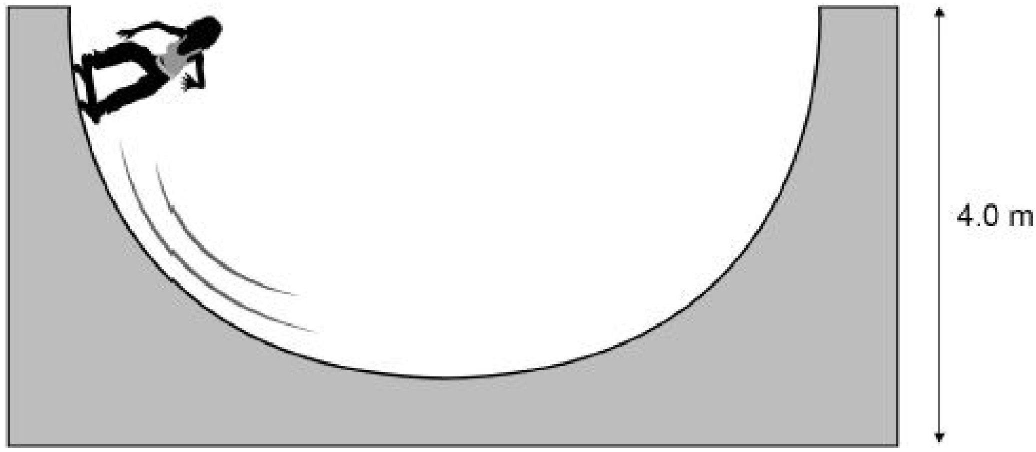
Physics Topic 1 Equations

weight =	$W = m\,g$
work done =	$W = F\,s$
kinetic energy =	$E_k = \frac{1}{2} m\,v^2$
gravitational potential energy =	$E_p = m\,g\,h$
power =	$P = \frac{E}{t}$
power =	$P = \frac{W}{t}$
efficiency =	$efficiency = \frac{useful\ output\ energy\ transfer}{total\ input\ energy\ transfer}$ (x 100 if calculating % rather than decimal value)
efficiency =	

How to tackle calculations questions:

- Highlight all the numbers/quantities in the question
- Highlight what the question is asking you to calculate
- Identify the equation that links together those quantities
- Rearrange the equation if needed
- Convert any units if needed
- Put the numbers into the equation
- Type the same thing into your calculator
- Write out your working
- Write out your answer
- Check whether you need to use a specific number of decimal places of significant figures

The diagram below shows a girl skateboarding on a semi-circular ramp.



The girl has a mass of 50 kg

(a) Calculate the gravitational potential energy (g.p.e.) of the girl at the top of the ramp.

Use the equation:

g.p.e. = mass × gravitational field strength × height

gravitational field strength = 9.8 N/kg

____

____

g.p.e. = ____________________ J

(2)

(b) The girl has a speed of 7 m/s at the bottom of the ramp.

Calculate the kinetic energy of the girl at the bottom of the ramp.

Use the equation:

kinetic energy = 0.5 × mass × $(\text{speed})^2$

____

____

Kinetic energy = ____________________ J

(2)

(c) Not all of the g.p.e. has been transferred to kinetic energy.

Which **two** statements explain why?

Tick **two** boxes.

Some energy is wasted.	☐
The mass of the girl is too low.	☐
The ramp is not high enough.	☐
The g.p.e. of the girl is not zero.	☐
The speed of the girl is too great.	☐

(2)

(d) Explain how lubricating the wheels of the skateboard can increase the speed of the girl.

Use ideas about energy in your explanation.

____

____

____

____

____

____

(3)

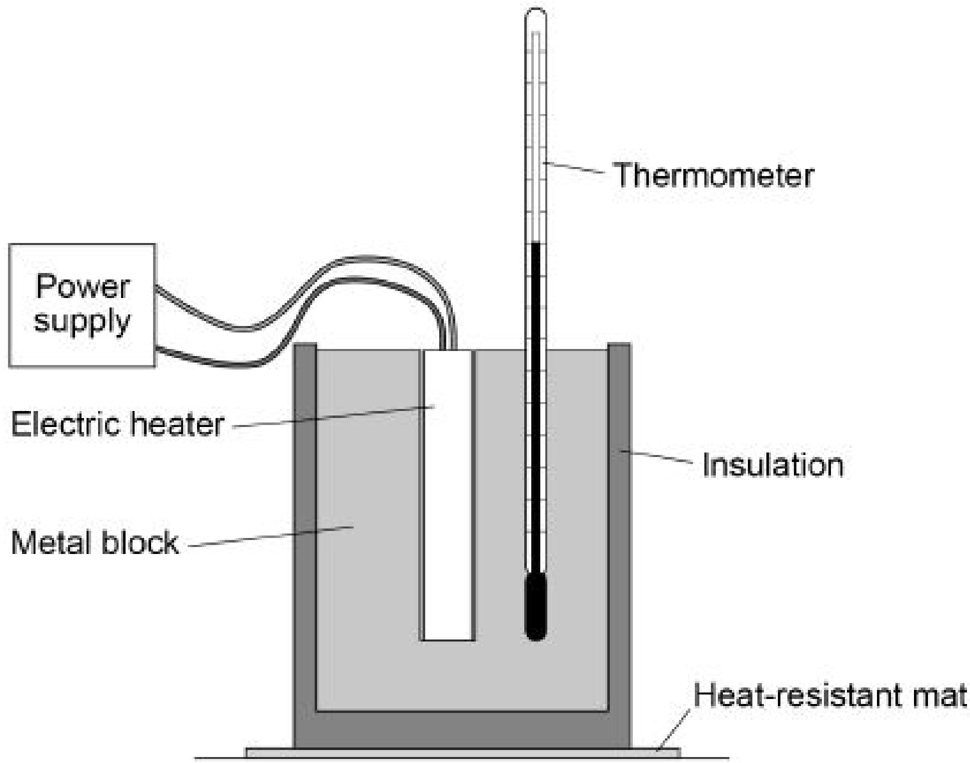
(Total 9 marks)

A student investigated how the temperature of a metal block changed with time.

An electric heater was used to increase the temperature of the block.

The heater was placed in a hole drilled in the block as shown in **Figure 1**.

Figure 1



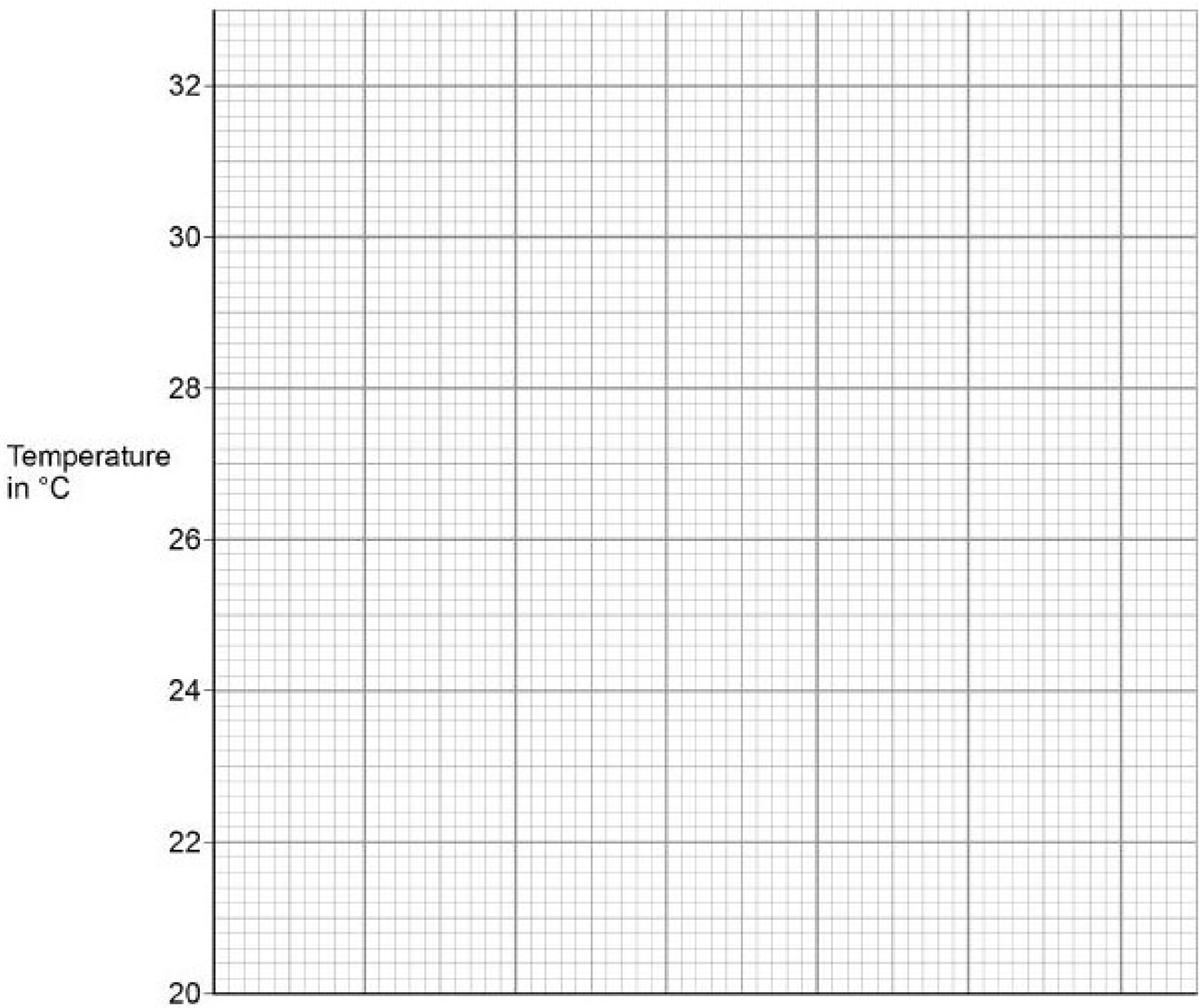
The student measured the temperature of the metal block every 60 seconds.
The table below shows the student's results.

Time in s	Temperature in °C
0	20.0
60	24.5
120	29.0
180	31.0
240	31.5

(a) Complete the graph of the data from the table above on the graph below.

- Choose a suitable scale for the x-axis.
- Label the x-axis.
- Plot the student's results.
- Draw a line of best fit.

Figure 2



(4)

(b) The rate of change of temperature of the block is given by the gradient of the graph.

Determine the gradient of the graph over the first 60 seconds.

____

____

____

____

Gradient = ____________________

(2)

change in thermal energy = mass × specific heat capacity × temperature change	$\Delta E = m\,c\,\Delta\theta$

(c) The metal block had a mass of 1.50 kg

The specific heat capacity of the metal was 900 J/kg °C

Calculate the change in thermal energy of the metal during 240 seconds.

Use the Physics Equations Sheet.

Give your answer in kilojoules.

____

____

____

____

____

____

____

____

Change in thermal energy = ____________________ kJ

(4)

(d) Another student repeated the investigation.

Give **two** variables this student would need to control to be able to compare their results with the results in the table above.

1. ____

2. ____

(2)

(Total 12 marks)

An energy input of 1.3×10^{18} J is supplied each year by power stations to the National Grid.

Not all of this energy is supplied to consumers. Some of the energy is wasted in the distribution process.

(a) Write the equation which links efficiency, total input energy transfer and useful output energy transfer.

____

____

(1)

(b) The energy supplied each year to consumers is 1.2×10^{18} J

Calculate the efficiency of the distribution process.

____

____

____

____

Efficiency = ________________________

(2)

Figure 1 shows a student making potato soup.

Figure 1

(a) The student places 0.5 kg of potato into a pan of water.

During cooking, the temperature of the potato increases from 20 °C to 100 °C

The specific heat capacity of the potato is 3400 J/kg °C

Calculate the change in thermal energy of the potato.

Use the equation:

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

____

____

____

____

____

____

Change in thermal energy = ____________________ J

(3)

(b) Why is the energy supplied by the cooker greater than that calculated in part (a)?

____

(1)

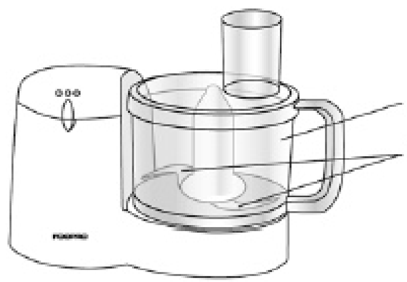
(c) Suggest **one** way that the student could reduce the time to heat the potato to 100 °C

____

(1)

Figure 2 shows a food processor.

Figure 2



(d) The student places the cooked potato into the jug of the food processor.

The food processor contains a motor that spins blades to chop the potato.

The total power input to the motor is 500 W

The useful power output from the motor is 300 W

Calculate the efficiency of the motor in the food processor.

Use the equation:

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

____

____

____

Efficiency = ____________________

(2)

(e) The jug is made of plastic with a low thermal conductivity.

Explain why this is an advantage.

____

____

____

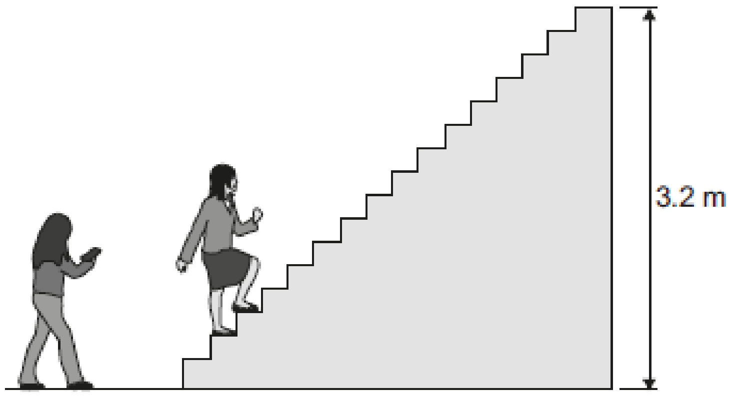
____

(2)

(Total 9 marks)

A student did an experiment to calculate her power.
The diagram below shows how she obtained the measurements needed.

The student first weighed herself and then ran up a flight of stairs. A second student timed how long it took her to go from the bottom to the top of the stairs. The height of the stairs was also measured.



(a) Complete the following sentence.

To run up the stairs the student must do work against

the force of ___________ .

(1)

(b) The student did 2240 J of work going from the bottom of the stairs to the top of the stairs.

The student took 2.8 seconds to run up the stairs.

(i) Calculate the power the student developed when running up the stairs.

____

____

Power = ___________ W

(2)

(ii) How much gravitational potential energy did the student gain in going from the bottom to the top of the stairs?

Tick (✓) **one** box.

much more than 2240 J ☐

2240 J ☐

much less than 2240 J ☐

(1)

(c) Another four students did the same experiment.

The measurements taken and the calculated values for power are given in the table.

Student	Weight in newtons	Time taken in seconds	Power in watts
A	285	3.8	240
B	360	2.4	480
C	600	3.4	560
D	725	4.0	580

(i) To make a fair comparison of their powers the students kept **one** variable in the experiment constant.

What variable did the students keep constant?

____

(1)

(ii) From the data in the table a student wrote the following conclusion.

'The greater the weight of the student the greater the power developed.'

Suggest why this conclusion may **not** be true for a larger group of students.

____

____

(1)

(Total 6 marks)

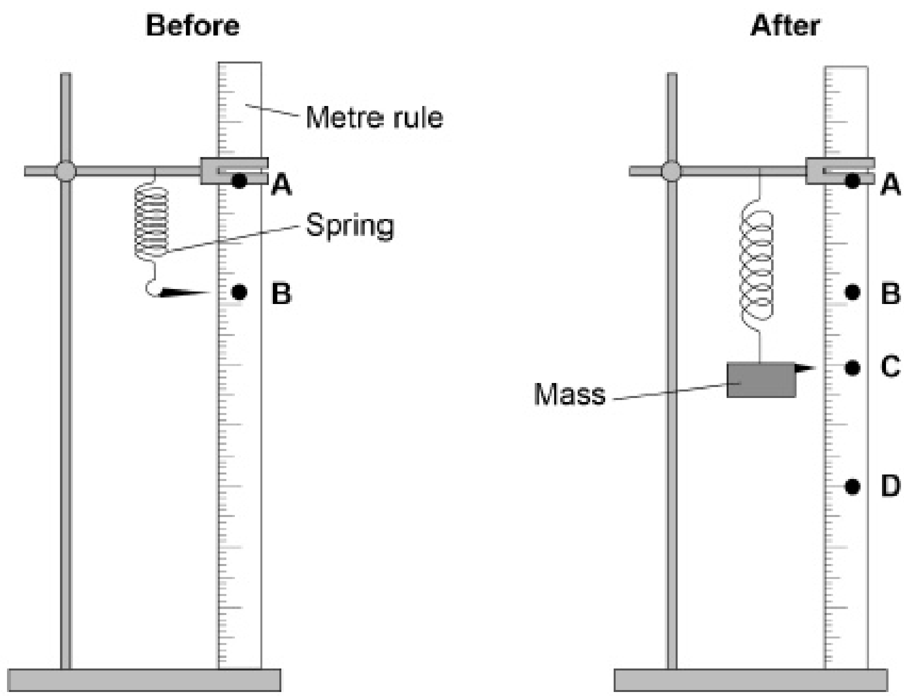
A student investigated the relationship between the force applied to a spring and the extension of the spring.

This is the method used.

1. Hang a spring from a rod.
2. Hang a mass from the spring.
3. Measure the extension of the spring.
4. Repeat steps 2 and 3 using different masses.

Figure 1 shows a spring before and after a mass had been hung from it.

Figure 1



(a) Give **two** ways in which the appearance of the spring has changed.

1. ____

____

2. ____

____

(2)

(c) The force applied to the spring is the weight of the mass hanging from the spring.

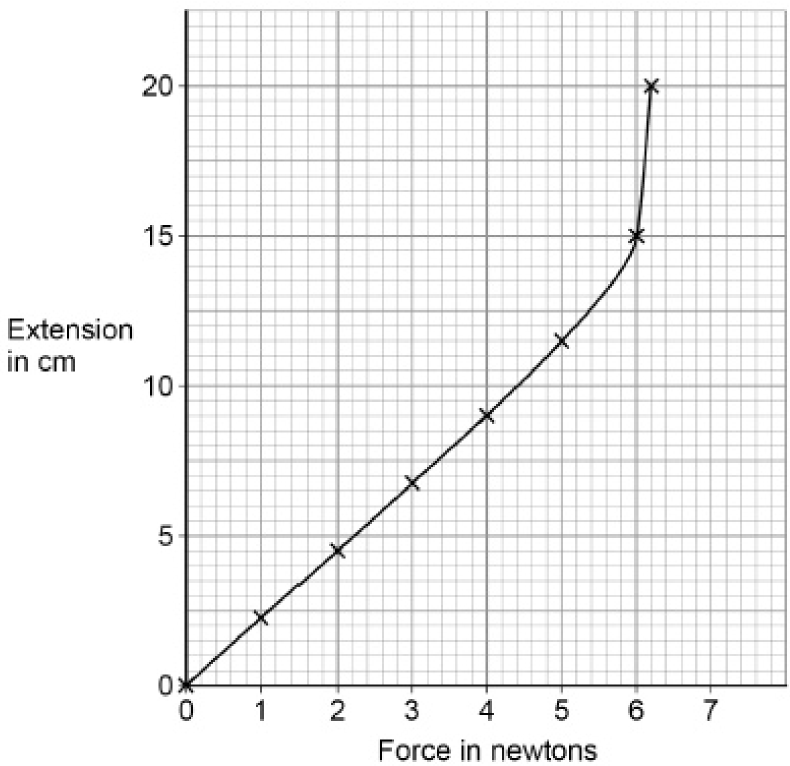
Write the equation that links gravitational field strength, mass and weight.

____

(1)

Figure 2 shows the student's results.

Figure 2



(d) During the investigation the limit of proportionality of the spring was exceeded.

What is the value of force at which this happened?

Give a reason for your choice.

Force = ____________________ N

Reason ____

____

(2)

(e) Suggest how the student could obtain a more accurate answer for the limit of proportionality of the spring.

You should include the additional readings the student should take.

____

____

____

____

(2)

(f) Write the equation that links extension, force and the spring constant.

____

(1)

(g) A different spring has a spring constant of 18 N/m

When an apple is hung from the spring, the spring extends 6.4 cm

The spring does not go past the limit of proportionality.

Calculate the force exerted by the apple on the spring.

____

____

____

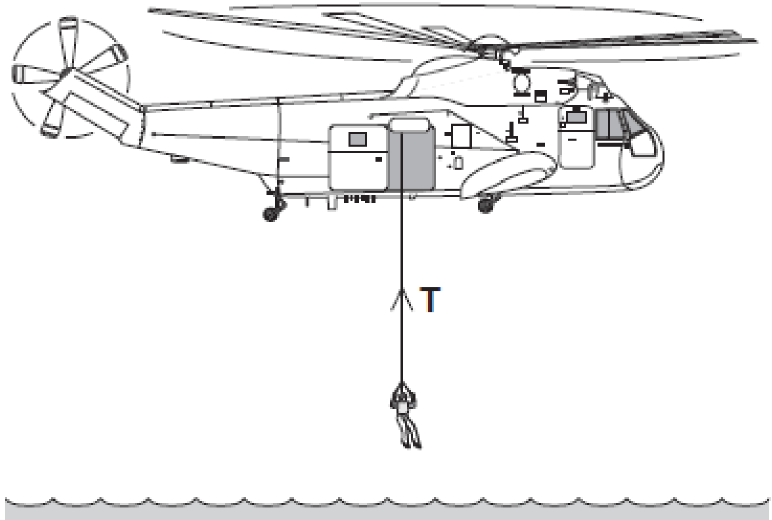
____

Force = ____________________ N

(3)

(Total 12 marks)

The diagram shows a helicopter being used to rescue a person from the sea.



(a) (i) The mass of the rescued person is 72 kg.

Use the equation in the box to calculate the weight of the rescued person.

weight = mass × gravitational field strength

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

____

____

Weight = ______________________ N

(2)

(ii) An electric motor is used to lift the person up to the helicopter.
The motor lifts the person at a constant speed.

State the size of the force, **T**, in the cable.

Force **T** = ______________________ N

(1)

(b) To lift the person up to the helicopter, the electric motor transformed 21 600 joules of energy usefully.

(i) Use a form of energy from the box to complete the following sentence.

gravitational potential	heat	sound

The electric motor transforms electrical energy to kinetic energy. The kinetic energy is then transformed into useful ________________________ energy.

(1)

(ii) It takes 50 seconds for the electric motor to lift the person up to the helicopter.

Use the equation in the box to calculate the power of the electric motor.

$$\text{power} = \frac{\text{energy transformed}}{\text{time}}$$

Show clearly how you work out your answer and give the unit.

Choose the unit from the list below.

coulomb (C) **hertz (Hz)** **watt (W)**

____

____

Power = ________________________

(3)

(Total 7 marks)

(a) $E_p = 50 \times 9.8 \times 4.0$

1

$E_p = 1960$ (J)

allow an answer rounded to 2000 (J)

1

*allow a maximum of **1** mark if g = 10 N/kg is used*

*an answer of 1960 scores **2** marks*

(b) $E_k = 0.5 \times 50 \times 7^2$

1

$E_k = 1225$ (J)

allow 1200 or 1230 (J)

1

*an answer of 1225 scores **2** marks*

(c) some energy is wasted

1

the g.p.e of the girl is not zero

1

(d) reduces the amount of friction

*do **not** accept reference to friction between the wheels and the ramp*

1

so more energy is usefully transferred

*allow less energy is wasted **or** less heating*

1

greater kinetic energy

1

[9]

(a) *x*-axis labelled **and** suitable scale

1

points plotted correctly

*allow 5 correctly plotted for **2** marks, 3−4 correctly plotted for **1** mark*

allow ± ½ square

2

line of best fit

1

(b) $\frac{4.5}{60}$

*allow ecf from line of best fit in part **(a)***

1

0.075 (°C/s)

1

*an answer of 0.075 (°C/s) scores **2** marks*

(c) $\Delta\theta$ = 11.5 (°C)

a calculation using an incorrect temperature scores max 3 marks

1

ΔE = 1.50 × 900 × 11.5

1

ΔE = 15 525 (J)

1

ΔE = 15.525 (kJ)

1

*an answer of 15.525 (kJ) **or** 15.53 (kJ) **or** 15.5 (kJ) scores **4** marks*

*an answer of 15 525 (kJ) scores **3** marks*

(d) any **two** from:

- mass of block*
- size / dimensions of block*
- material of block*

allow same block for **1 mark*

- current through heater

allow power of heater

- thickness of insulation*
- material of insulation*

allow same insulation for **1 mark*

- time interval
- starting temperature (of block / heater)

2

[12]

(a) efficiency $= \frac{\text{useful output energy transfer}}{\text{total input energy transfer}} (\times 100)$

allow $\textit{efficiency} = \frac{\textit{useful output}}{\textit{total input}} (\times 100)$

1

(b) (efficiency =) $\frac{1.2 \times 10^{18}}{1.3 \times 10^{18}} (\times 100)$

1

= 0.92
or
92 (%)

allow an answer that rounds to 0.92

or
92 (%)

1

ignore units

an answer of 0.92 or 92 (%) scores ***2*** *marks*

(a) 80 °C

1

$\Delta E = 0.5 \times 3400 \times 80$

1

$\Delta E = 136\,000$ (J)

an answer of 136 000 (J) scores ***3*** *marks*

1

(b) energy is dissipated into the surroundings

allow any correct description of wasted energy

1

(c) put a lid on the pan

allow any sensible practical suggestion

eg add salt to the water

1

(d) efficiency = 300/500

1

efficiency = 0.6

*an answer of 0.6 or 60% scores **2** marks*

allow efficiency = 60%

*an answer of 0.6 with a unit scores **1** mark*

*an answer of 60 without a unit scores **1** mark*

1

(e) lower rate of energy transfer

1

(so) potato soup will remain at a higher temperature

1

[9]

(a) gravity

accept weight for gravity

air resistance is insufficient

1

(b) (i) 800

*allow **1** mark for correct substitution ie*

$P = \frac{2240}{2.8}$

provided no subsequent step

2

(ii) 2240 J

1

(c) (i) (vertical) height

accept (height of) stairs

1

(ii) a fast / short time (for a lighter student) may give the greatest power

accept time is a factor

or

a slow / long time (for a heavy student) may give the least power

fitness is insufficient

1

[6]

(a) any **two** from:

- length of coils increased
- increased gap between coils
- spring has become longer
- spring has become thinner

2

(b) **B** and **C**

either order

1

(c) weight = mass × gravitational field strength

allow $W = m\,g$

1

(d) 5.5 (N)

allow any value in the range 5.0 to 5.8 (N)

1

up to that point force and extension are (directly) proportional

allow the line starts to curve

1

(e) use smaller intervals (for applied force)

allow any value for interval between 0.1 N and 0.2 N

1

between a total applied force of 5 to 6 Newtons

1

(f) force = spring constant × extension

1

(g) 0.064 m

1

18 × 0.064

1

= 1.152 (N)

*an answer of 1.152 (N) scores **3** marks*

allow 115.2 (N)

1

[12]

(a) (i) 720

*allow **1** mark for correct substitution,*

ie 72 × 10 provided no subsequent step shown

2

(ii) 720

or

their (a)(i)

1

(b) (i) gravitational potential

allow gravitational

allow potential

1

(ii) 432

*allow **1** mark for correct substitution, ie* $\frac{21600}{50}$ *provided no subsequent step shown*

2

watt / W

1

[7]