1. A student investigated the thermal conductivity of different metals.

This is the method used:

1. Measure the mass of an ice cube.
2. Put the ice cube on a metal block which is at room temperature.
3. Measure the mass of the ice cube after one minute.
4. Repeat with other blocks of the same mass made from different metals.

The following table shows the student's results.

Metal	**Initial mass of ice cube in grams**	**Final mass of ice cube in grams**	**Change in mass of ice cube in grams**
Aluminium	25.85	21.14	4.71
Copper	26.20	20.27	5.93
Lead	25.53	21.97	3.56
Steel	24.95	19.45	5.50

(a) The initial temperature of each ice cube was –15 °C

Why was it important that the initial temperature of each ice cube was the same?

Tick (✓) **one** box.

Initial temperature was a continuous variable. ☐

Initial temperature was a control variable. ☐

Initial temperature was the dependent variable. ☐

Initial temperature was the independent variable. ☐

(1)

(b) Which metal had the highest thermal conductivity?

Give a reason for your answer.

Metal: _____

Reason: _____

_____

_____

(2)

(c) Suggest **one** source of random error in the student's investigation.

_____

_____

_____

_____

(1)

(d) An ice cube has a temperature of −15.0 °C

The total thermal energy needed to raise the temperature of this ice cube to 0.0 °C and completely melt the ice cube is 5848 J

specific heat capacity of ice = 2100 J/kg °C
specific latent heat of fusion of ice = 334 000 J/kg

Calculate the mass of the ice cube.

Mass of ice cube = _____ kg

(5)

(Total 9 marks)

2. (a) During one year, 1.25×10^{18} J of energy was transferred from the National Grid.

number of seconds in 1 year = 3.16×10^{7}

Calculate the mean energy transferred from the National Grid each second.

Give your answer to 3 significant figures.

_____

_____

_____

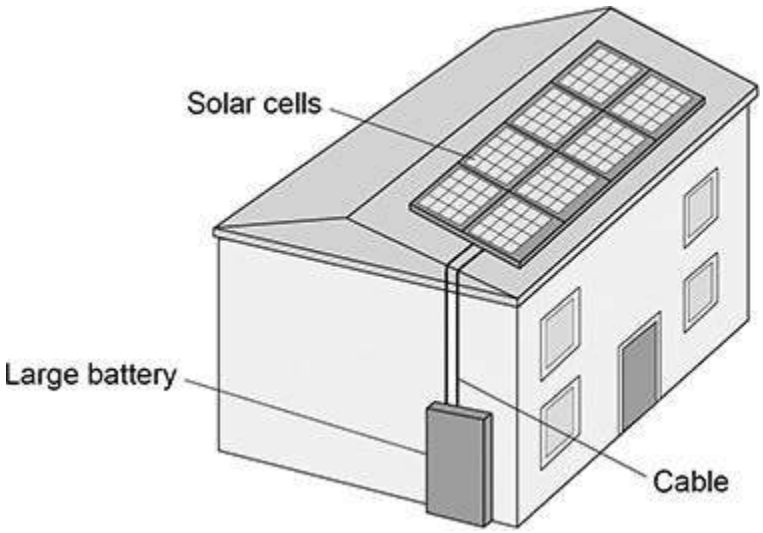
Energy each second (3 significant figures) = _____ J

(2)

The figure below shows a house with a solar power system.

The solar cells generate electricity.

When the electricity generated by the solar cells is not needed, the energy is stored in a large battery.



(b) The charge flow through the cable between the solar cells and the battery in 24 hours was 27 000 coulombs.

Calculate the mean current in the cable.

Mean current = _____A

(4)

(c) At one time, the total power input to the solar cells was 7.8 kW.

The efficiency of the solar cells was 0.15

Calculate the useful power output of the solar cells.

Useful power output = _____W

(3)

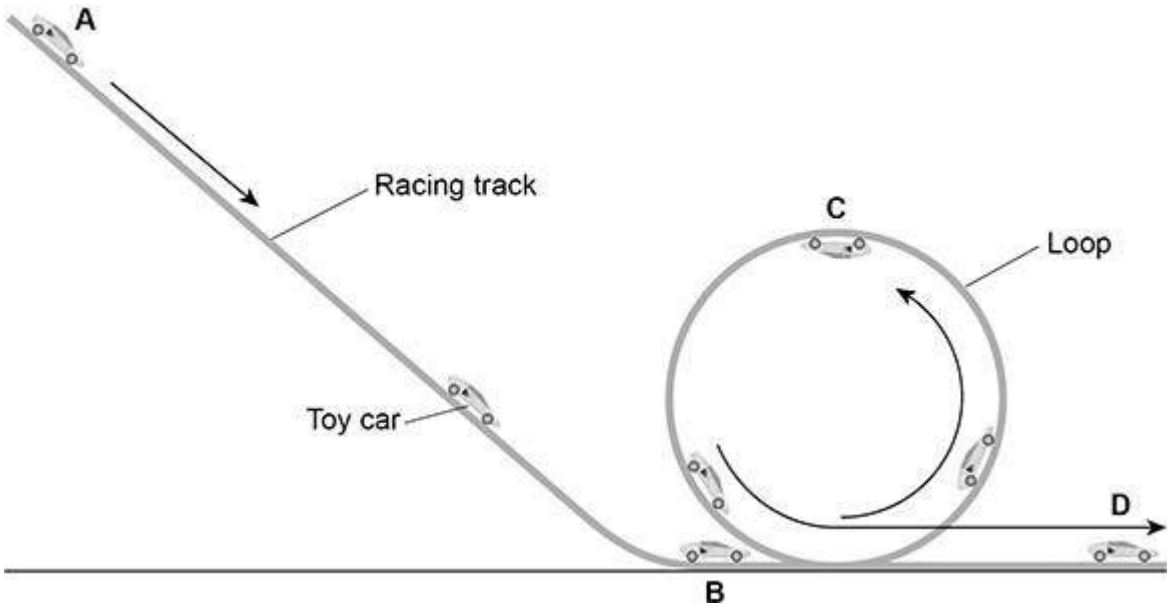
(d) It is unlikely that **all** of the electricity that the UK needs can be generated by solar power systems.

Explain why.

(2)

(Total 11 marks)

3. The figure below shows a toy car in different positions on a racing track.



(a) The toy car and racing track can be modelled as a closed system.

Why can the toy car and racing track be considered 'a closed system'?

Tick (✓) **one** box.

The racing track and the car both have gravitational potential energy. ☐

The racing track and the car are always in contact with each other. ☐

The total energy of the racing track and the car is constant. ☐

(1)

(b) The car is released from rest at position **A** and accelerates due to gravity down the track to position **B**.

mass of toy car = 0.040 kg

vertical height between position **A** and position **B** = 90 cm

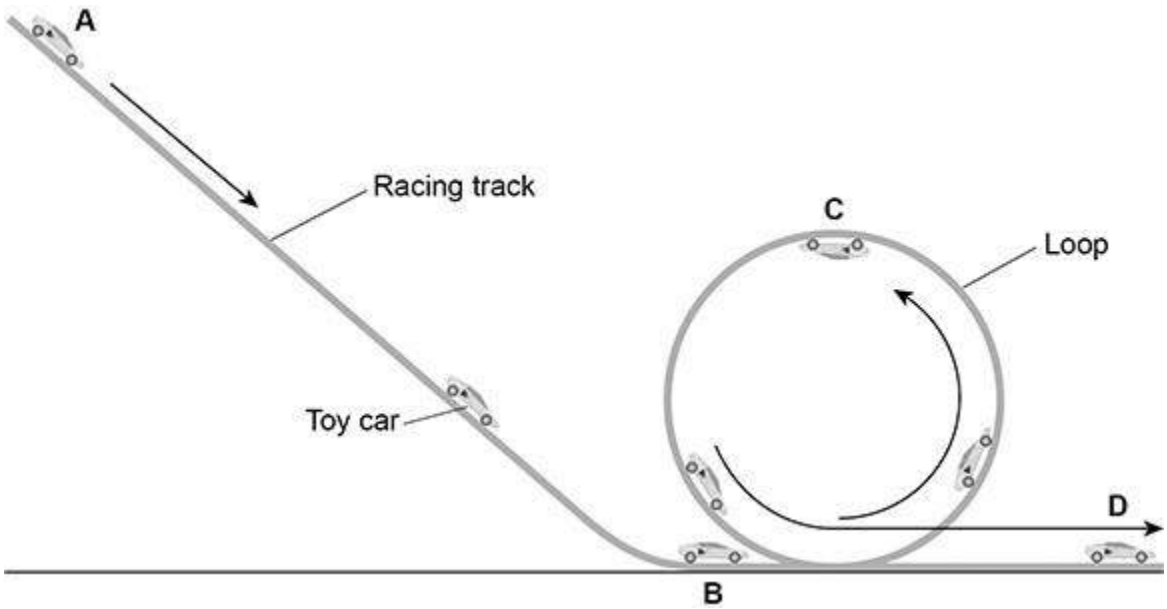
gravitational field strength = 9.8 N/kg

Calculate the maximum possible speed of the toy car when it reaches position **B**.

Speed = _____ m/s

(5)

The figure above is repeated below.



(c) At position **C** the car's gravitational potential energy is 0.20 J greater than at position **B**.

How much kinetic energy does the car need at position **B** to complete the loop of the track?

Give a reason for your answer.

Tick (✓) **one** box.

Less than 0.20 J	☐
Exactly 0.20 J	☐
More than 0.20 J	☐

Reason _____

_____

_____

(2)

(Total 8 marks)

4. Electric cars have motors that are powered by a battery.

Diesel cars have engines that are powered by diesel fuel.

The following table compares one type of electric car with one type of diesel car.

Power source	Energy density in MJ / kg	Mass of power source in kg	Total mass of car in kg	Time to recharge battery or refill fuel tank in minutes
Battery	0.95	280	1600	40
Diesel fuel	45	51	1500	3

(a) The electric car has a range of 400 km with a fully charged battery.

The diesel car has a range of 1120 km with a full tank of diesel.

Explain the difference in the time needed to complete a 500 km journey using the electric car compared with the diesel car.

Assume both cars travel at the same speed.

_____

_____

_____

_____

_____

_____

(2)

(b) Energy density is the amount of energy stored per kilogram of the energy source.

Show why the diesel car has a greater range than the electric car.

Use data from the table above.

Assume the efficiency of the two cars is the same.

Include calculations in your answer.

(3)

Engineers have developed a way of charging electric cars while they are driving along the road.

Coils of wire buried under the road transfer energy to the car's battery as the car is passing over the coils.

The figure below shows a charging lane on a motorway.

(c) Suggest **two** advantages of using this method to charge electric cars compared with plugging them into the mains electricity supply.

1 _____

_____

_____

_____

2 _____

_____

_____

_____

(2)

(d) When electric cars are not being driven, energy stored in their batteries could be used to meet sudden peaks in electricity demand.

Suggest how.

_____

_____

_____

_____

_____

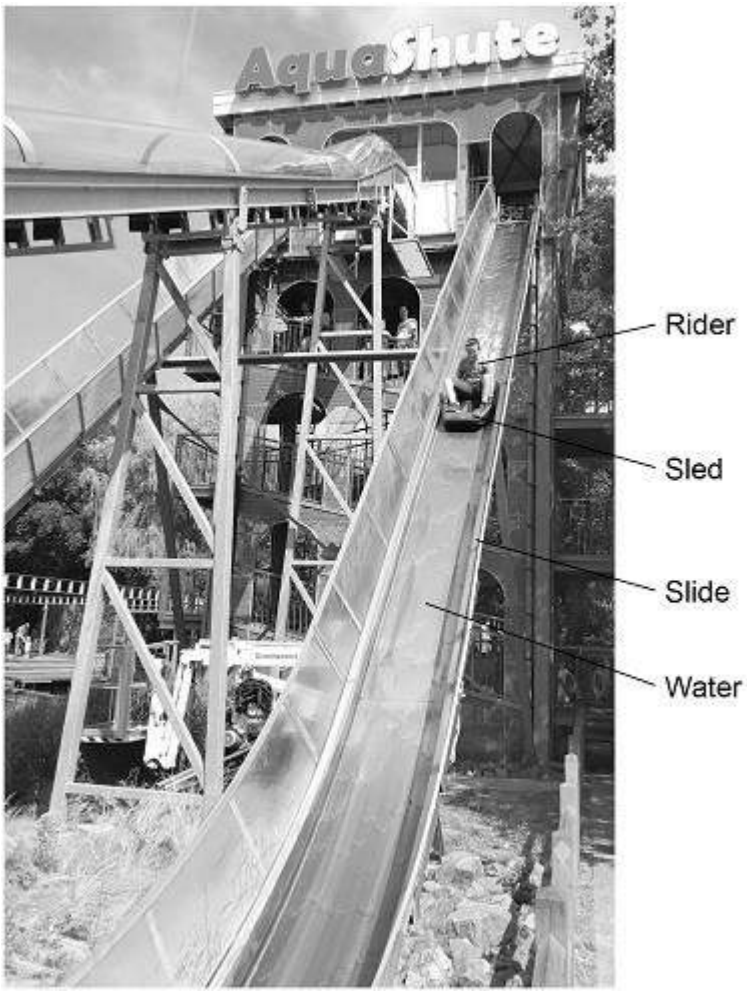
_____

(2)

(Total 9 marks)

5. The photograph below shows a theme park ride called AquaShute.

Riders of the AquaShute sit on a sled and move down a slide.



(a) A light gate and data logger can be used to determine the speed of each rider and sled.

What two measurements are needed to determine the speed of a rider and sled?

Tick (✓) **two** boxes.

Gravitational field strength	☐
Length of sled	☐
Mass of rider and sled	☐
Temperature of surroundings	☐
Time for sled to pass light gate	☐

(2)

(b) The decrease in gravitational potential energy of one rider on the slide was 8.33 kJ.

The rider moved through a vertical height of 17.0 m.

gravitational field strength = 9.8 N/kg

Calculate the mass of the rider.

_____

_____

_____

_____

Mass of rider = _____ kg

(4)

(c) At the bottom of the slide, all riders and their sleds have approximately the same speed.

Explain why.

_____

_____

_____

_____

_____

_____

_____

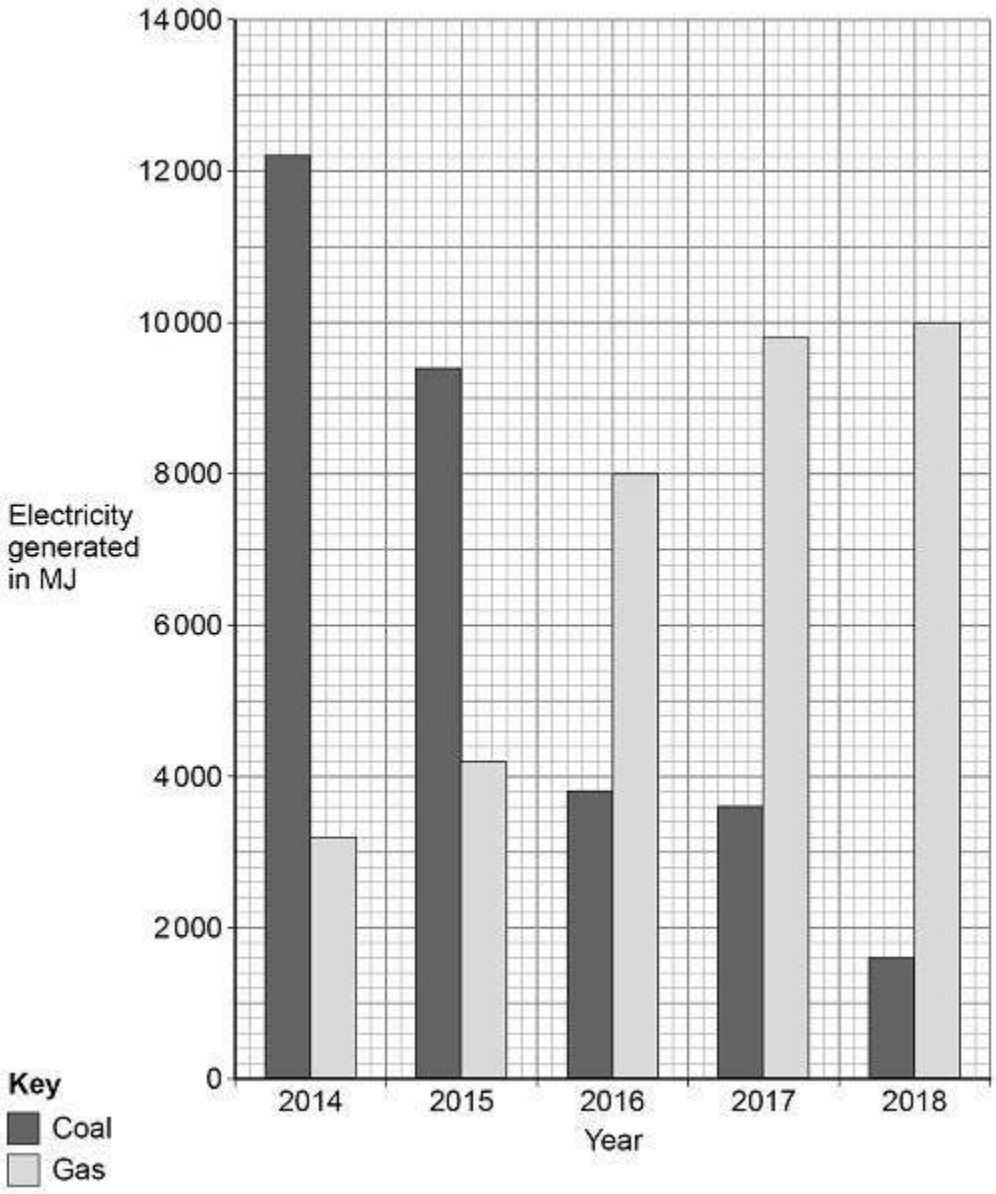
_____

(4)

(Total 10 marks)

6. **Figure 1** shows how much electricity was generated using coal-fired and gas-fired power stations in January for 5 years in the UK.

Figure 1



(a) Determine the percentage increase in electricity generated using gas-fired power stations from 2014 to 2018.

_____

_____

_____

Percentage increase = _____ %

(2)

(b) Give **two** environmental advantages of using a gas-fired power station to generate electricity compared with using a coal-fired power station.

1 _____

_____

2 _____

_____

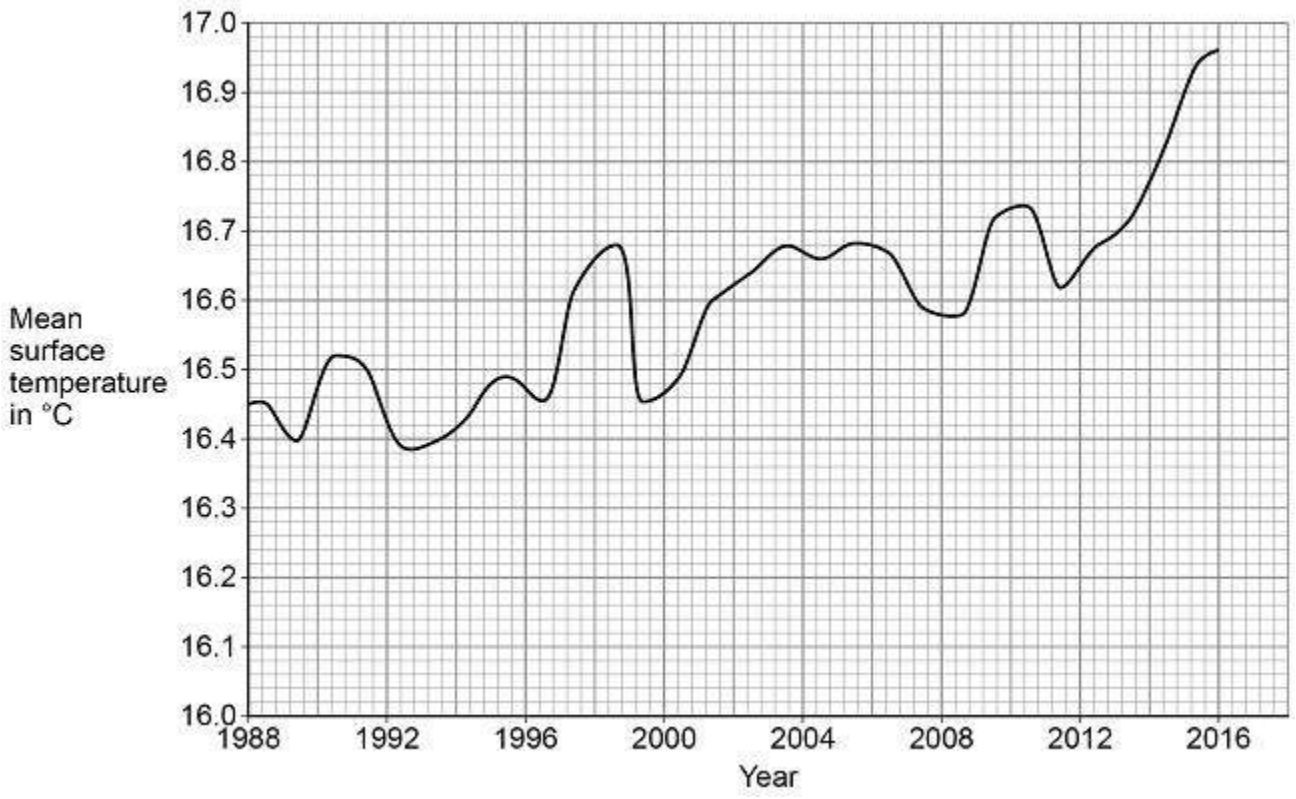
(2)

The mean surface temperature of the sea changes throughout the year.

A change in the mean surface temperature from year to year indicates climate change.

Figure 2 shows how the mean surface temperature changed between 1988 and 2016.

Figure 2



(c) A student does not believe that climate change is occurring.

Explain how the data in **Figure 2** suggests the student is wrong.

_____

_____

_____

_____

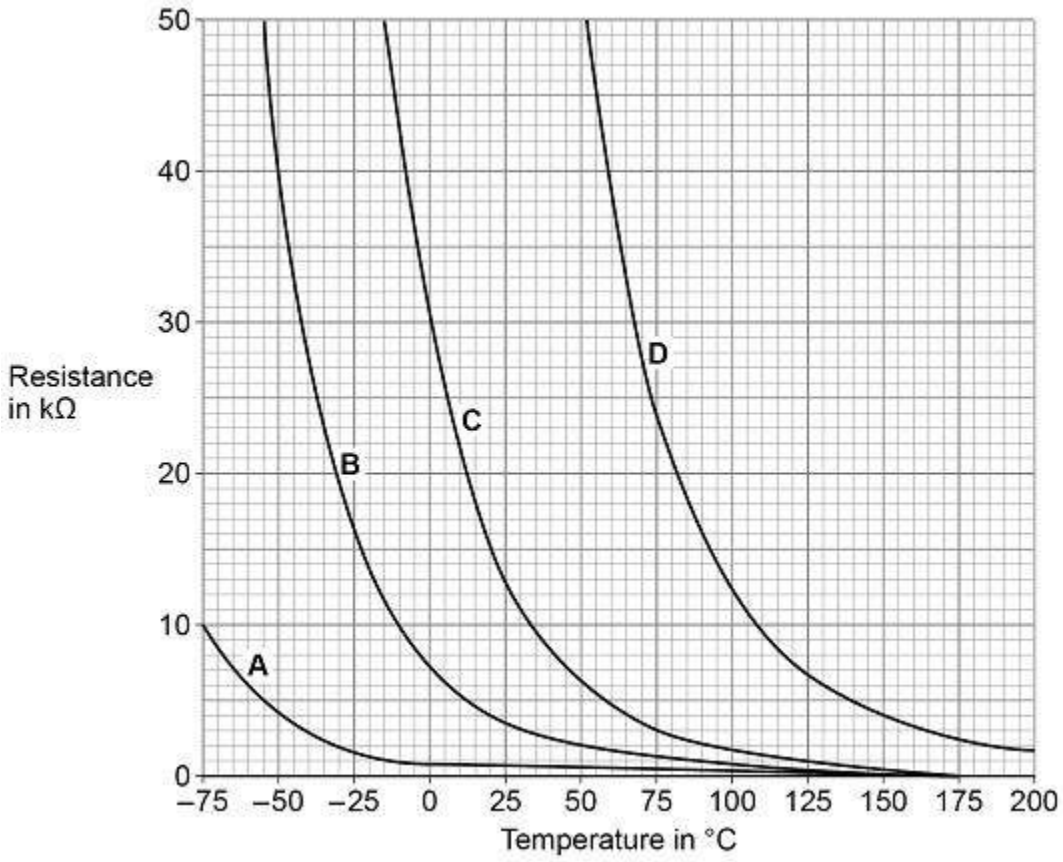
_____

(2)

(d) A thermistor can be used to measure temperature.

Figure 3 shows how the resistance of four different thermistors A, B, C and D, varies with temperature.

Figure 3



Which of the four thermistors would be the most suitable to measure the surface temperature of the sea?

Tick (✓) **one** box.

Explain your answer.

A	B	C	D
☐	☐	☐	☐

_____

_____

_____

_____

(3)

(Total 9 marks)

7. **Figure 1** shows a person using an electric lawn mower.

Figure 1

(a) The lawn mower is connected to the mains electricity supply.

What is the frequency of the mains electricity supply in the UK?

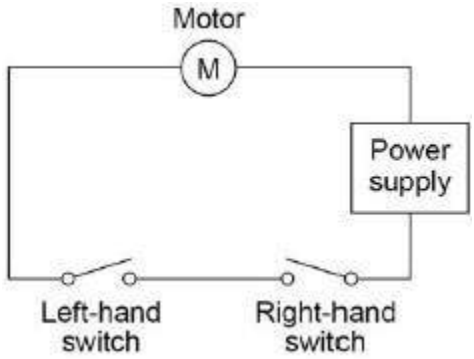
Frequency = _____ Unit _____

(2)

The lawn mower has a switch on each side of the handle.

Figure 2 shows the circuit diagram for the lawn mower.

Figure 2



(b) The motor in the lawn mower can only be turned on when the person using it holds the handle of the lawn mower with both hands.

Explain why.

_____

_____

_____

_____

(2)

(c) The power input to the motor is 1.8 kW

The resistance of the motor is 32 Ω

Calculate the current in the motor.

_____

_____

_____

_____

Current = _____ A

(3)

(d) The useful power output from the motor is 1.5 kW

Calculate the time it takes for the motor to transfer 450 000 J of useful energy.

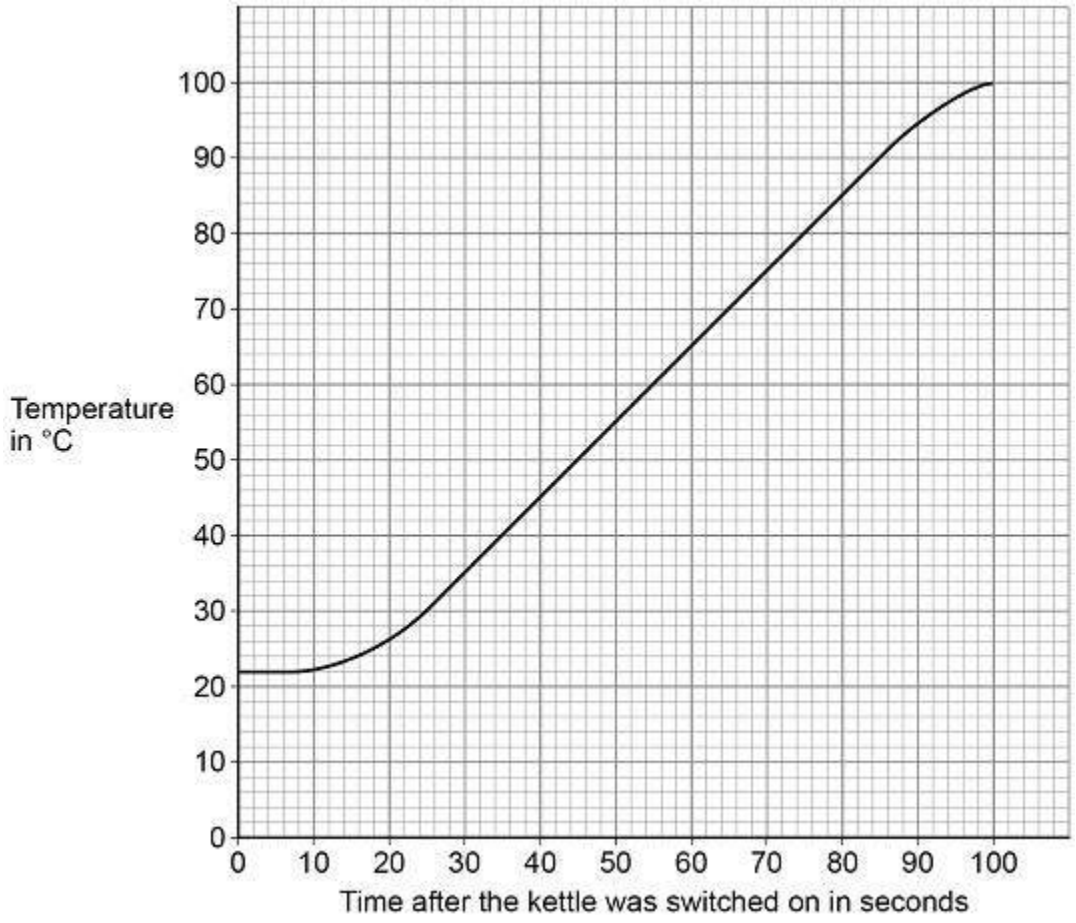
Time = _____ seconds

(3)

(Total 10 marks)

8. An electric kettle was switched on.

The graph below shows how the temperature of the water inside the kettle changed.



(a) When the kettle was switched on the temperature of the water did **not** immediately start to increase.

Suggest **one** reason why.

_____

_____

_____

(1)

(b) The energy transferred to the water in 100 seconds was 155 000 J.

specific heat capacity of water = 4200 J/kg °C

Determine the mass of water in the kettle.

Use the graph above.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

_____

Mass of water (2 significant figures) = _____ kg

(5)

(c) The straight section of the line in above graph can be used to calculate the useful power output of the kettle.

Explain how.

_____

_____

_____

_____

_____

_____

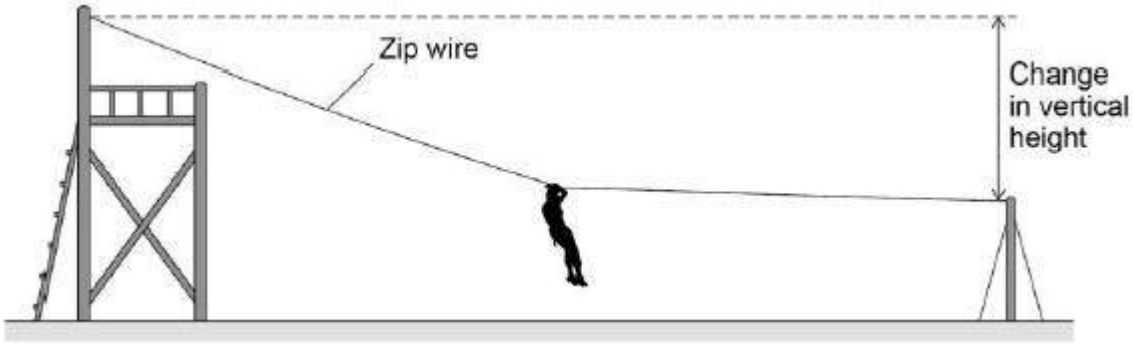
_____

(3)

(Total 9 marks)

9. **Figure 1** shows a person sliding down a zip wire.

Figure 1



(a) As the person slides down the zip wire, the change in the gravitational potential energy of the person is 1.47 kJ

The mass of the person is 60 kg

gravitational field strength = 9.8 N/kg

Calculate the change in vertical height of the person.

Change in vertical height = _____ m

(3)

(b) As the person moves down the zip wire her increase in kinetic energy is less than her decrease in gravitational potential energy.

Explain why.

(2)

(c) Different people have different speeds at the end of the zip wire.

Explain why.

_____

_____

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

10. **Figure 1** shows a cyclist riding along a straight, level road at a constant speed.

Figure 1

(a) Complete the sentences.

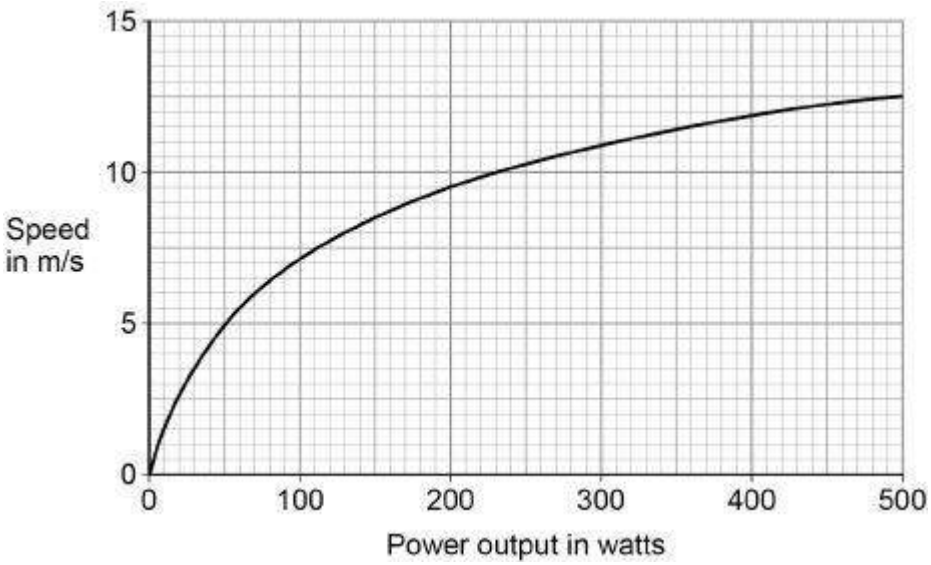
As the cyclist rides along the road, the _____ energy store in the cyclist's body decreases.

The speed of the cyclist is constant when the work done by the cyclist is _____ the work done against air resistance.

(2)

Figure 2 shows how the speed changes as the power output of the cyclist changes.

Figure 2



(b) Write down the equation that links power, time and work done.

_____

(1)

(c) Calculate the work done by the cyclist when his power output is 200 W for 1800 seconds.

_____

_____

_____

_____

Work done = _____ J

(3)

(d) Calculate the percentage increase in speed of the cyclist when the power output changes from 200 W to 300 W.

_____

_____

_____

_____

Percentage increase in speed = _____

(2)

(e) The maximum speed this cyclist can travel on a level road is 14 m/s.

How does cycling uphill affect the maximum speed of this cyclist?

Explain your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 11 marks)

11. The photograph below shows a coffee machine. The coffee machine uses an electric element to heat water.

(a) The coffee machine has a metal case.

Why would it be dangerous for the live wire of the electric cable to touch the metal case?

_____

_____

(1)

(b) The power output of the coffee machine is 2.53 kW.

The mains potential difference is 230 V.

Calculate the current in the coffee machine.

Current = _____ A

(3)

(c) The coffee machine heats water from 20 °C to 90 °C.

The power output of the coffee machine is 2.53 kW.

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

Calculate the mass of water that the coffee machine can heat in 14 seconds.

Mass = _____ kg

(5)

(Total 9 marks)

12. Nuclear power stations generate electricity through nuclear fission. Electricity can also be generated by burning shale gas.

(a) Shale gas is natural gas trapped in rocks. Shale gas can be extracted by a process called fracking. There is some evidence that fracking causes minor earthquakes. Burning shale gas adds carbon dioxide to the atmosphere.

Describe the advantages of nuclear power compared with the use of shale gas to generate electricity.

(3)

(b) What is the name of **one** fuel used in nuclear power stations?

(1)

(c) Describe the process of nuclear fission.

(4)

(Total 8 marks)

13. The diagram below shows a wind turbine.

(a) At a particular wind speed, a volume of 2.3×10^4 m^3 of air passes the blades each second.

The density of air is 1.2 kg/m^3.

Calculate the mass of air passing the blades per second.

Mass of air per second = _____ kg

(3)

(b) The power output of the turbine is directly proportional to the kinetic energy of the air passing the blades each second.

Describe the effect on the power output when the wind speed is halved.

(3)

(c) At a different wind speed, the wind turbine has a power output of 388 kW.

The mass of air passing the wind turbine each second is 13 800 kg.

Calculate the speed of the air passing the blades each second.

Assume that the process is 100% efficient.

Speed of air = _____ m/s

(3)

(Total 9 marks)

14. (a) Complete the sentence. Choose answers from the box.

charge	**potential difference**	**power**	**temperature**	**time**

The current through an ohmic conductor is directly proportional to the

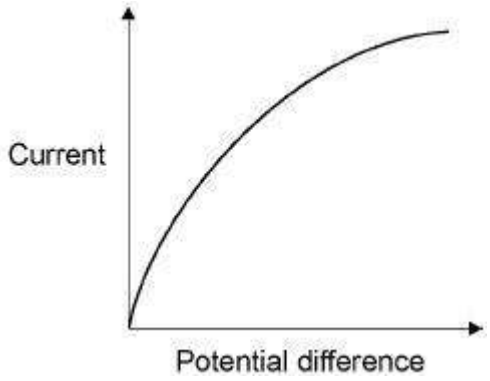
_____ across the component, provided

that the _____ remains constant.

(2)

(b) **Figure 1** shows a current − potential difference graph for a filament lamp.

Figure 1



Explain how the resistance of a filament lamp changes as the potential difference across it increases.

_____

_____

_____

_____

_____

_____

(3)

(c) Many householders are replacing their filament lamps with LED lamps which are more energy efficient.

What does more energy efficient mean?

_____

_____

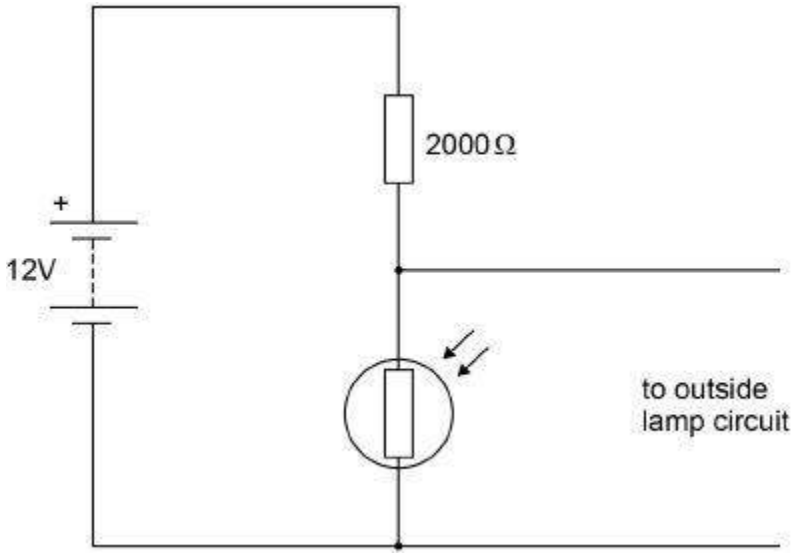
_____

(1)

A Light Dependent Resistor (LDR) is used to turn on an outside lamp when it gets dark.

Part of the circuit is shown in **Figure 2**.

Figure 2



(d) The light intensity decreases.

What happens to the potential difference across the LDR and the current in the LDR?

Potential difference _____

Current _____

(2)

(e) What is the resistance of the LDR when the potential difference across it is 4 V?

Give a reason for your answer.

Explain your answer.

Resistance = _____ Ω

Reason _____

_____

_____

(2)

(f) Calculate the current through the LDR when the resistance of the LDR is 5000 Ω.

Give your answer to 2 significant figures.

Current = _____ A

(4)

(Total 14 marks)

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