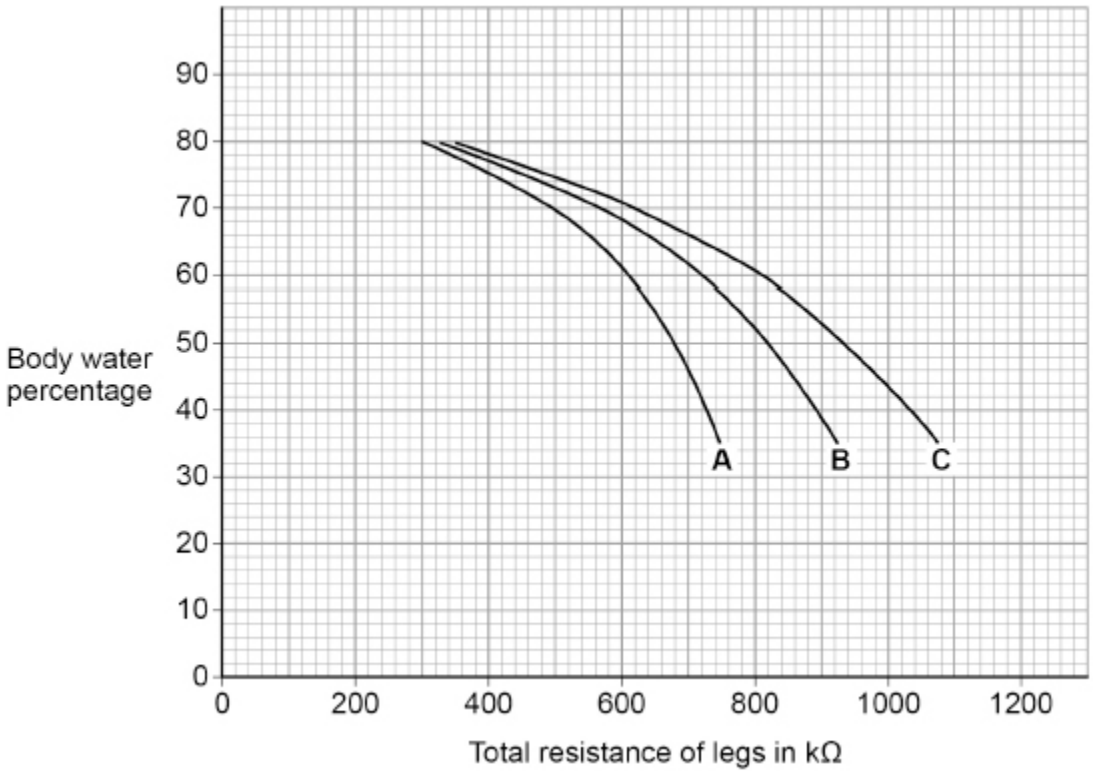
(1)

(h) The height of the student is programmed into the scales.

The scales place the student into a category, **A**, **B** or **C**, based on height and mass.

Figure 4 shows how the scales use the category and the total resistance of the legs to determine the body water percentage.

Figure 4



The total resistance of the student's legs is 600 kΩ. A healthy body water percentage is between 45% and 65%.

The different measurements of the mass of the student mean that the student could be in either category **A** or category **B**.

Evaluate if the student has a healthy body water percentage.

(3)

(Total 15 marks)

10. A piece of steel is heated until it has all melted.

(a) Calculate the change in thermal energy when the temperature of the piece of steel is increased by 50 °C.

mass of steel = 4.0 kg

specific heat capacity of steel = 420 J/kg °C

Use the equation:

change in thermal energy = mass × specific heat capacity × temperature change

_____

_____

_____

Change in thermal energy = _____ J

(2)

(b) The internal energy of the steel increases as the steel is heated.

What is meant by 'internal energy of the steel'?

Tick (✓) **one** box.

The change in energy of the steel particles as the steel melts. ☐

The energy added to the steel particles as they are heated. ☐

The total kinetic energy and potential energy of the steel particles. ☐

(1)

(c) Solid steel cannot be poured.

Which statement about the particles in a solid gives the reason why?

Tick (✓) **one** box.

The number of particles always stays the same. ☐

The particles are close together. ☐

The particles are in fixed positions. ☐

The particles have a fixed size. ☐

(1)

(d) Complete the sentence.

Choose the answer from the box.

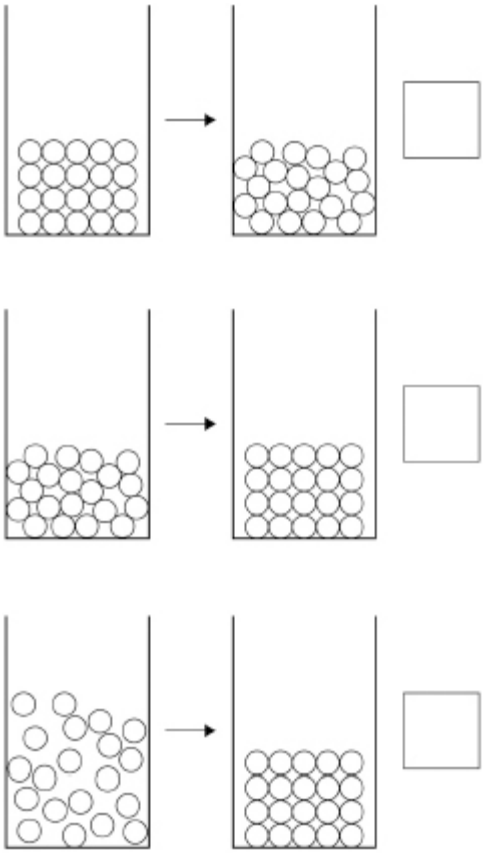
decreases	**stays the same**	**increases**

As the piece of solid steel melts, the mass of the steel _____.

(1)

(e) Which diagram shows how the arrangement of particles changes when a solid melts and becomes a liquid?

Tick (✓) **one** box.



(1)

(f) The density of steel decreases as it melts.

How does the spacing of the particles change as the steel melts?

_____

_____

(1)

(g) Complete the sentence.

Choose the answer from the box.

chemical	**permanent**	**physical**

Melting is an example of a _____ change.

(1)

(h) Steel is a mixture of iron and a small amount of carbon.

The table below shows the mass of carbon in 1.0 kg of different types of steel.

Type of steel	**Mass of carbon in 1.0 kg of steel**
Low carbon	2.0 g
Medium carbon	4.5 g
High carbon	7.0 g

A 4.0 kg piece of steel contains 18 grams of carbon.

Determine which type of steel the 4.0 kg piece is made from.

You should include a calculation in your answer.

Type of steel _____

(3)

(i) The 4.0 kg piece of solid steel was heated until it reached its melting point.

The additional energy required to melt the piece of steel was 280 000 J.

Calculate the specific latent heat of fusion of the steel.

Use the Physics Equations Sheet.

Specific latent heat of fusion of steel = _____ J/kg

(3)

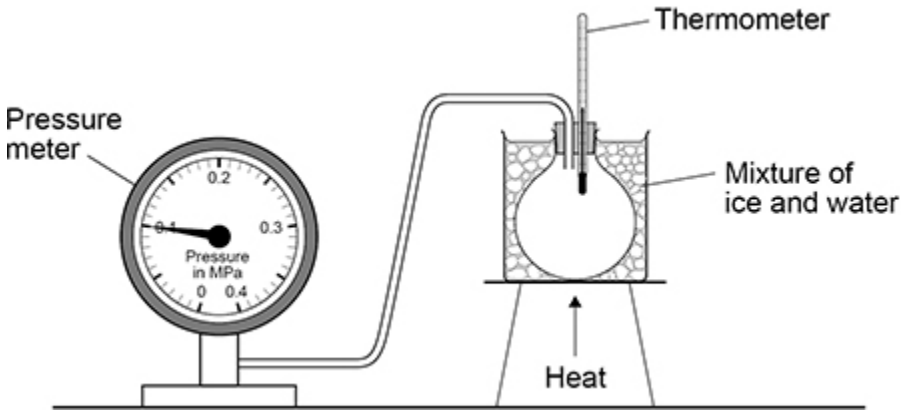
(Total 14 marks)

11. A student investigated how the pressure of a gas depends on its temperature.

The volume of the gas did **not** change.

Figure 1 shows the equipment used.

Figure 1



(a) Pressure is sometimes measured in units called atmospheres.

1 atmosphere is 10^5 pascals (Pa).

What is 1 atmosphere in kilopascals (kPa)?

_____

_____

1 atmosphere = _____ kPa

(1)

(b) The student took four pressure readings for each temperature.

The table below shows the pressure readings when the temperature was 50.0 °C

Temperature in °C	**Pressure in MPa**			
	1	**2**	**3**	**4**
50.0	0.115	0.120	0.121	0.116

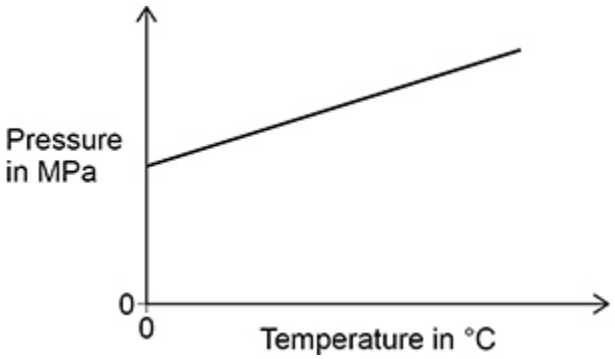
Calculate the uncertainty in the mean pressure.

Uncertainty = ± _____ MPa

(2)

(c) **Figure 2** shows a sketch graph of the results.

Figure 2



The student said that as the temperature increases the pressure increases.

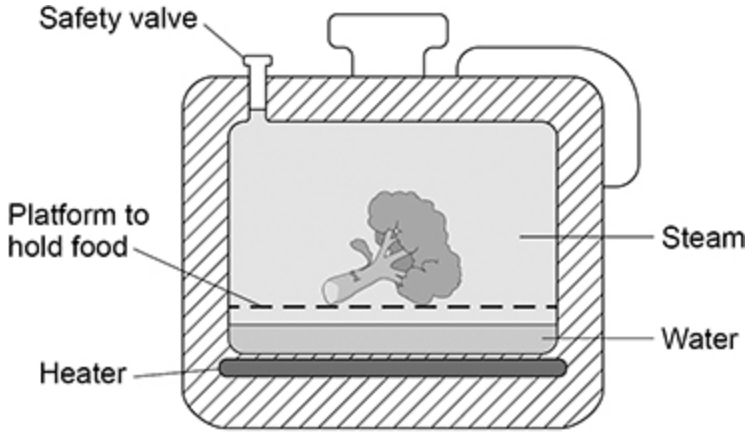
Give a better description of the relationship between temperature and pressure.

(1)

A pressure cooker is a sealed pot that uses steam to cook food.

Figure 3 shows a pressure cooker.

Figure 3



(d) When the water in the pressure cooker starts to boil:

- the amount of steam in the pressure cooker increases
- the temperature of the steam increases above 100 °C

Explain why these changes make the pressure in the cooker increase.

(5)

(e) If the pressure inside the pressure cooker becomes greater than 200 kPa then some of the steam is released through the safety valve.

The released steam expands as it moves into the atmosphere.

Explain how a change in density of the steam is caused by a change in the arrangement of particles in the steam as it is released.

_____

_____

_____

_____

_____

_____

(3)

(Total 12 marks)

12. In an experiment, a beam of alpha particles was directed at a thin sheet of gold foil.

(a) Most of the alpha particles passed straight through the gold foil.

Alpha particles which passed close to the nucleus of a gold atom did **not** pass straight through.

What happened to the alpha particles which passed close to the nucleus of a gold atom?

_____

_____

(1)

(b) The results suggested that the diameter of the nucleus of a gold atom is $\frac{1}{6000}$ of the diameter of the atom.

The diameter of a gold atom is 0.18 nm

Calculate the diameter of a gold nucleus in nm

_____

_____

_____

_____

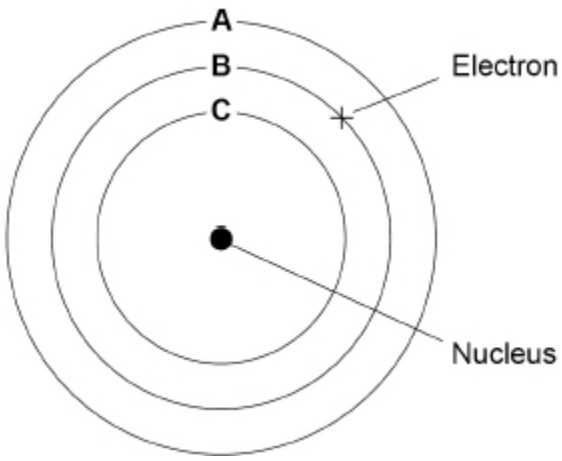
Diameter = _____ nm

(2)

(c) Further experiments showed that gold nuclei are surrounded by electrons in different energy levels.

Figure 1 shows three of the energy levels around the nucleus of a gold atom.

Figure 1



The electron in energy level **B** absorbs electromagnetic radiation.

Which energy level will the electron be in after it has absorbed the electromagnetic radiation?

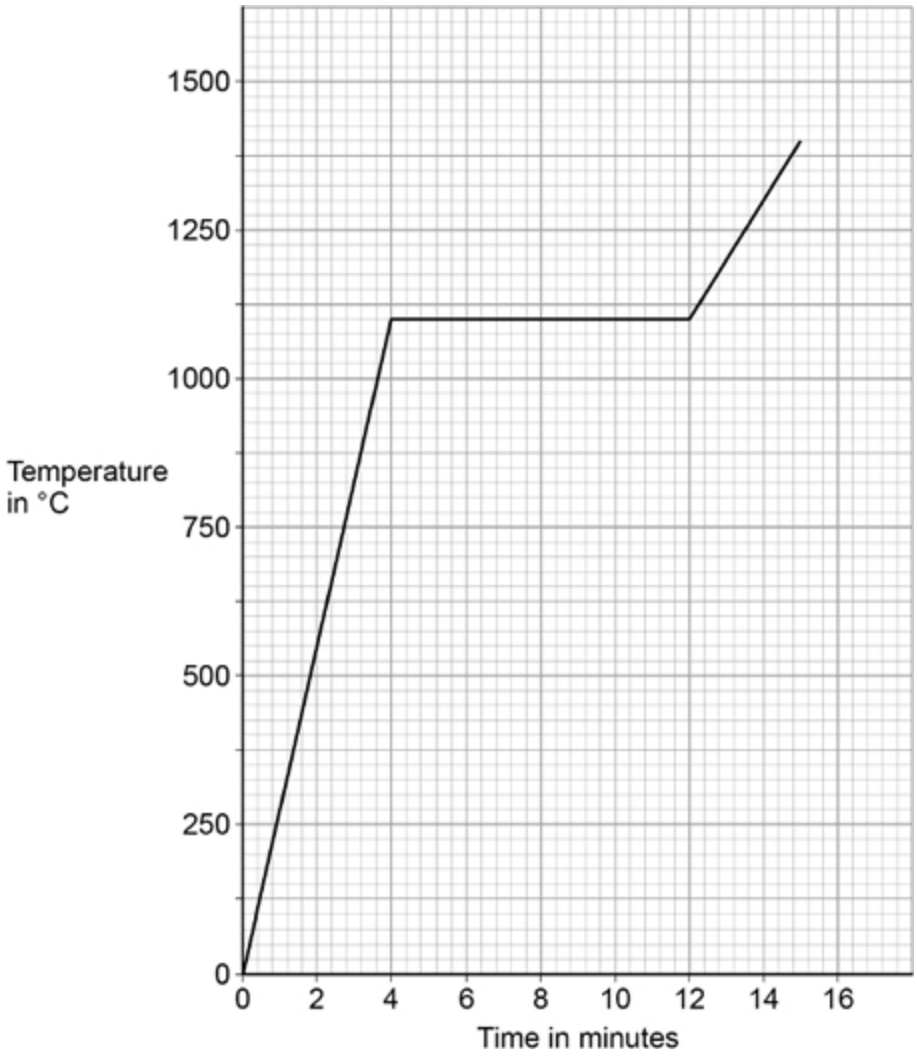
Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐

(1)

Figure 2 shows how the temperature of a small sample of gold changes as it is heated from a solid to a liquid.

Figure 2



(d) What is the melting point of the gold?

Melting point = _____ °C

(1)

(e) How many minutes did it take for all of the gold in the sample to change from solid to liquid?

Time taken = _____ minutes

(1)

(f) What does the gradient of the graph in **Figure 2** represent?

Tick (✓) **one** box.

The internal energy of the gold ☐

The rate of change of temperature of the gold ☐

The specific heat capacity of the gold ☐

(1)

(Total 7 marks)

13. Between 1951 and 1992 the USA tested nuclear weapons in a desert.

(a) Complete the sentence.

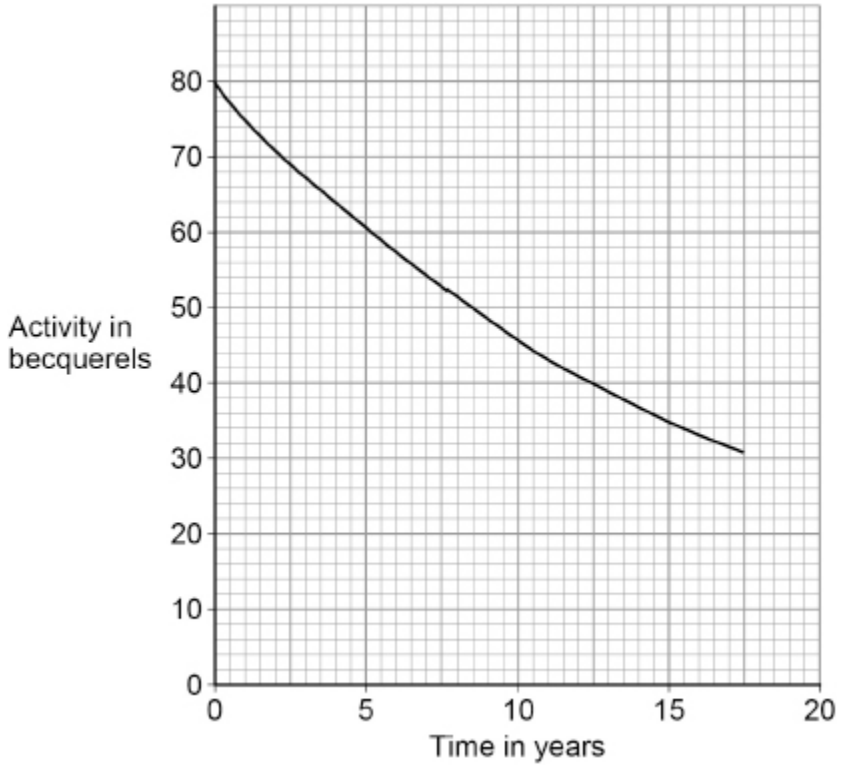
Choose the answer from the box.

contamination	**irradiation**	**ionisation**	**decay**

Radioactive dust from the nuclear weapons testing settled on the desert. This is called radioactive _____.

The desert now contains radioactive tritium.

The graph below shows how the activity of the tritium in a sample taken from the desert changed with time.



(1)

(b) The sample was collected from the desert in 1992.

Determine the activity of the tritium in the sample in 2007.

_____

_____

Activity = _____ Bq

(2)

(c) How much time did it take for the activity of the tritium in the sample to decrease from 80 Bq to 40 Bq?

_____

_____

Time = _____ years

(1)

(d) What is the half-life of tritium?

Half-life = _____ years

(1)

(e) The sample started with 45 billion atoms of tritium.

After 4 years the sample had 36 billion atoms of tritium.

Calculate the percentage of the tritium in the sample that remained after 4 years.

_____

_____

_____

_____

Percentage of tritium remaining = _____ %

(2)

(f) A scientist determined the activity of a sample of tritium every minute for 3 minutes.

The table below shows the results.

Time in minutes	Activity in Bq
0	149
1	151
2	148
3	152

Why do the activity readings in table vary?

Tick (✓) **one** box.

Radioactive decay is a random process. ☐

Temperature changes affect the radioactive decay. ☐

The number of radioactive nuclei keeps increasing and decreasing. ☐

(1)

(g) What safety precaution should scientists take when working with radioactive materials in a laboratory?

Tick (✓) **one** box.

Tie long hair back before handling the materials. ☐

Use long tongs to handle the materials. ☐

Wear safety goggles when handling the materials. ☐

(1)

(h) Studies show that children born near the area of the desert containing tritium were more likely to develop cancer.

It is important that the results from these studies are checked by other scientists.

What is this process called?

Tick (✓) **one** box.

Experiment review	☐
Peer review	☐
Results review	☐
Test review	☐

(1)

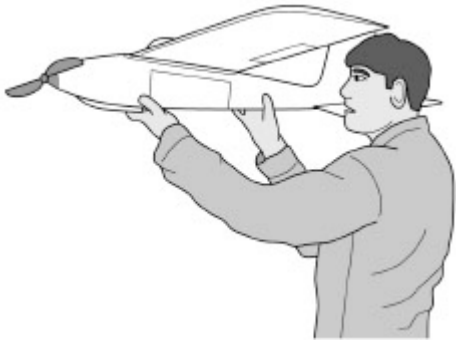
(Total 10 marks)

14. A drone is a miniature aircraft that has a remote control.

An inventor designed a battery powered drone.

The inventor tested what would happen if the battery runs out of charge during a flight.

Figure 5 shows the inventor about to launch the drone.



(a) After the drone was launched, it moved at a constant speed and gained height.

The thermal stores of energy of the drone increased.

Describe **two** other changes to the energy stores of the drone as it moved at a constant speed and gained height.

1 _____

_____

2 _____

_____

(2)

When the drone reached a height of 840 m the motor was switched off.

The motor was switched back on after a short time, when the drone had fallen to a lower height above the ground.

The change in gravitational potential energy of the drone during the fall to this lower height was 3920 J.

The mass of the drone is 2.5 kg.

gravitational field strength = 9.8 N/kg

(b) Calculate the height above the ground of the drone when the motor was switched back on.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

_____

_____

Height above ground = _____ m

(4)

(c) When the motor was switched off, the kinetic energy of the drone was 150 J.

Calculate the maximum possible speed of the drone when the motor was switched back on.

Use the Physics Equations Sheet.

Give your answer in km/s.

Maximum possible speed of drone = _____ km/s

(5)

(Total 11 marks)

Mark schemes

1.

(a) the current in both lamps is the same

1

(b) (4.5 - 1.5 =) 3 (V)

allow (4.5 - 1.5 =) 3.0 (V)

1

(c) $P = 1.5 \times 1.2$

1

1.8 (W)

1

(d)

$$R = \frac{1.5}{1.2}$$

1

1.25 (Ω)

allow 1.3 (Ω)

1

(e) $Q = 1.2 \times 40$

1

48 (C)

1

(f) the temperature of each lamp increases

1

(g) lamp **X** no longer emits light

1

because the circuit is no longer complete

dependent on MP1

allow because there is no current

1

[11]

2.

(a) the same distance as the lift

1

(b) it decreases

1

(c) $E = 1300 \times 9.8 \times 4.0$

1

$E = 50960$ (J)

allow 51000 (J)

1

(d) kinetic

1

internal

1

this order only

(e) the distance moved by the lift

1

the weight of the people in the lift

1

(f) $E_e = 0.5 \times 880\,000 \times 0.015^2$

1

$E_e = 99$ (J)

1

(g) less energy is transferred

1

[11]

3. (a) a renewable energy resource that uses hot rocks underground

1

(b) $\Delta E = 15 \times 3800 \times 9.0$

1

513 000 (J)

1

(c) 9600 (J)

1

(d) 1 W

1

(e)

$$\text{height} = \frac{196}{5.0 \times 9.8}$$

1

4 (m)

allow 4.0 (m)

1

(f) **EITHER**

releases carbon dioxide

ignore references to pollution

1

which contributes to global warming

allow climate change for global warming
allow which is a greenhouse gas
allow which contributes to the greenhouse effect

OR

releases sulfur / nitrogen dioxide (1)

allow other oxides of nitrogen

which causes acid rain (1)

OR

releases soot (1)

allow carbon for soot
allow particulates

which can cause global dimming (1)

allow reduces air quality
allow causes smog

1

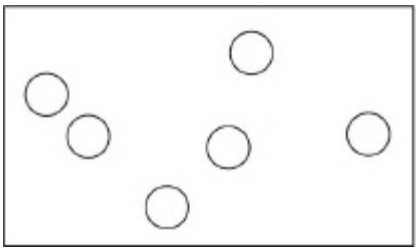
[9]

4. (a) metal has a high thermal conductivity

1

(b) 6 particles all spread apart irregularly within the box

e.g.



1

(c) air particles collide with the walls of the container

1

(d) decreases

1

(e) (the pressure) decreased as temperature decreased

1

(the pressure) increased as temperature increased

*allow **2** marks for it decreased then increased*

1

(f) 90 (m^3)

1

(g)

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

or

$$\rho = \frac{m}{V}$$

1

(h)

$$1100 = \frac{m}{90}$$

*allow ecf from part **(f)***

1

mass = 90 × 1100

1

99 000 (kg)

1

[11]

5. (a) $\Delta\theta = \frac{7.5}{30}$

1

$\Delta\theta$ = 0.25 (°C)

1

(b) bar Y drawn to 16 **and** bar Z drawn to 12

allow ± half a small square

1

y-axis labelled 'temperature in °C'

unit must be present

1

(c) Y

1

because it showed the smallest change in temperature

reason only scores if Y is chosen

1

(d) less than 12.0 °C

1

(e) *E* = 0.0150 × 334 000

1

E = 5010 (J)

1

(f) resolution

1

(g) density = $\frac{\text{mass}}{\text{volume}}$

or

$\rho = \frac{m}{V}$

1

(h) $0.300 = \frac{m}{0.186}$

1

$m = 0.300 \times 0.186$

1

$m = 0.0558$ (g)

1

[14]

6. (a) it can be replenished as it is used

1

(b) biomass – renewable
nuclear – Non-renewable
natural gas – Non-renewable

all 3 correct

Energy resource	Renewable	Non-renewable
Biomass	✓	
Nuclear		✓
Natural gas		✓

allow 1 mark for two correct answers

2

(c) kinetic

answers must be in the correct order

1

chemical

1

(d) less energy is needed to heat the house

1

the roof is a better insulator

1

(e) E = 26 000 × 30

1

780 000 (J)

1

(f) efficiency = $\frac{\text{useful power output}}{\text{total power input}}$

1

(g) $0.15 = \frac{\text{useful power output}}{26000}$

1

useful power output = 26000 × 0.15

1

useful power output = 3900 (W)

1

(h) sometimes it is not sunny/windy

1

so there's more chance of electricity being generated at any time

OR

more electricity is generated (1)

which reduces the running costs (of the eco-home) (1)

if no other mark scored, allow a reference to reduced greenhouse gas emissions or reduced global warming for 1 mark

1

[15]

7. (a) alpha

1

(b) 2

1

(c) 82

1

(d) 50

1

(e) $\frac{1500}{30}$

1

50 (counts per second)

1

(f) the count-rate decreased

allow decreased to (almost) zero

1

because (gamma) radiation is absorbed by lead

allow (gamma) radiation cannot penetrate (thick) lead

1

(g) the lead was exposed to gamma radiation

1

(h) electromagnetic waves

1

(i) any one from:

- (longer tongs give) a greater distance between the scientist and the radioactive source
- (longer tongs) reduce the amount of radiation the scientist is exposed to
- (longer tongs) reduce the risk of cell mutation

allow (longer tongs) reduce the risk of cancer

1

[11]

8. (a) kinetic energy (of the beater / food)

ignore sound

1

internal / thermal energy (of the surroundings / whisk / food)

1

(b)

$$\text{power} = \frac{\text{work done}}{\text{time}}$$

or

$$P = \frac{W}{t}$$

1

(c)

$$92 = \frac{23\,000}{\text{time}}$$

1

$$\text{time} = \frac{23\,000}{92}$$

1

250 (s)

1

(d) $P = I^2 R$

1

(e) $I = 0.500$ A

1

$P = 0.500^2 \times 640$

allow a correct substitution of an incorrectly / not converted current

1

$P = 160$ (W)

allow a correct calculation using an incorrectly / not converted current

1

(f) 230 (V)

1

(g) decreases

1

[12]

9. (a) voltmeter symbol correct and connected across the resistors

1

(b) the total resistance must be less than 20 Ω

allow the total resistance cannot be more than 20 Ω

1

because the total resistance of the resistors (in parallel) is less than the resistance of the smallest resistor

allow the total resistance of the resistors (in parallel) is less than either resistor

1

(c) potential difference = current × resistance

or

$V = IR$

1

(d) 480 mA = 0.48 A

1

$V = 0.48 \times 7.5$

allow a correct substitution of an incorrectly / not converted value for current

1

$V = 3.6$ (V)

allow an answer consistent with their incorrectly / not converted value for current

1

(e) x-axis labelled Resistance of R in Ω **and** y-axis labelled Total resistance (of resistors) in Ω

1

both points plotted correctly

points must be plotted within ½ small square

1

curved line of best fit drawn

allow a line of best fit which ignores an outlier

1

(f) reading from graph consistent with their line of best fit

allow an answer within ½ small square

1

(g) random

1

(h) in category A the body water percentage is 61%

allow a value for A between 60% and 62%

1

in category B the body water percentage is 68%

1

if in category A they have a healthy body water percentage **and** if in category B they have an unhealthy body water percentage

1

[15]

10. (a) $\Delta E = 4.0 \times 420 \times 50$

1

$\Delta E = 84\,000$ (J)

1

(b) the total kinetic energy and potential energy of the steel particles

1

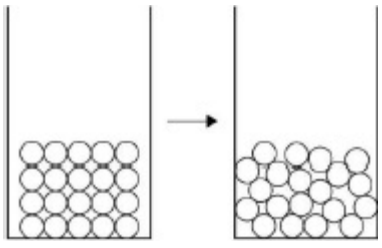
(c) the particles are in fixed positions

1

(d) stays the same

1

(e)



1

(f) (the space between the particles) increases

allow the particles move further apart

1

(g) physical

1

(h) $\text{mass per kg} = \frac{18}{4.0}$

1

mass per kg = 4.5 g

1

medium carbon

dependent on MP2

OR

mass in 4.0 kg of medium carbon steel = 4.5 × 4.0 (1)

allow mass in 4.0 kg of low carbon steel = 8 (g)

allow mass in 4.0 kg of high carbon steel = 28 (g)

mass in 4.0 kg of medium carbon steel = 18 g (1)

dependent on MP1

medium carbon (1)

dependent on MP2

1

(i) 280 000 = 4.0 × *L*

1

$L = \frac{280\,000}{4.0}$

1

L = 70 000 (J/kg)

1

[14]

11. (a) 100 (kPa)

allow 10^2 *(kPa)*

1

(b) range = 0.006 (MPa)

allow mean = 0.118

1

uncertainty = ± 0.003 (MPa)

*an answer of uncertainty = 0.118 (MPa) scores **0** marks*

1

(c) the relationship is linear

allow the relationship obeys y = mx + c

allow the gradient (of the graph) is constant

*do **not** accept (directly) proportional*

1

(d) (as the amount of steam increases) the number of particles increases

1

and (as the temperature increases) particles move faster

allow (as the temperature increases) the (average) kinetic energy of the particles increases

1

particles collide with the wall of the cooker

if MP3 is not awarded no subsequent marks may be awarded

1

these collisions are more frequent

1

and each collision exerts more force

1

particles refers to particles in the steam throughout

(e) the particles spread out

*do **not** allow particles expand*

1

so the steam / gas takes up a greater <u>volume</u>

allow there is less gas in the same <u>volume</u>

1

and density = $\frac{\text{mass}}{\text{volume}}$ so the density decreases

*do **not** allow density of particles decreases*

1

[12]

12. (a) they changed direction

allow

deflected/reflected/repelled

1

(b)

an answer of 0.000 03 (nm) or 3.0×10^{-5} (nm) scores 2 marks

diameter = $\frac{0.18}{6000}$

1

= 0.000 030 (nm)

allow 3.0×10^{-5} (nm)

1

(c) A

1

(d) 1100 (°C)

1

(e) 8 (minutes)

allow 12 (minutes)

1

(f) the rate of change of temperature of the gold

1

[7]

13. (a) contamination

1

(b) 2007-1992 = 15

allow an indication of the student reading from 15 years on the graph

1

35 (Bq)

allow an answer between 34 and 36 (Bq)

1

(c) 12.5 (years)

1

(d) 12.5 (years)

allow the same value as their answer to (c)

1

(e)

$\frac{36\,000\,000\,000}{45\,000\,000\,000}$ (× 100)

allow $\frac{36}{45}$ *(× 100)*

1

80 (%)

1

(f) radioactive decay is a random process

1

(g) use long tongs to handle the materials

1

(h) peer review

1

[10]

14. (a) chemical store of energy decreases

1

gravitational potential energy of the drone increases

1

(b) $3920 = 2.5 \times 9.8 \times \Delta h$

1

$$\Delta h = \frac{3920}{2.5 \times 9.8}$$

1

$\Delta h = 160$ (m)

1

(840 - 160) = 680 (m)

allow an answer consistent with their calculated value of Δh using the correct equation

OR

Initial $E_p = 2.5 \times 9.8 \times 840$ (1)

allow initial $E_p = 20580$

Final E_p(= 20580 - 3920)
= 16660 (1)

allow correct use of an incorrectly calculated value of E_p using the gravitational potential energy equation

$$h = \frac{16660}{2.5 \times 9.8} \text{ (1)}$$

allow a correct substitution and rearrangement using their calculated value of E_p using the gravitational potential energy equation

= 680 (m) (1)

allow an answer consistent with their calculated value of E_p using the gravitational potential energy equation

1

(c) max E_k = 3920 + 150 (= 4070 J)

allow max E_k = 4070 J

1

4070 = 0.5 × 2.5 × v^2

allow a substitution using their value for kinetic energy

1

$$v = \sqrt{\frac{4070}{0.5 \times 2.5}}$$

allow a correct re-arrangement using their value for kinetic energy

allow $v^2 = \frac{4070}{0.5 \times 2.5}$

1

v = 57.06... (m/s)

allow v = 57 (m/s)

1

v = 0.057... (km/s)

allow an answer consistent with their calculated value for v using the kinetic energy equation

1

[11]