

Energy 2

Name: _____

Class: _____

Date: _____

Time: **87 minutes**

Marks: **86 marks**

Comments:

1.

Figure 1 shows a kettle a student used to determine the specific heat capacity of water.

Figure 1



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The student placed different masses of water into the kettle and timed how long it took for the water to reach boiling point.

The student carried out the experiment three times.

The student's results are shown in the table below.

Mass of water in kg	Time for water to boil in seconds				Mass × change in temperature in kg°C	Energy supplied in kJ
	1	2	3	Mean		
0.25	55	60	63	59	20	131
0.50	105	110	116	110	40	243
0.75	140	148	141	143	60	314
1.00	184	190	183	182	80	401
1.25	216	215	211	214	100	471
1.50	272	263	266	267	120	587
1.75	298	300	302		140	

(a) Suggest how the student was able to ensure that the change in temperature was the same for each mass of water.

(2)

- (b) Calculate the uncertainty in the student's measurements of time to boil when the mass of water was 1.75 kg.

Uncertainty = _____ s

(2)

- (c) The power rating of the kettle is 2.20 kW.

Calculate the average electrical energy used by the kettle, in kJ, for 1.75 kg of water to reach boiling point.

Average energy = _____ kJ

(2)

- (d) Use information from the table above to calculate the change in temperature of the water during the investigation.

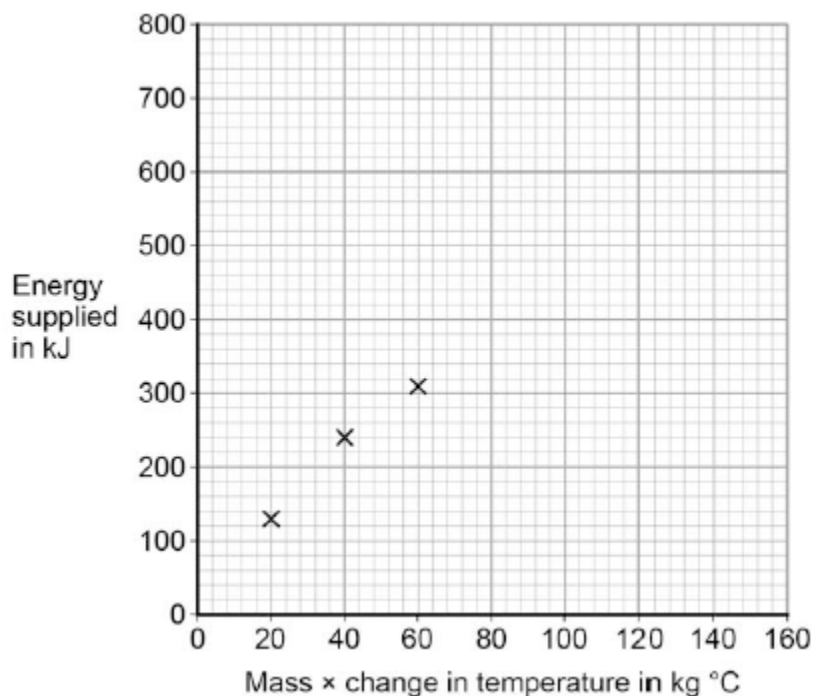
Change in temperature = _____ °C

(2)

- (e) The student plotted a graph of energy supplied in kJ against mass \times change in temperature in $\text{kg } ^\circ\text{C}$.

Figure 2 shows the graph the student plotted.

Figure 2



Use data from the table above to plot the four missing points.

Draw a line of best fit on the graph.

(3)

- (f) Use the graph to determine the mean value of the specific heat capacity of water, for the student's investigation.

Specific heat capacity of water = _____ $\text{J / kg } ^\circ\text{C}$

(4)

- (g) The student's value for the specific heat capacity of water was greater than the accepted value.

Suggest why.

(1)

- (h) The kettle used in the experiment had a label stating that the power rating of the kettle was 2.2 kW.

The student did not measure the power of the kettle.

Suggest why measuring the power of the kettle may improve the student's investigation.

(1)

(Total 17 marks)

2.

Different energy sources are used to generate electricity.

- (a) Use words from the box to match the correct energy source to each of the descriptions given in the table.

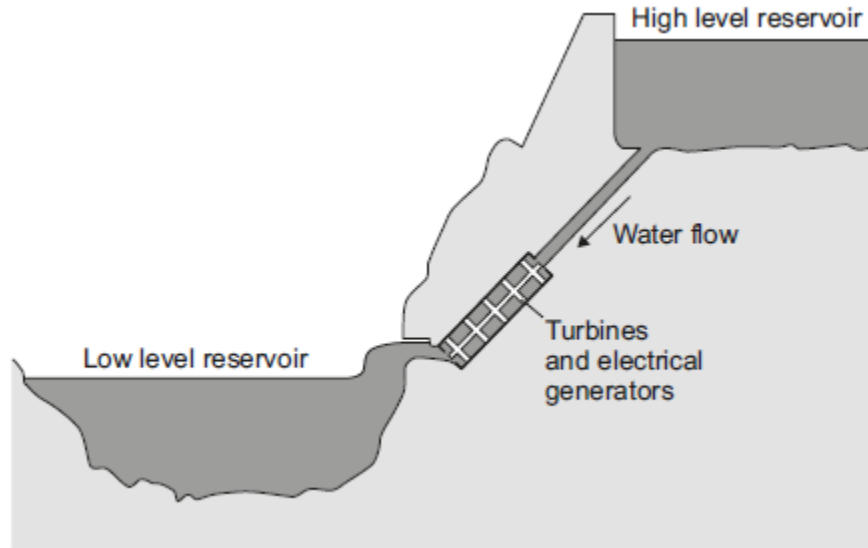
biofuel	coal	geothermal	nuclear	waves
----------------	-------------	-------------------	----------------	--------------

Description	Energy source
Energy from the Earth's core is used to heat water.	
Fission of uranium nuclei is used to heat water.	
Gases from rotting plant material are burned to heat water.	

(3)

- (b) Energy can be stored in a pumped storage power station.

The figure shows a pumped storage power station.



When electricity is needed, the water in the high level reservoir is allowed to flow to the low level reservoir. The flowing water generates electricity.

Use the correct answer from the box to complete each sentence.

electrical	gravitational potential	kinetic	nuclear	sound
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The water in the high level reservoir stores _____ energy.

The flowing water has _____ energy.

The water turns the turbine which is connected to the generator.

The generator produces some _____, this is wasted energy.

(3)

- (c) The total power input to a pumped storage power station is 600 MW.

The useful power output is 540 MW.

- (i) Calculate the efficiency of this pumped storage power station.

Efficiency = _____

(2)

- (ii) Calculate how much power is wasted by the pumped storage power station.

Power = _____ MW

(1)

- (iii) How is the temperature of the surroundings affected by the energy wasted by the pumped storage power station?

(1)

(Total 10 marks)

3.

All European Union countries are expected to generate 20% of their electricity using renewable energy sources by 2020.

The estimated cost of generating electricity in the year 2020 using different energy sources is shown in **Table 1**.

Table 1

Energy source	Estimated cost (in the year 2020) in pence per kWh
Nuclear	7.8
Solar	25.3
Tidal	18.8
Wind	10.0

France generated 542 billion kWh of electricity using nuclear power stations in 2011. France used 478 billion kWh of electricity and sold the rest of the electricity to other countries in 2011.

- (a) France may continue generating large amounts of electricity using nuclear power stations instead of using renewable energy resources.

Suggest **two** reasons why.

1. _____

2. _____

(2)

(b) Give **two** disadvantages of generating electricity using nuclear power stations.

1. _____

2. _____

(2)

(c) A panel of solar cells has an efficiency of 0.15.

The total power input to the panel of solar cells is 3.2 kW.

Calculate the useful power output of this panel of solar cells in kW.

Useful power output = _____ kW

(2)

(d) **Table 2** shows the manufacturing cost and efficiency of different types of panels of solar cells.

Table 2

Type of Solar Panel	Cost to manufacture a 1 m ² solar panel in £	Efficiency in %
A	40.00	20
B	22.50	15
C	5.00	10

Some scientists think that having a low manufacturing cost is more important than improving the efficiency of solar cells.

Use information from **Table 2** to suggest why.

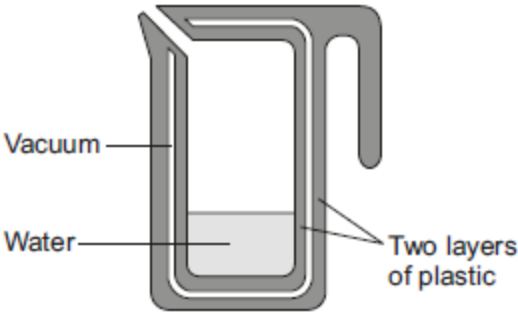
(2)

(Total 8 marks)

4.

A new design for a kettle is made from two layers of plastic separated by a vacuum. After the water in the kettle has boiled, the water stays hot for at least 2 hours.

The new kettle is shown below.



- (a) The energy transferred from the water in the kettle to the surroundings in 2 hours is 46 200 J.

The mass of water in the kettle is 0.50 kg.

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

The initial temperature of the water is 100 °C.

Calculate the temperature of the water in the kettle after 2 hours.

Temperature after 2 hours = _____ °C

(3)

- (b) Calculate the average power output from the water in the kettle to the surroundings in 2 hours.

Average power output = _____ W

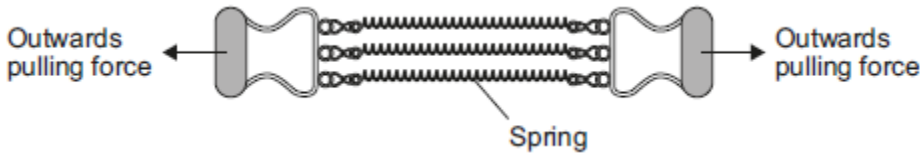
(2)

(Total 5 marks)

5.

Figure 1 shows an exercise device called a chest expander. The three springs are identical.

Figure 1



A person pulls outwards on the handles and does work to stretch the springs.

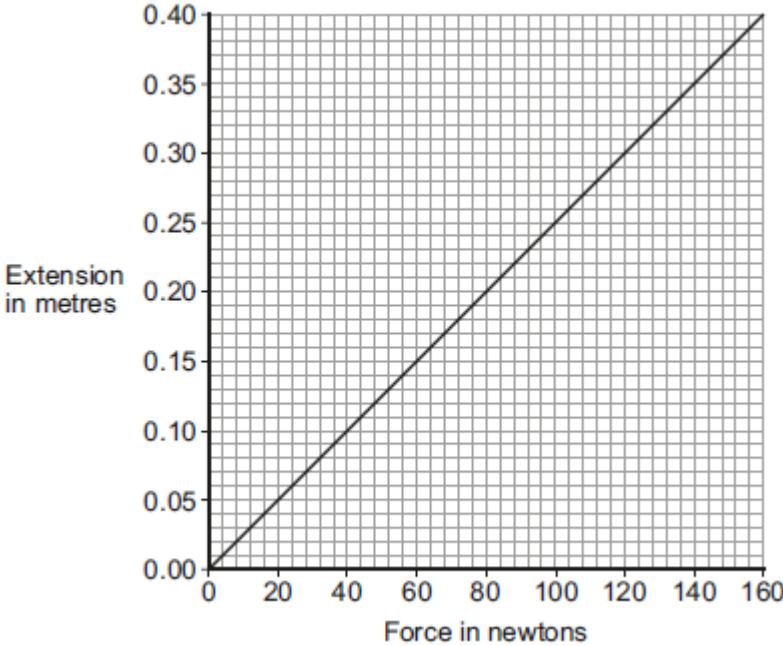
(a) Complete the following sentence.

When the springs are stretched _____ energy is stored in the springs.

(1)

(b) Figure 2 shows how the extension of a single spring from the chest expander depends on the force acting on the spring.

Figure 2



(i) How can you tell, from Figure 2, that the limit of proportionality of the spring has not been exceeded?

(1)

- (ii) Use data from **Figure 2** to calculate the spring constant of the spring.
Give the unit.

Spring constant = _____ Unit _____

(3)

- (iii) Three identical resistors joined in parallel in an electrical circuit share the total current in the circuit.

In a similar way, the three springs in the chest expander share the total force exerted.

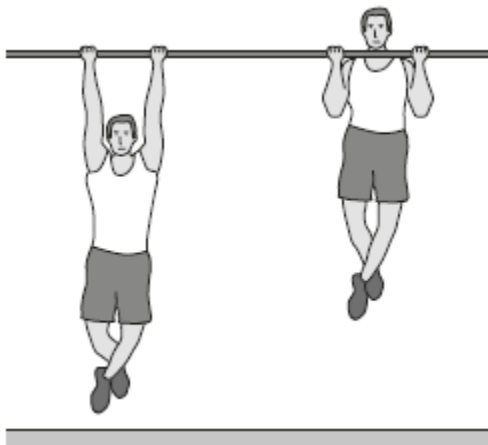
By considering this similarity, use **Figure 2** to determine the total force exerted on the chest expander when each spring is stretched by 0.25 m.

Total force = _____ N

(2)

- (c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

Power = _____ W

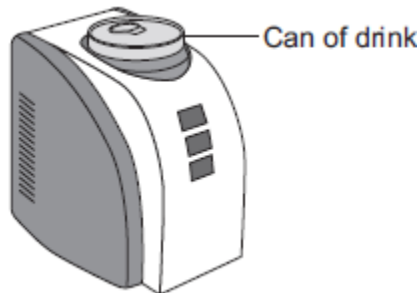
(3)

(Total 10 marks)

6.

A 'can-chiller' is used to make a can of drink colder.

The image below shows a can-chiller.



- (a) The initial temperature of the liquid in the can was 25.0 °C.
The can-chiller decreased the temperature of the liquid to 20.0 °C.
The amount of energy transferred from the liquid was 6930 J.
The mass of liquid in the can was 0.330 kg.

Calculate the specific heat capacity of the liquid.

Give the unit.

Specific heat capacity = _____ unit _____

(4)

(b) Energy is transferred through the metal walls of the can of drink by conduction. Explain how.

(4)

(c) The energy from the can of drink is transferred to the air around the can-chiller. A convection current is set up around the can-chiller. Explain how.

(3)

(d) The can-chiller has metal cooling fins that are designed to transfer energy quickly to the surroundings.

Give **two** features that would help the metal cooling fins to transfer energy quickly to the surroundings.

1. _____
2. _____

(2)

(Total 13 marks)

7.

Electricity can be generated using various energy sources.

- (a) Give **one** advantage and **one** disadvantage of using nuclear power stations rather than gas-fired power stations to generate electricity.

Advantage _____

Disadvantage _____

(2)

- (b) (i) A single wind turbine has a maximum power output of 2 000 000 W.

The wind turbine operated continuously at maximum power for 6 hours.

Calculate the energy output in kilowatt-hours of the wind turbine.

Energy output = _____ kWh

(2)

- (ii) Why, on average, do wind turbines operate at maximum power output for only 30% of the time?

(1)

- (c) An on-shore wind farm is made up of many individual wind turbines.

They are connected to the National Grid using underground power cables.

Give **one** advantage of using underground power cables rather than overhead power cables.

(1)

(Total 6 marks)

8.

Iceland is a country that generates most of its electricity using geothermal power stations and hydroelectric power stations.

- (a) (i) Complete the following sentences to describe how some geothermal power stations work.

In regions where volcanoes are active, the ground is hot.

Cold _____ is pumped down into the ground

and is _____ by hot rocks.

It returns to the surface as steam. The steam is used to turn a turbine.

The turbine drives a _____ to produce electricity.

(3)

- (ii) Which **one** of the following statements about geothermal power stations is true?

Tick (✓) **one** box.

Geothermal power stations use fossil fuels.

Geothermal power stations produce carbon dioxide.

Geothermal power stations provide a reliable source of electricity.

(1)

- (b) What is needed for a hydroelectric power station to be able to generate electricity?

Tick (✓) **one** box.

Falling water

A long coastline

Lots of sunny days

(1)

(Total 5 marks)

9.

Table 1 shows information about different light bulbs.

The bulbs all have the same brightness.

Table 1

Type of bulb	Input power in watts	Efficiency
Halogen	40	0.15
Compact fluorescent (CFL)	14	0.42
LED	7	0.85

- (a) (i) Calculate the useful power output of the CFL bulb.

Useful power output = _____ watts

(2)

- (ii) Use your answer to part (i) to calculate the waste energy produced each second by a CFL bulb.

Waste energy per second = _____ joules

(1)

- (b) (i) A growth cabinet is used to investigate the effect of light on the rate of growth of plants.

The figure below shows a growth cabinet.



In the cabinet the factors that affect growth can be controlled.

A cooler unit is used to keep the temperature in the cabinet constant. The cooler unit is programmed to operate when the temperature rises above 20 °C.

The growth cabinet is lit using 50 halogen bulbs.

Changing from using halogen bulbs to LED bulbs would reduce the cost of running the growth cabinet.

Explain why.

(4)

(ii) A scientist measured the rate of growth of plants for different intensities of light.

What type of graph should be drawn to present the results?

Give a reason for your answer.

(1)

(c) **Table 2** gives further information about both a halogen bulb and a LED bulb.

Table 2

Type of bulb	Cost to buy	Lifetime in hours	Operating cost over the lifetime of one bulb
Halogen	£1.50	2 000	£16.00
LED	£30.00	48 000	£67.20

A householder needs to replace a broken halogen light bulb.

Compare the cost efficiency of buying and using halogen bulbs rather than a LED bulb over a time span of 48 000 hours of use.

Your comparison must include calculations.

(4)

(Total 12 marks)

Mark schemes

- 1.** (a) water boils at the same temperature each time 1
- control starting temp by allowing enough time for water and kettle to reach room temperature 1
- (b) uncertainty = $(302 - 298) / 2$ 1
- uncertainty = ± 2 (s)
ignore missing \pm 1
- (c) (Energy transferred = Power \times time)
- $E = 2.20 \times 300$ 1
- $E = 660$ (kJ) 1
- allow 660 (kJ) without working shown for 2 marks*
allow answer calculated using incorrect value for t (298 or 302) for 1 mark
- (d) (mass \times change in temperature) / mass 1
- allow 1 mark for any correct pair of values from the table*
- eg 20 / 0.25*
- 80 ($^{\circ}\text{C}$) 1
- allow 80 ($^{\circ}\text{C}$) without working shown for 2 marks*
- (e) four points plotted correctly 2
- allow 1 mark for three correctly plotted points*
- ecf their 5.3*
allow $\pm 1\text{mm}$
- accurate line drawn 1
- line should be straight and drawn with a ruler*
- line must not go through the origin*
- (f) values read correctly from graph 1
- correct conversion into J 1

correct use of $\Delta y / \Delta x$

1

value in range 4200 – 4800

1

allow value in range 4200 – 4800 without working shown for 4 marks

- (g) some of the energy supplied does not raise the temperature of the water
some of the energy is wasted is insufficient

1

- (h) (the power of the kettle may not be 2.2kW)

(by measuring the power) the student can accurately calculate the amount of energy supplied to each mass of water

1

[17]

2.

- (a) geothermal

1

nuclear

1

biofuel

1

- (b) gravitational (potential)

1

kinetic

1

sound

1

- (c) (i) 90% or 0.9(0)

an answer of 0.9(0) with a unit gains 1 mark

2

- (ii) 60 (MW)

allow 10%

1

- (iii) increased

1

[10]

3.

(a) any **two** from:

- cost per kWh is lower (than all other energy resources)
allow it is cheaper
ignore fuel cost
ignore energy released per kg of nuclear fuel
- infrastructure for nuclear power already exists
accept cost of setting up renewable energy resources is high
accept many renewable power stations would be needed to replace one nuclear power station
accept (France in 2011 already had a) surplus of nuclear energy, so less need to develop more renewable capacity for increased demand in the future
accept France benefits economically from selling electricity
- more reliable (than renewable energy resources)
accept (nuclear) fuel is readily available
ignore destruction of habitats for renewables

2

(b) any **two** from:

- non-renewable
allow nuclear fuel is running out
- high decommissioning costs
accept high commissioning costs
- produces radioactive / nuclear waste
allow waste has a long half-life
- long start-up time
- nuclear accidents have widespread implications
allow for nuclear accident a named nuclear accident
eg Fukushima, Chernobyl
ignore visual pollution

2

(c) 0.48 (kW)

allow 1 mark for correct substitution
ie $0.15 = P / 3.2$
an answer of 480 W gains 2 marks
an answer of 48 or 480 scores 1 mark

2

- (d) the higher the efficiency, the higher the cost (per m² to manufacture)

accept a specific numerical example

1

more electricity could be generated for the same (manufacturing) cost using lower efficiency solar panels

or

(reducing the cost) allows more solar panels to be bought

accept a specific numerical example

1

[8]

4.

- (a) 78 (°C)

allow 2 marks for correct temperature change ie 22 °C

allow 1 mark for correct substitution

$$\text{ie } 46\,200 = 0.5 \times 4200 \times \theta$$

or

$$\frac{46200}{0.5 \times 4200} = \theta$$

3

- (b) 6.4 (W)

allow 2 marks for an answer that rounds to 6.4

allow 1 mark for correct substitution

$$\text{ie } 46\,200 = P \times 7200$$

an answer of 23 000 or 23 100 or 385 gains 1 mark

2

[5]

5.

- (a) elastic potential

1

- (b) (i) line is straight

accept line does not curve

1

- (ii) 400

allow 1 mark for correct substitution of any pair of numbers correctly taken from the graph e.g. $160 = k \times 0.40$

2

newtons per metre **or** N/m

if symbols are used they must be correct

1

- (iii) 300

allow 1 mark for correctly obtaining force on 1 spring = 100N

2

(c) 52

allow **2** marks for calculating change in gpe for 1 chin-up as 260 (J)
or for 12 chin-ups as 3120 (J)

an answer 4.3 gains **2** marks

allow **1** mark for correct substitution into gpe equation ie $gpe = 65 \times 10 \times 0.4 (\times 12)$

or

correct use of power equation with an incorrect value for energy transferred

3

[10]

6.

(a) 4200

allow **2** marks for correct substitution

ie $6930 = 0.330 \times c \times 5.0$

answers of 1050 **or** 840

or

correctly calculated answer from correct substitution of incorrect temperature change

or

identification of temperature change ie 5°C

gain **1** mark

3

J / kg°C

accept J / kg K

1

(b) (in a metal) free electrons

to gain full credit the answer must be in terms of free electrons

1

gain kinetic energy

accept move faster

1

(free electrons) transfer energy to other electrons / ions / atoms

do **not** accept particles

1

by collision

allow a maximum of **2** marks for answers in terms of atoms / ions / particles

- gaining kinetic energy or vibrating faster / more
- transferring energy by collisions

1

(c) (air) particles spread out

1

(which causes the) air to become less dense / expand
do not accept particles become less dense

1

(so the) warm air rises
do not accept heat rises
particles rise is insufficient

1

(d) large surface area

ignore references to type of metal or external conditions

1

black / dark (colour)

1

[13]

7.

(a) advantage

any **one** from:

- produce no / little greenhouse gases / carbon dioxide
allow produces no / little polluting gases
allow doesn't contribute to global warming / climate change
allow produce no acid rain / sulphur dioxide
reference to atmospheric pollution is insufficient
produce no harmful gases is insufficient
- high(er) energy density in fuel
accept one nuclear power station produces as much power as several gas power stations
nuclear power stations can supply a lot of or more energy is insufficient
- long(er) operating life
allow saves using reserves of fossil fuels or gas

1

disadvantage

any **one** from:

- produce (long term) radioactive waste
accept waste is toxic
accept nuclear for radioactive
- accidents at nuclear power stations may have far reaching or long term consequences
- high(er) decommissioning costs
accept high(er) building costs
- long(er) start up time

1

- (b) (i) 12 000 (kWh)
allow 1 mark for correct substitution eg
 2000×6
or
 $2\ 000\ 000 \times 6$
or

$$\frac{12\ 000\ 000}{1000}$$

an answer of 12 000 000 scores 1 mark

2

- (ii) any idea of unreliability, eg
- wind is unreliable
reference to weather alone is insufficient
 - shut down if wind too strong / weak
 - wind is variable

1

(c) any **one** from:

- cannot be seen
- no hazard to (low flying) aircraft / helicopters
- unlikely to be or not damaged / affected by (severe) weather
unlikely to be damaged is insufficient
- (normally) no / reduced shock hazard
safer is insufficient
less maintenance is insufficient
installed in urban areas is insufficient

1

[6]

8. (a) (i) water

1

heated
accept boiled or turned to steam
*do **not** accept evaporated*

1

generator

1

(ii) geothermal power stations provide a reliable source of electricity

1

(b) falling water

1

[5]

9.

(a) (i) 5.88 (watts)

an answer of 5.9 scores 2 marks
allow 1 mark for correct substitution ie

$$0.42 = \frac{\text{power out}}{14}$$

allow 1 mark for an answer of 0.0588 or 0.059

2

(ii) 8.12

allow 14 – their (a)(i) correctly calculated

1

(b) (i) input power / energy would be (much) less (reducing cost of running)

accept the converse

electricity is insufficient

1

(also) produce less waste energy / power

accept 'heat' for waste energy

1

(as the waste energy / power) increases temperature of the cabinet

1

so cooler on for less time

1

(ii) line graph

need to get both parts correct

accept scattergram or scatter graph

both variables are continuous

allow the data is continuous

1

(c) number of bulbs used-halogen=24 (LED=1)

1

total cost of LED = £30 + £67.20 = £97.20

accept a comparison of buying costs of halogen £36 and LED £30

1

total cost of halogen= 24 x £1.50 + 24 x £16.00 = £420

or

buying cost of halogen is £36 **and** operating cost is £384

accept a comparison of operating costs of halogen £384 and LED £67.20

allow for 3 marks the difference in total cost is £322.80 if the number 24 has not been credited

1

statement based on correct calculations that overall LED is cheaper
*must be **both** buying **and** operating costs*

an alternative way of answering is in terms of cost per hour:

buying cost per hour for LED $\left(\frac{£30.00}{48000}\right) = 0.0625\text{p}/£0.000625$

buying cost per hour for halogen = $\left(\frac{£1.50}{2000}\right) = 0.075\text{p}/£0.00075$
a calculation of both buying costs scores 1 mark

operating cost per hour for LED = $\left(\frac{£67.20}{48000}\right) = 0.14\text{p}/£0.0014$

operating cost per hour for halogen = $\left(\frac{£16.00}{2000}\right) = 0.8\text{p}/£0.008$
a calculation of both operating costs scores 1 mark

all calculations show a correct unit

***all** units correct scores 1 mark*

statement based on correct calculations of **both** buying **and** operating costs, that overall LED is cheaper

correct statement scores 1 mark

1

[12]