Section 1: Energy 1

	Question	Answers
1.1	**Describe the energy change involved in projecting an object up a hill**	**KE → GPE via a push force**
1.2	Describe the energy change involved in a moving object hitting an obstacle	KE → Thermal/KE via a push force
1.3	Describe the energy change involved in an object accelerating by a constant force	Chemical (from a fuel) →KE via a push force
1.4	**Describe the energy change involved in a vehicle slowing down**	**KE → Thermal store of the environment via friction**
1.5	Describe the energy change involved in bringing water to the boil in an electric kettle	Thermal energy store from heater → Thermal energy store of water via heating
1.6	Describe the energy change involved in a battery electrically transferring energy to a light bulb	Chemical energy → thermal energy of the bulb electrically
1.7	What is the energy store of a moving object?	Kinetic energy
1.8	What is the energy store of a stretched spring?	Elastic Potential energy
1.9	**What is the energy store of an object raised above ground level?**	**Gravitational Potential energy**
1.10	**What is the equation to determine kinetic energy?**	**Kinetic energy = 0.5 x mass x (speed)^2** $$E_k = \frac{1}{2} m v^2$$
1.11	**What is the equation to determine elastic potential energy in a stretched spring?**	**Elastic potential energy = 0.5 x spring constant x (extension)^2** $$E_e = \frac{1}{2} k e^2$$
1.12	**What is the equation to determine the energy gained by an object raised about ground level?**	**GPE = mass x gravitational field strength x height** $$E_p = m g h$$
1.13	**What is the equation to determine the change in energy stored or released from a system as its temperature?**	**Change in thermal energy = mass x specific heat capacity x temperature change** $$\Delta E = m c \Delta \theta$$
1.14	Define specific heat capacity	The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree celcius

Section 1: Energy 2

	Question	Answers
2.1	Define Power	Power is the rate at which energy is transferred or the rate at which work is done
2.2	**What is the equation to determine the rate at which energy is transferred?**	$$\boldsymbol{power = \frac{energy\ transferred}{time}}$$ $$\boldsymbol{P = \frac{E}{t}}$$
2.3	What is 1 Watt equal to?	An energy transfer of 1 joule per second is equal to a power of 1 watt
2.4	Two electric motors lift the same weight through the same height, but one does it faster than the other. Which one has more power and why?	The one that lifts the weight faster has more power, as the same energy is transferred in a shorter time.
2.5	What is the law of conservation of energy?	Energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed
2.6	What is a closed system?	Where there are no net changes to the total energy of a system.
2.7	Describe "dissipated" energy	Where energy is stored in less useful ways (where energy is wasted)
2.8	**Name 2 ways to reduce unwanted energy transfers**	**Use lubrication, or thermal insulation**
2.9	What does a high thermal conductivity mean?	A high thermal conductivity means the material has a high rate of energy transfer across the material via conduction
2.10	What factors can affect the rate of cooling of a building?	The thickness and thermal conductivity of its walls.
2.11	**What is the equation relating useful energy output and the total energy input?**	$$\boldsymbol{efficiency = \frac{useful\ output\ energy\ transfer}{total\ input\ energy\ transfer}}$$
2.12	What is the equation relating useful power output to the total power input?	$$efficiency = \frac{useful\ output\ power}{total\ input\ power}$$
2.13	(HT) How can you increase the efficiency of an intended energy transfer?	e.g. Rotating (so KE), so increase mass or velocity e.g. Falling (so GPE) in increase mass or height e.g. Elastic (so EPE) so increase the spring constant or extension e.g. Thermal (so ΔE) so increase the mass, the specific heat capacity or change in temperature

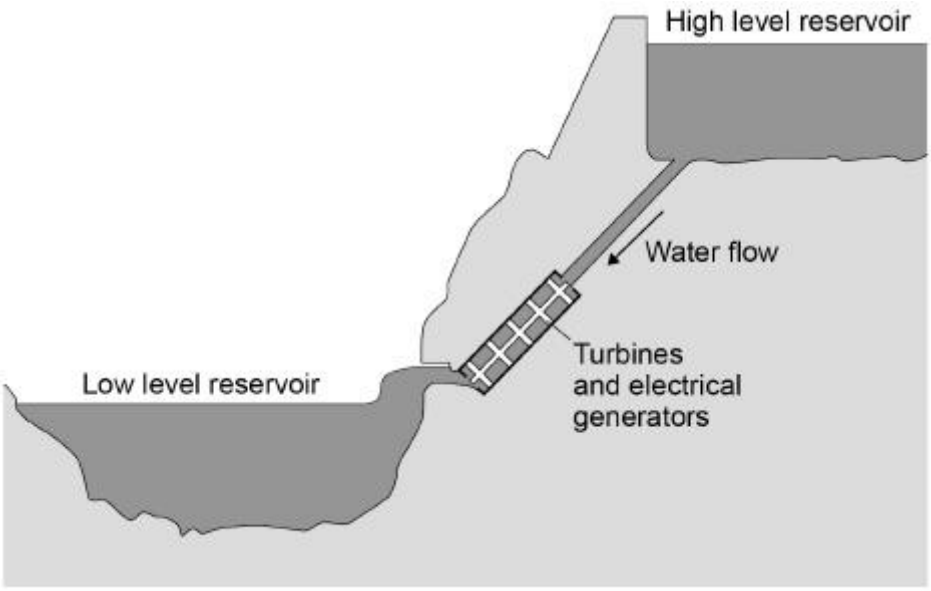
- **Section 1: Energy 3**

	Question	Answers
	What are the main energy resources for use on Earth?	Fossil fuels (coal, oil and gas), nuclear fuel, bio-fuel, wind, hydro-electricity, geothermal, the tides, the Sun and water waves.
	Define renewable energy resources	**A renewable energy resource is one that is being (or can be) replenished as it is used.**
	Name the main uses of energy resources	**Transport, electricity generation and heating**
	Which energy resources are renewable?	Bio-fuel, wind, hydro-electricity, geothermal, the tides, the Sun and water waves.
	Which energy resources are non-renewable?	Coal, Oil, Gas, Nuclear fuel
	Why are some energy resources more reliable that others?	Some resources (like coal) can be used whenever demand is required. Other resources (like wind) may be limited based on weather conditions.
	What environmental impacts are there from using fossil fuels (coal, oil or gas)	Burning fossil fuels causes the release of CO2, which contributes to global warming
	What environmental impacts are there from using renewable energy sources?	**Hydro – requires the flooding of a valley** **Wind – typically built on farm land** **Tidal – can impact marine life** **Solar – mining for resources can damage environment**
	What are the trends in the uses of energy resources?	Increasing renewable usage and decreasing fossil fuel usage
	What are some of the reasons as to why the uses of energy resources aren't always dealt with?	There may be issues because of political, social, ethical or economic considerations.

- Required Practical : An investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease in one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.

FOUNDATION

Q1. The diagram shows the flow of water through a hydroelectric power station.



The falling water turns the turbines.

The movement of the turbines causes the electrical generators to generate electricity.

(a) Write the equation which links kinetic energy, mass and speed.

_____

(1)

(b) In 1 minute, a mass of 9 000 kg of water flows through the turbines.

The speed of the water is 30 m/s

Calculate the total kinetic energy of the water passing through the turbines in 1 minute.

Give your answer in kilojoules (kJ).

_____

_____

_____

Kinetic energy = _____ kJ

(3)

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

_____

_____

(1)

(d) The efficiency of the turbines and generators is 80%

Calculate the useful output energy transfer from the hydroelectric power station in 1 minute.

Use your answer to part (b).

Useful output energy transfer = _____ kJ

(3)

(e) A small group of people live in an area in the mountains.

The people plan to buy an electricity generating system that uses either the wind or the flowing water in a nearby river.

- The wind turbine costs £50 000 to buy and install.
- The hydroelectric generator costs £20 000 to buy and install.
- The average power output from the wind turbine is 10 kW
- The hydroelectric generator will produce a constant power output of 8 kW

Compare the advantages and disadvantages of the two methods of generating electricity.

Use your knowledge of energy resources and information given.

(4)

(Total 12 marks)

Q2.

A scientist cooled the air inside a container.

(a) The temperature of the air changed from 20 °C to 0 °C

The volume of the container of air stayed the same.

Explain how the motion of the air molecules caused the pressure in the container to change as the temperature decreased.

_____

_____

_____

_____

_____

_____

(3)

(b) The air contained water that froze at 0 °C

The change in internal energy of the water as it froze was 0.70 kJ

The specific latent heat of fusion of water is 330 kJ/kg

Calculate the mass of ice produced.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

_____

Mass of ice = _____ kg

(3)

(c) The air also contained oxygen, nitrogen and carbon dioxide.

Oxygen boils at −183 °C and freezes at −218 °C
Nitrogen boils at −195 °C and freezes at −210 °C

Carbon dioxide sublimates at −78 °C

The scientist continued to cool the air to a temperature of −190 °C

What is the state of each substance at −190 °C?

Tick (✓) **one** box for **each** row of the table.

Substance	Solid	Liquid	Gas
Oxygen			
Nitrogen			
Carbon dioxide			

(2)

(d) The air also contained a small amount of argon.

As the temperature of the air decreased from 20 °C to –190 °C the argon changed from a gas to a liquid to a solid.

Explain the changes in the arrangement and movement of the particles of the argon as the temperature of the air decreased.

(6)

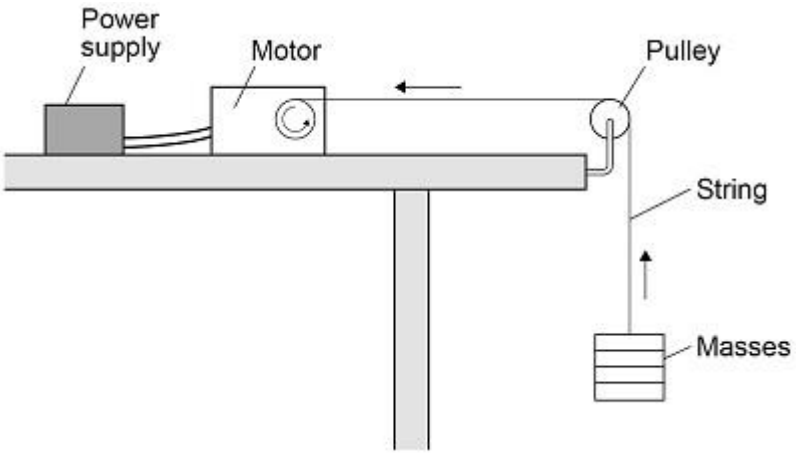
(Total 14 marks)

Q3.

A student used an electric motor to lift a mass.

He investigated how the efficiency of the motor varied with the mass lifted.

The diagram below shows the apparatus used.



(a) Energy is transferred to the electric motor by the power supply.

Why is the energy transferred to the motor greater than the gravitational potential energy gained by the mass?

Tick (✓) **two** boxes.

Energy is not conserved	☐
Friction in the motor causes energy transfer to the surroundings	☐
The temperature of the motor increases	☐
Thermal energy from the surroundings is transferred to the mass	☐
Wasted energy is destroyed	☐

(2)

(b) The student calculated the gravitational potential energy gained by different masses as they were lifted.

The student used the equation:

gravitational potential energy = mass × 9.8 × height

Describe how the student could make accurate measurements to use in the calculations.

_____

_____

_____

_____

_____

_____

_____

(4)

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

_____

_____

(1)

(d) The efficiency of the motor was 15%.

The student calculated that the useful output energy transfer was 1.20 J

Calculate the total input energy transfer.

_____

_____

_____

_____

_____

_____

_____

_____

Total input energy transfer = _____ J

(4)

(Total 11 marks)

HIGHER

Q4.

Ice cream is made by cooling a mixture of liquid ingredients until they freeze.

(a) Which statement describes the motion of the particles in solid ice cream?

Tick (✓) **one** box.

They are stationary. ☐

They move freely. ☐

They vibrate about fixed positions. ☐

(1)

(b) How do the kinetic energy and the potential energy of the particles change as a liquid is cooled and frozen?

Tick (✓) **one** box.

Kinetic energy	**Potential energy**	
Decreases	Decreases	☐
Decreases	Does not change	☐
Does not change	Decreases	☐
Does not change	Does not change	☐

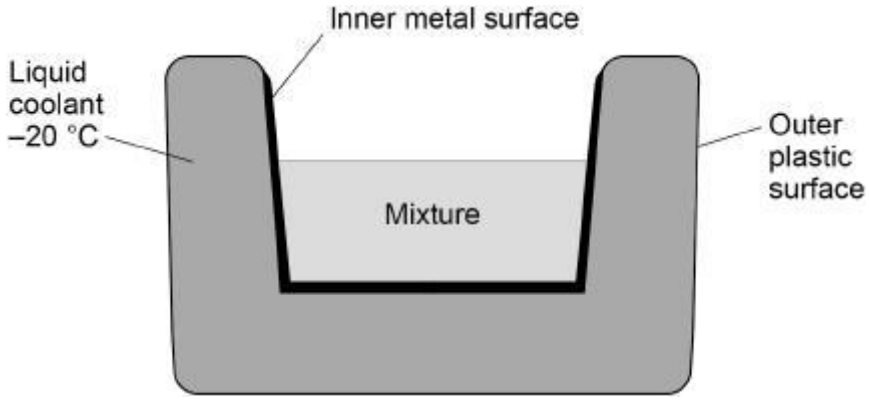
(1)

The diagram below shows a bowl used for making ice cream.

The walls of the bowl contain a liquid coolant.

The bowl is cooled to –20 °C before the mixture is put in the bowl.

The bowl causes the mixture to cool down and freeze.



(c) Explain why the different thermal conductivities of metal and plastic are important in the design of the bowl.

Metal _____

_____

_____

_____

Plastic _____

_____

_____

_____

(4)

(d) The liquid coolant has a freezing point below –20 °C

Explain **one** other property that the liquid coolant should have.

_____

_____

_____

_____

(2)

(e) The initial temperature of the mixture was +20 °C. The mixture froze at –1.5 °C.

A total of 165 kJ of internal energy was transferred from the mixture to cool and freeze it.

specific heat capacity of the mixture = 3500 J/kg °C

specific latent heat of fusion of the mixture = 255 000 J/kg

Calculate the mass of the mixture.

Give your answer to 2 significant figures.

_____

_____

Mass (2 significant figures) = _____ kg

(6)

(Total 14 marks)

Q5.

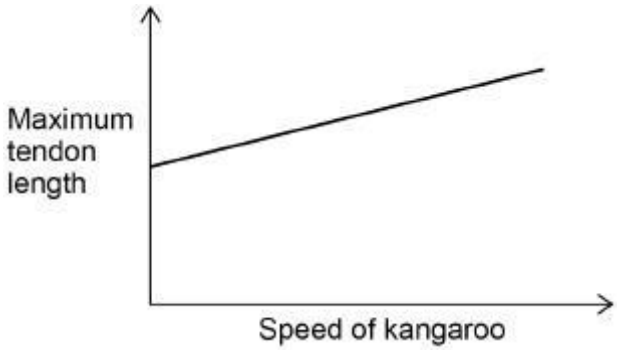
Kangaroos are large animals that travel by jumping.

The photograph below shows a kangaroo.

Each leg of a kangaroo has a tendon connected to a muscle. Each tendon can be modelled as a spring.

When a jumping kangaroo lands on the ground, the tendons stretch.

(a) The diagram below shows a sketch graph of how the maximum tendon length during a jump changes with the speed of the kangaroo.



Explain why a kangaroo can jump higher as its speed increases.

(3)

(b) A kangaroo has a maximum gravitational potential energy during one jump of 770 J

When the kangaroo lands on the ground 14% of the maximum gravitational potential energy is transferred to elastic potential energy in one tendon.

The tendon has an unstretched length of 35.0 cm

When the kangaroo lands on the ground the tendon stretches to a length of 42.0 cm

Calculate the spring constant of the tendon.

Spring constant = _____ N/m

(5)

(Total 8 marks)

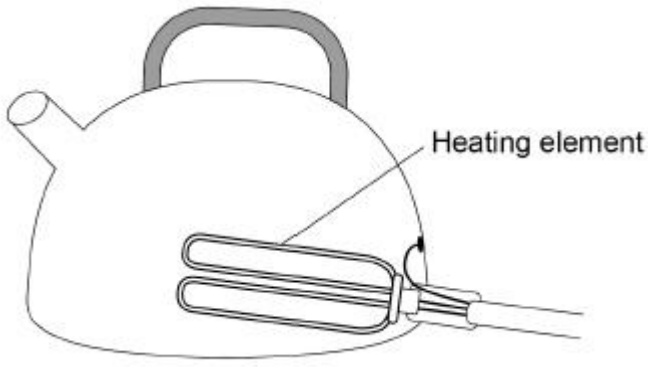
Q6.

A student investigated how the mass of water in an electric kettle affected the time taken for the water to reach boiling point.

The kettle switched off when the water reached boiling point.

Figure 1 shows the kettle.

Figure 1



(a) The heating element of the kettle was connected to the mains supply.

Explain why the temperature of the heating element increased.

_____

_____

_____

(2)

(b) Give **one** variable that the student should have controlled.

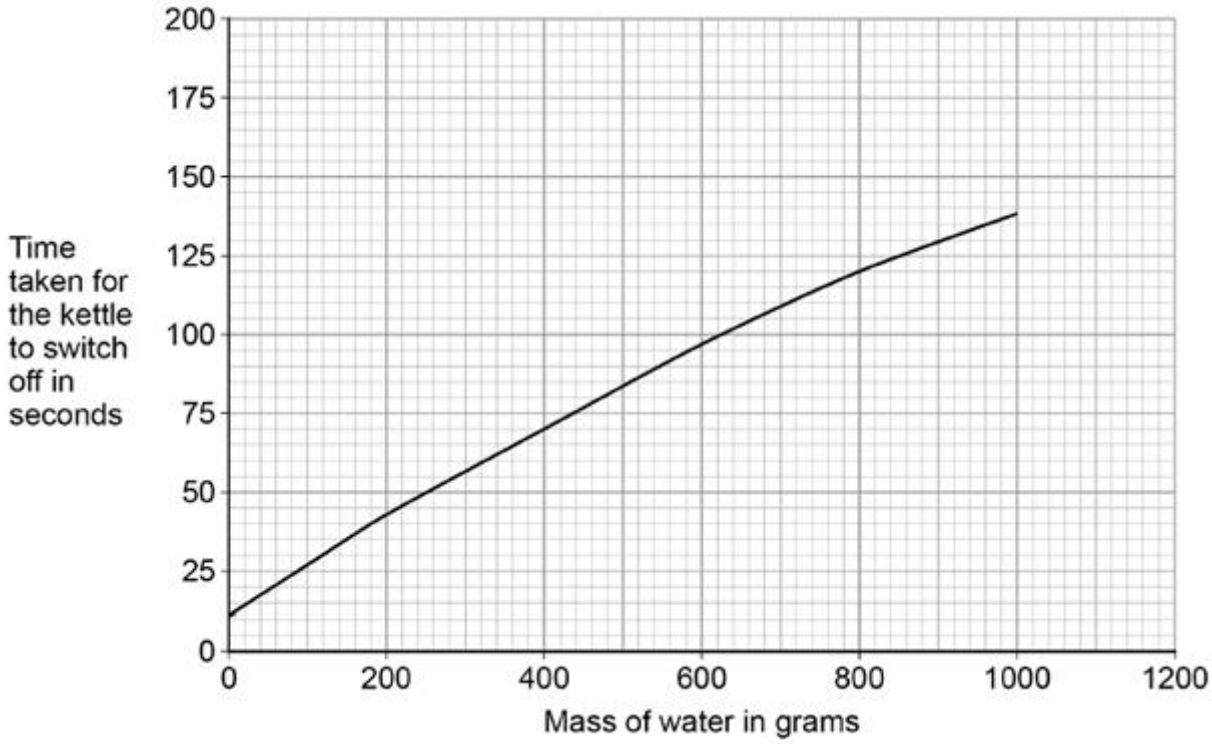
_____

_____

(1)

Figure 2 shows how the mass of water in the kettle affected the time taken for the kettle to switch off.

Figure 2



(c) Suggest why the line on **Figure 2** does **not** go through the origin.

_____

_____

(1)

(d) Suggest why the results give a non-linear pattern.

_____

_____

(1)

(e) The power of the kettle was 2.6 kW

The kettle took 120 seconds to heat 0.80 kg of water from 18 °C to 100 °C

Calculate the specific heat capacity of water using this information.

Give your answer to 2 significant figures.

Specific heat capacity = _____ J/kg °C

(6)

(Total 11 marks)

Q1.

(a) kinetic energy = 0.5 × mass × (speed)^2

allow $E = \frac{1}{2}mv^2$

1

(b) 0.5 × 9000 × 30^2

1

4 050 000

1

4050 (kJ)

*an answer of 4050 (kJ) scores **3** marks*

*an answer of 4 050 000 scores **2** marks*

1

(c) efficiency =

$$\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$$

1

(d) $0.80 = \frac{\text{useful output energy transfer}}{4050}$

allow ecf from (b)

1

(useful output energy transfer =) 0.80 × 4 050

1

= 3240 (kJ)

*an answer of 3240 (kJ) scores **3** marks*

1

(e)

Level 2: Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	3-4
Level 1: Relevant features are identified and differences noted.	1-2
No relevant content	0
Indicative content **advantages of both methods:** • both renewable sources of energy • both have no fuel (cost) • no carbon dioxide produced **advantages of wind**	

• higher average power output **advantages of hydroelectric** • constant / reliable power (output) • lower (installation) cost **disadvantages of wind** • higher (installation) cost • variable / unreliable power output **disadvantages of hydroelectric** • lower power output **disadvantages of both methods** • (may be) noisy • visual pollution	

4

[12]

Q2.

(a) pressure decreased

1

because molecules have less (kinetic) energy
allow less speed/velocity

1

so fewer collisions (with the wall/container each second)
allow collide with less force
allow less force on the walls

1

(b) $0.70 = m \times 330$

1

or
$700 = m \times 330\,000$
$m = \frac{0.70}{330}$
or
$m = \frac{700}{330\,000}$
allow correct rearrangement using converted value(s) of E to J and/or L to J/kg

1

m = 0.0021 (kg)
allow 0.0021(212121...)
allow correct calculation using converted value(s) of E and/or L

1

*an answer of 0.0021(212121...) scores **3** marks*
***3** marks can only be awarded for m = 0.0021(212121...) (kg)*

(c)

Substance	Solid	Liquid	Gas
Oxygen		✓	

Nitrogen			✓
Carbon dioxide	✓		

2 correct answers scores **1** mark.
if more than one tick in a row, neither can score a mark

2

(d) **Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

5–6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

No relevant content

0

Indicative content

cooling

- as the argon cools the particles slow down
- particles in a liquid move slower than particles in a gas
- particles in a solid move slower than particles in a liquid
- as the liquid/solid cools the particles get closer together
- as the liquid/solid cools the density increases

gas to liquid

- particles change from being spread apart to touching each other
- particles will (collide with other particles more often and) change direction more often

liquid to solid

- particles change from a random arrangement to a regular pattern
- particles change from moving freely to fixed positions
- particles change from moving freely/randomly to vibrating

explanation

- (internal) energy (of the argon) decreases
- (kinetic) energy (of the particles) decreases with temperature
- (potential) energy (of the particles) changes with change of state (of the argon)
- forces between particles in a gas are negligible/zero
- attractive forces act between atoms when they are close to each other
- attractive forces between particles are stronger in a solid than in a liquid

to access level 3 there must be an explanation of changes to arrangement and movement of particles during either cooling or a change of state

[14]

Q3.

(a) friction in the motor causes energy transfer to the surroundings

1

the temperature of the motor increases

1

(b) **Level 2**: The design / plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

3–4

Level 1: The design / plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- measure mass using a balance / scales, or use masses with known values
- measure weight with a newtonmeter **or** use known weights
- measure the height using a metre rule (through which the mass is raised)
- repeat for different masses
- ensure metre rule is vertical when measuring height of bench (using a set square)
- account for size of hanger (measuring from floor to base of hanger, or subtracting height of hanger from height of bench)
- repeat readings and calculate a mean (after discarding anomalies)
- calculate mean to reduce the effect of random errors

A Level 2 answer should include named measuring instruments for mass / weight (or using known masses / weights) and height as well as one method of ensuring accurate results.

(c)

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

1

(d)

*an answer of 8.0 or 8 (J) scores **4** marks*

*an answer of 0.08 (J) scores **3** marks*

15 % = 0.15

1

$$0.15 = \frac{1.20}{E}$$

this mark may be awarded if efficiency is incorrectly / not converted

1

$$E = \frac{1.20}{0.15}$$

this mark may be awarded if efficiency is incorrectly / not converted

1

E = 8.0 (J)

this mark may be awarded if efficiency is incorrectly / not converted

1

[11]

Q4.

(a) they vibrate about fixed positions.

1

(b) kinetic energy decreases potential energy decreases

1

(c) metal: has a high thermal conductivity

1

which increases the rate of energy transfer from the mixture
allow ice cream for mixture

1

plastic: has a low thermal conductivity

1

which reduces the rate of energy transfer from the surroundings (to the liquid coolant at –20°C)
ignore references to insulation throughout

1

(d) a high specific heat capacity

1

so it can absorb a large amount of energy with only a small temperature change

1

(e) 165 kJ = 165000 J

1

$\Delta E = m \times 3500 \times 21.5$
and
$\Delta E = m \times 255000$

1

$165000 = 75250\ m + 255000\ m$
or
$165000 = 330250\ m$
this mark may be awarded if E is incorrectly/not converted

1

$m = \frac{165000}{75250 + 255000}$
or
this mark may be awarded if E is incorrectly/not converted

1

$m = \frac{165000}{330250}$
allow an answer consistent with their value of E

m = 0.499621 (kg)

1

m = 0.50 (kg)
this answer only
If no marks awarded other than the first marking point:
either

*165 000 = m × 3500 × 21.5 scores **1** mark*
*m = 2.192… scores **1** mark*
*m = 2.2 (kg) scores **1** mark.*
these marks may be awarded if E is incorrectly/not converted
or
*165 000 = m × 255 000 scores **1** mark*
*m = 0.647 scores **1** mark*
*m = 0.65kg scores **1** mark.*
these marks may be awarded if E is incorrectly/not converted

1

[14]

Q5.

(a) the (maximum tendon) extension increases (as speed increases)
allow the tendons stretch more (as speed increases)

1

so the elastic potential energy increases
allow so the (elastic) force increases

1

which is transferred to gravitational potential energy

1

(b) E = 770 × 0.14
allow E = 107.8 (J)

1

extension = 0.070m

1

$107.8 = 0.5 \times k \times 0.070^2$
this mark may be awarded if extension is incorrectly/not converted and/or if the efficiency equation has not been applied

1

$k = 2 \times \frac{107.8}{0.070^2}$
this mark may be awarded if extension is incorrectly/not converted and/or if the efficiency equation has not been applied

1

k = 44 000 (N/m)
this mark may be awarded if extension is incorrectly/not converted
this mark may not be awarded if the efficiency equation has not been applied

1

[8]

Q6.

(a) electrons collide with particles in the heating element
allow there is a current in the heating element

1

which increases the (kinetic) energy of the particles (in the heating element)

allow internal store of energy increases
allow the particles (in the heating element) vibrate more rapidly

1

(b) the starting temperature of the water
allow the starting temperature of the kettle

1

(c) (the heating element of) the kettle took time to heat up

1

(d) the (rate of) energy transfer (per kg of water) to the surroundings decreases as the mass of water increases
allow the efficiency of the kettle changes as the mass of water changes

or

the efficiency of the kettle increases as the mass of water increases
allow the (rate of) energy transfer (per kg of water) to the surroundings changes as the mass of water changes

1

(e)
*an answer of 4800 (J/kg °C) scores **6** marks*
*a correct answer given to more than 2 s.f. scores **5** marks*

E = 2600 × 120
allow a correct substitution of an incorrectly/not converted value of P and/or t.

1

E = 312 000 (J)
this answer only
the equation E = Pt must have been used to score subsequent marks.

1

312 000 = 0.80 × c × (100-18)
or
312 000 = 0.80 × c × (82)
allow use of their value of E calculated using E = Pt for this and subsequent steps

1

$$c = \frac{312\,000}{0.80 \times 82}$$

1

c = 4 756

1

c = 4 800 (J/kg °C) (2 s.f.)
this mark can only be scored for a correct rounding of a value of c calculated using correct equations

1

[11]