Q1.

A student heated water in an electric kettle.

(c) The resistance of the heating element in the kettle is 15 Ω.

The current in the heating element is 12 A.

Calculate the power of the heating element.

Use the equation:

$$\text{power} = (\text{current})^2 \times \text{resistance}$$

Power = _____ W

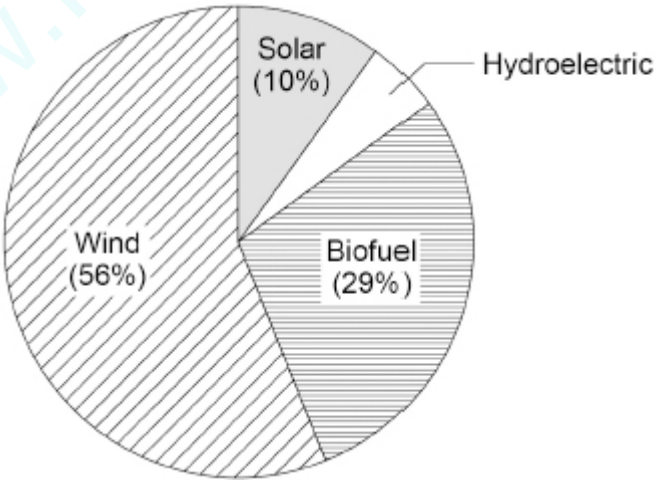
(2)

Q2.

The UK uses renewable energy resources to generate some of its electricity.

Figure 1 shows the proportion of electricity generated by different renewable energy resources in the UK in 2020.

Figure 1



(a) Calculate the percentage of electricity generated using hydroelectric power.

Percentage = _____ %

(2)

A remote village in the UK uses a hydroelectric generator to provide electricity.

(b) The mass of water that passes through the hydroelectric generator each day is 2 500 000 kg.

The change in vertical height of the water is 15.0 m.

gravitational field strength = 9.8 N/kg

Calculate the decrease in gravitational potential energy of the water.

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

Decrease in gravitational potential energy = _____ J

(2)

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

(c) Write down the equation which links energy (*E*), power (*P*) and time (*t*).

(1)

(d) The hydroelectric generator transfers electrical power of 3000 W to the village.

Calculate the energy transferred to the village in 60 minutes.

Energy transferred = _____ J

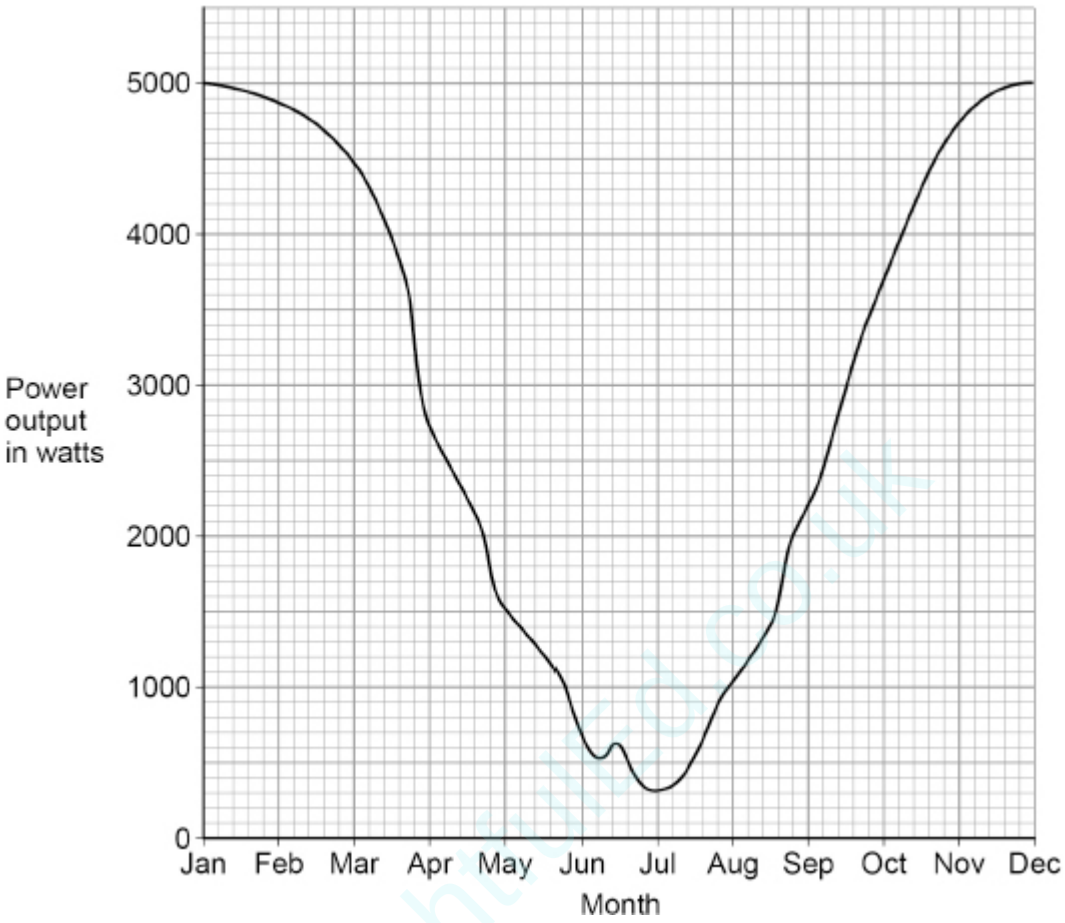
(3)

(e) The hydroelectric generator is turned by falling river water.

Figure 2 shows how the power output of the hydroelectric generator varied during

one year.

Figure 2



Explain **one** reason why the power output varied.

_____

_____

_____

_____

_____

(2)

(Total 10 marks)

Q3.

A remote village in the UK uses a hydroelectric generator to provide electricity.

(a) DO NOT DO THIS Q: In one day, 2 500 000 kg of water passes through the hydroelectric generator.

The change in gravitational potential energy of the water is 367.5 MJ.

gravitational field strength = 9.8 N/kg

(b) The generator transfers 3.0 kW of electrical power.

Calculate the time taken for the generator to transfer 2.16×10^7 J of energy.

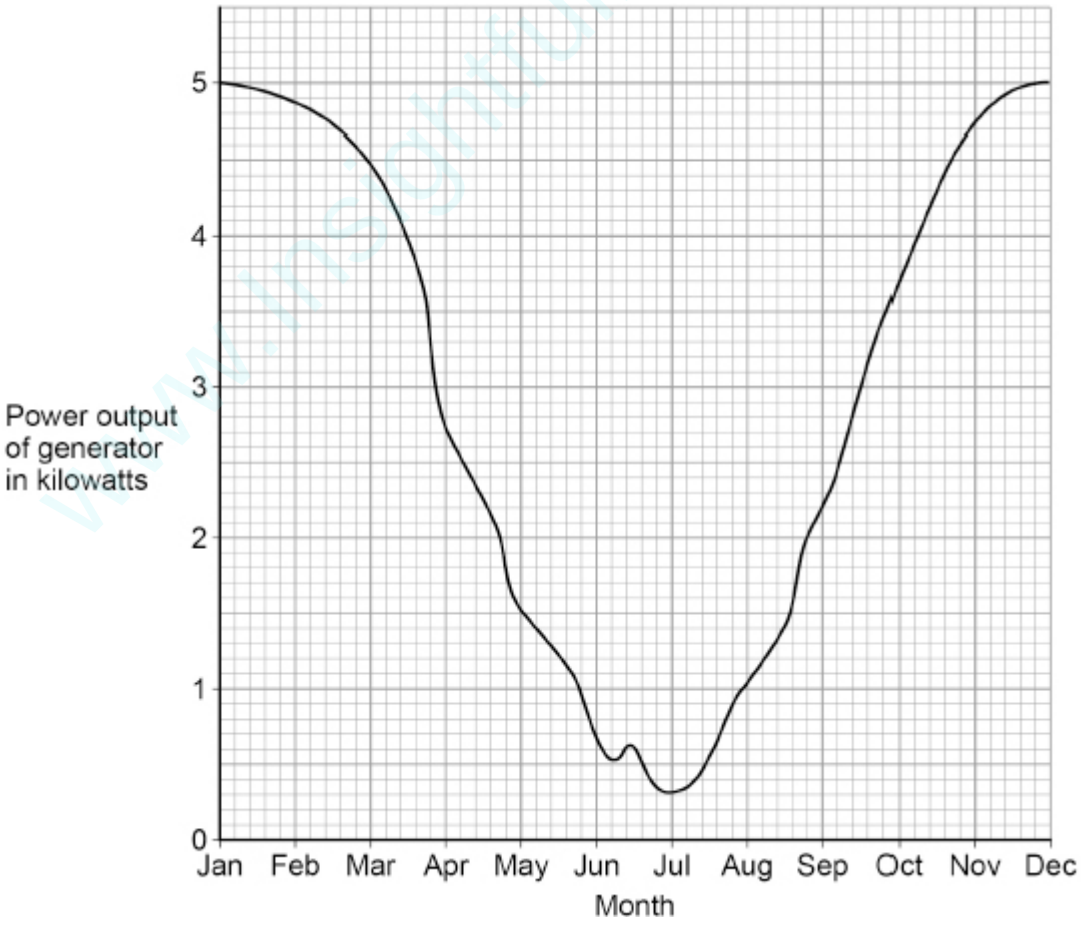
Use the Physics Equations Sheet.

Give your answer in standard form.

Time taken (in standard form) = _____ s

(5)

(c) The figure below shows how the power output of the generator varied during one year.



A solar power system is installed in the remote village in addition to the hydroelectric generator.

Explain why this improves the reliability of the electricity supply to the village.

Use information from the figure above.

_____

_____

_____

_____

_____

(2)

(Total 11 marks)

Q4.

The photograph below shows an electric car being recharged.

(b) Which equation links energy transferred (*E*), power (*P*) and time (*t*)?

Tick (✓) **one** box.

energy transferred = $\frac{\text{power}}{\text{time}}$ ☐

energy transferred = $\frac{\text{time}}{\text{power}}$ ☐

energy transferred = power × time ☐

energy transferred = power^2 × time ☐

(1)

(c) The battery in the electric car can store 162 000 000 J of energy.

The charging station has a power output of 7200 W.

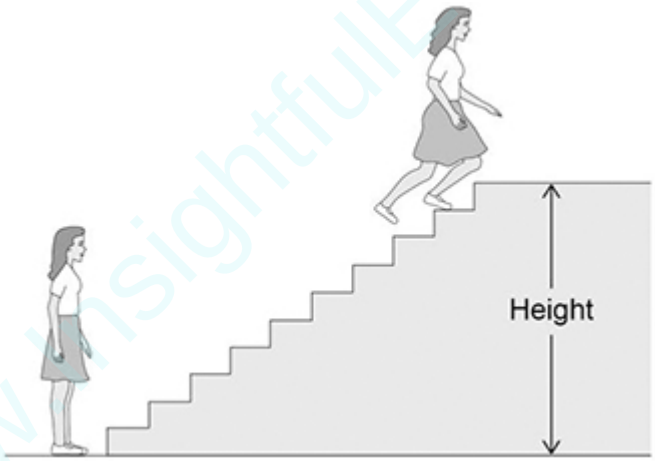
Calculate the time taken to fully recharge the battery from zero.

Time taken = _____ s

(3)

Q5.

The figure below shows a girl doing an experiment to determine her power output by running to the top of some stairs.



(a) The mass of the girl was 60.0 kg.

The height of the stairs was 175 cm.

The girl ran to the top of the stairs in 1.40 s.

gravitational field strength = 9.8 N/kg

Calculate the power output of the girl.

Use the Physics Equations Sheet.

_____

_____

_____

_____

Power = _____ W

(5)

(b) The **total** power output of the girl was greater than the answer to part (a).

Suggest **two** reasons why.

1. _____

_____

2. _____

_____

(2)

(c) A boy took more than 1.40 s to run up the same stairs.

The power output of the boy was the same as the power output of the girl.

What conclusion can be made about the boy's mass?

Tick (✓) **one** box.

The boy's mass was greater than the girl's mass.	☐
The boy's mass was lower than the girl's mass.	☐
The boy's mass was the same as the girl's mass.	☐

(1)

(Total 8 marks)

Q6.

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)

Q7.

The image shows a battery-powered drone.

(a) RETRIEVAL: Complete the sentences.

Choose the answers from the box.

chemical		**elastic potential**
gravitational potential	**kinetic**	**nuclear**

As the drone accelerates upwards

its _____ energy increases

and its _____ energy increases.

The _____ energy store

of the battery decreases.

(3)

(b) In the USA, drones are not allowed to be flown too high above the ground.

Suggest **one** possible risk of flying a drone too high above the ground.

_____

_____

_____

(2)

(c) Write down the equation that links energy transferred, power and time.

_____

(1)

(d) The drone can fly for 25 minutes before the battery needs recharging.

The power output of the battery is 65.0 W

Calculate the maximum energy stored by the battery.

_____

_____

_____

_____

Maximum energy = _____ joules

(3)

(Total 8 marks)

Q8.

The diagram below shows a wind turbine.

(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)

Q9.

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

Figure 1

(a) RETRIEVAL Complete the sentences.

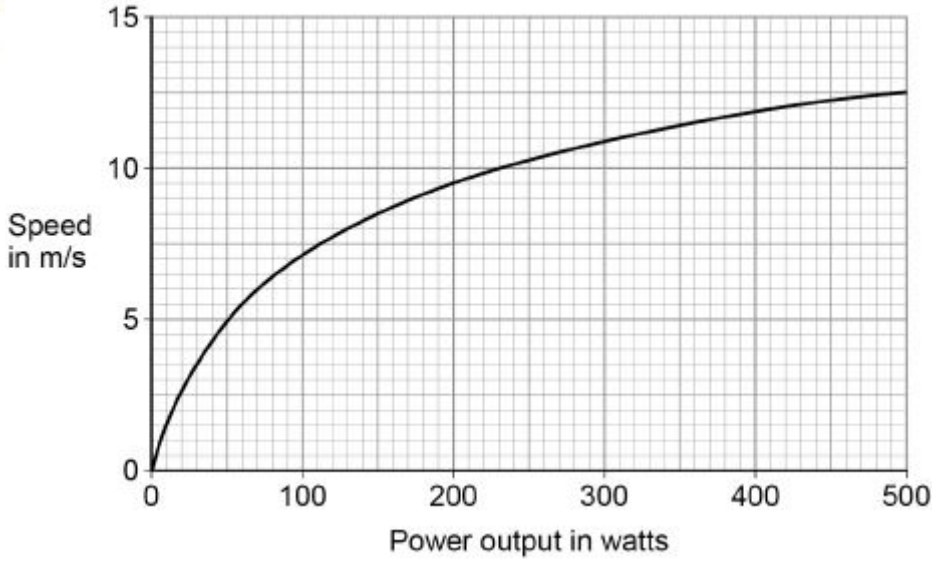
As the cyclist rides along the road, the _____ energy store in the cyclist's body decreases.

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.

_____

_____

_____

_____

_____

_____

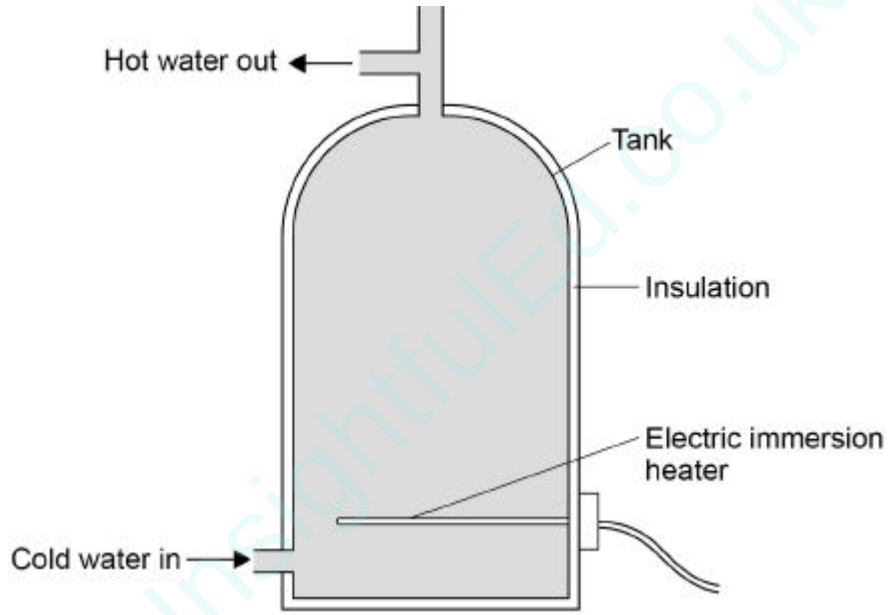
(3)

(Total 11 marks)

Q10.

Figure 1 shows a hot water tank made of copper.

Figure 1



(b) The tank is insulated. When the water is hot, the immersion heater switches off.

Complete the sentences.

Compared to a tank with no insulation, the rate of energy transfer from the

water in an insulated tank is _____ .

This means that the water in the insulated tank stays _____

for longer.

(2)

Figure 2 shows how temperature varies with time for water in a tank heated with an immersion heater.

Figure 3 shows how temperature varies with time for water in a tank heated with a solar panel.

Figure 2

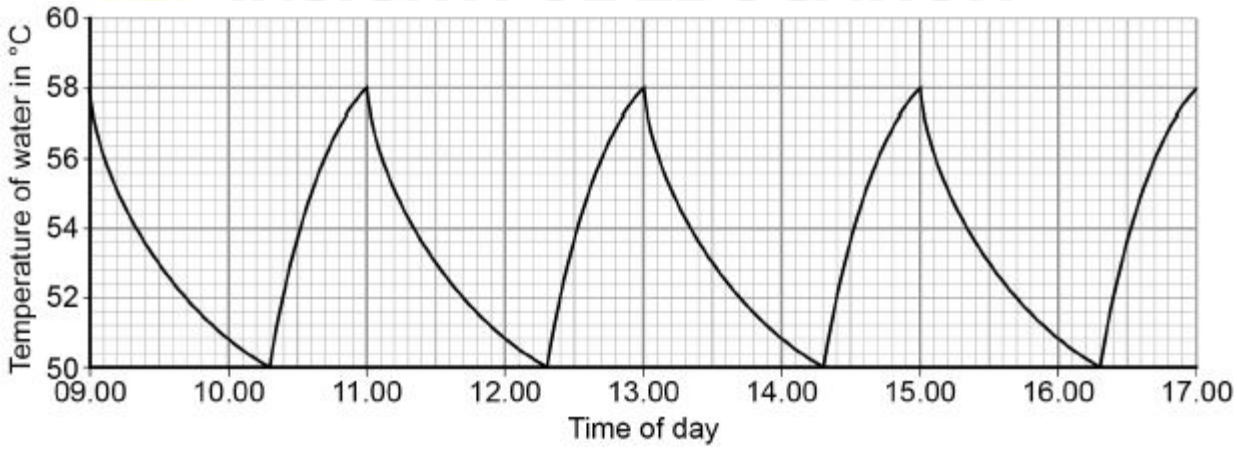
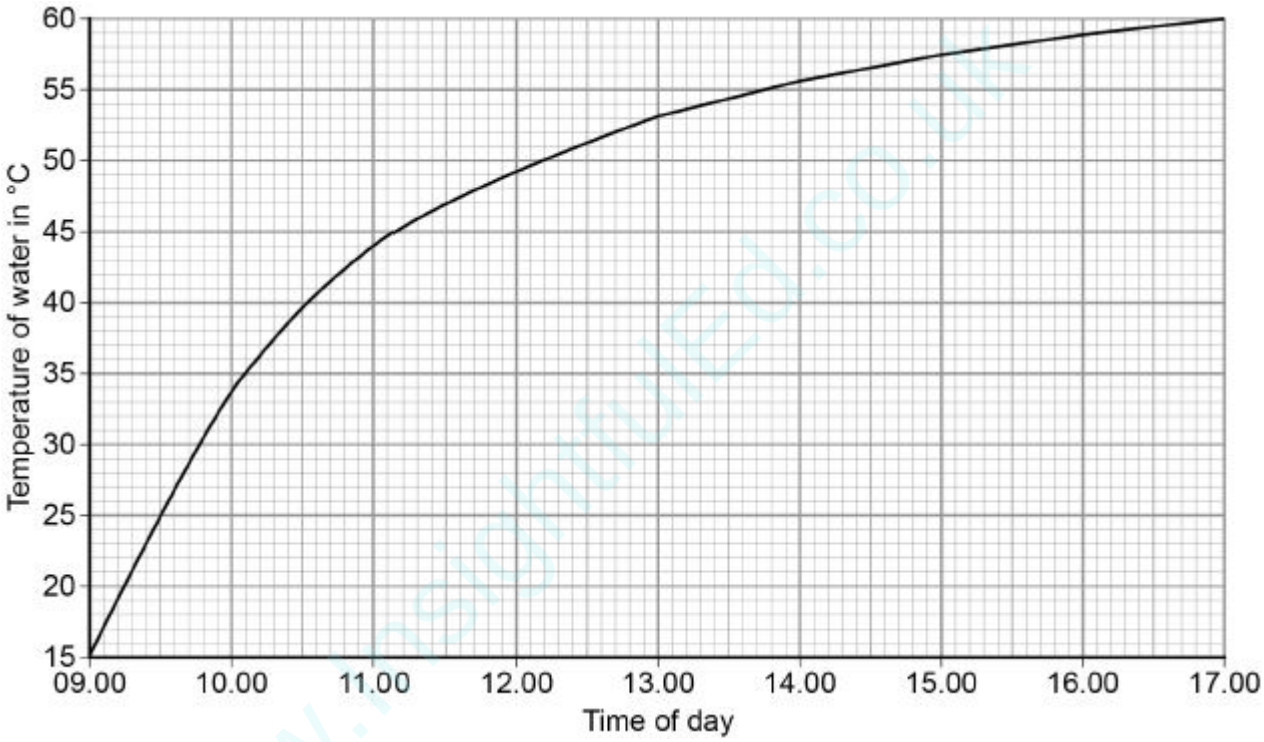


Figure 3



(d) During one morning, a total of 4 070 000 J of energy is transferred from the electric immersion heater.

4 030 000 J of energy are transferred to the water.

Calculate the proportion of the total energy transferred to the water.

_____

_____

_____

_____

Proportion of total energy = _____

(2)

(e) Write down the equation that links energy transferred, power and time.

_____

(1)

(f) The power output of the immersion heater is 5000 W.

Calculate the time taken for the immersion heater to transfer 4 070 000 J of energy.

Give the unit.

_____

_____

_____

_____

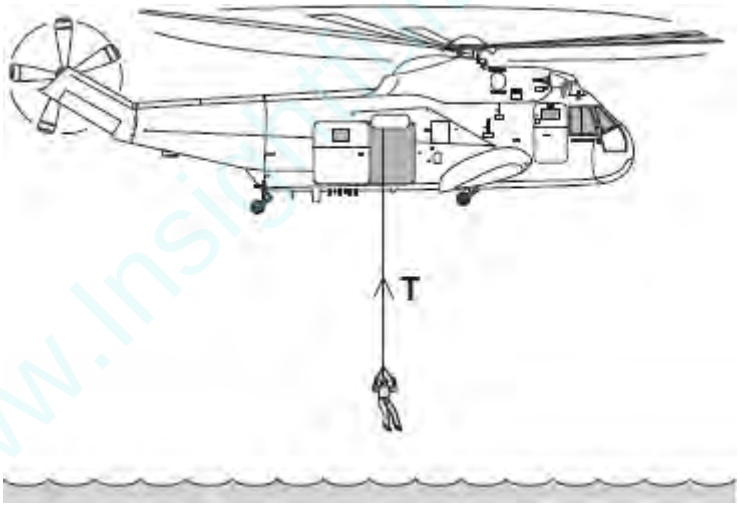
Time = _____ Unit _____

(4)

(Total 12 marks)

Q11.

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



(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)**

_____

_____

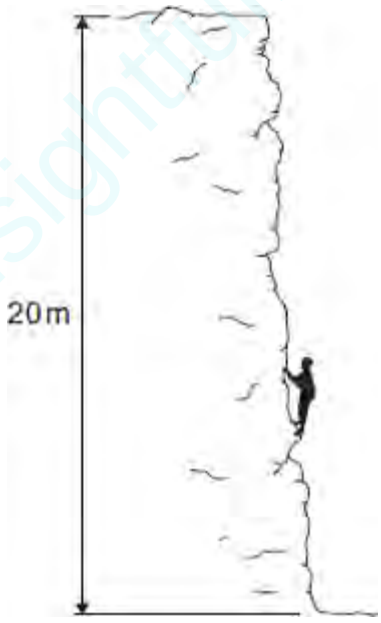
Power = _____

(3)

(Total 7 marks)

Q12.

The diagram shows a climber part way up a cliff.



(a) Complete the sentence.

When the climber moves up the cliff, the climber

gains gravitational _____ energy.

(1)

(b) The climber weighs 660 N.

(i) Calculate the work the climber must do against gravity, to climb to the top of

the cliff.

_____

_____

Work done = _____ J

(2)

(ii) It takes the climber 800 seconds to climb to the top of the cliff.
During this time the energy transferred to the climber equals the work done by the climber.

Calculate the power of the climber during the climb.

_____

_____

Power = _____ W

(2)

(Total 5 marks)

Q13.

Figure 1 shows a lift inside a building.

Figure 1

(a) The motor in the lift does 120 000 J of work in 8.0 seconds.

Calculate the power output of the motor in the lift.

Use the equation:

$$\text{Power output} = \frac{\text{work done}}{\text{time}}$$

Power output = _____ W

(2)

(b) The power input to the motor is greater than the power output.

Tick **two** reasons why.

Energy is transferred in heating the surroundings.	☐
Friction causes energy to be transferred in non-useful ways.	☐
The motor is connected to the mains electricity supply.	☐
The motor is more than 100% efficient.	☐
There are only four people in the lift.	☐

(2)

(d) Write down the equation that links gravitational field strength, gravitational potential energy, height and mass.

_____

_____

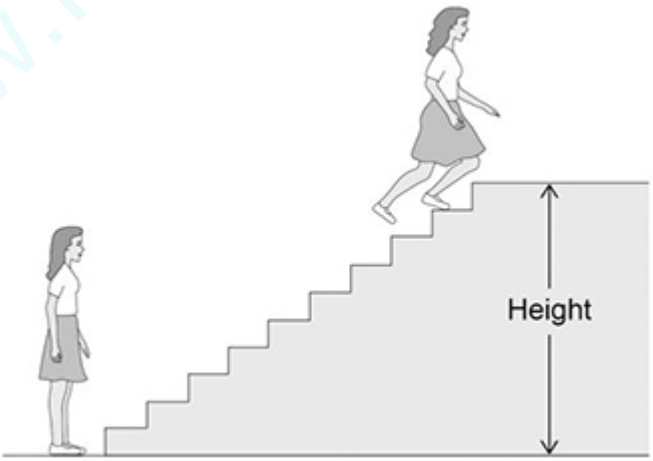
(1)

(Total 10 marks)

Q14.

A girl ran to the top of some stairs.

The figure shows the stairs.



(a) The girl measured the height of the stairs.

What measuring instrument should she have used?

_____

(1)

(c) A boy ran up the same stairs and did 1800 J of work.

The time it took the boy to run up the stairs was 1.44 s.

Calculate the power of the boy.

Use the equation:

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

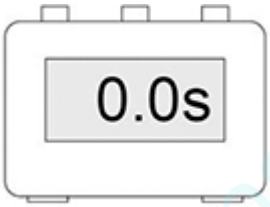
Power = _____ W

(2)

(d) Which stop-clock was used to measure the time the boy took to run up the stairs?

Tick (✓) **one** box.

Stop-clock A

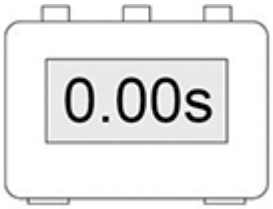


☐

Stop-clock B

☐

Stop-clock C



☐

(1)

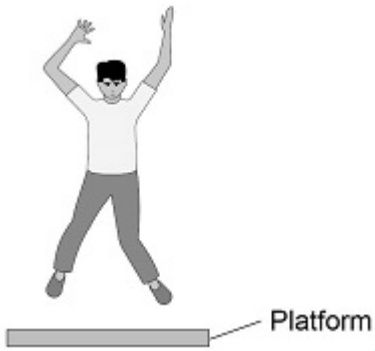
Q15.

A scientist investigated how the maximum muscle power of humans varies with age and gender.

The scientist asked volunteers to stand on a platform and to jump as high as they could.

Figure 1 shows a volunteer taking part in the experiment.

Figure 1



An electronic timer measured the time that the volunteer was in the air.

(a) The muscle power in watts per kg is calculated using the following equation:

$$\text{muscle power} = \frac{9.8 \times \text{jump height}}{\text{time}}$$

One volunteer has a muscle power of 41 W/kg

He was in the air for 0.12 s

Calculate his jump height.

_____

_____

_____

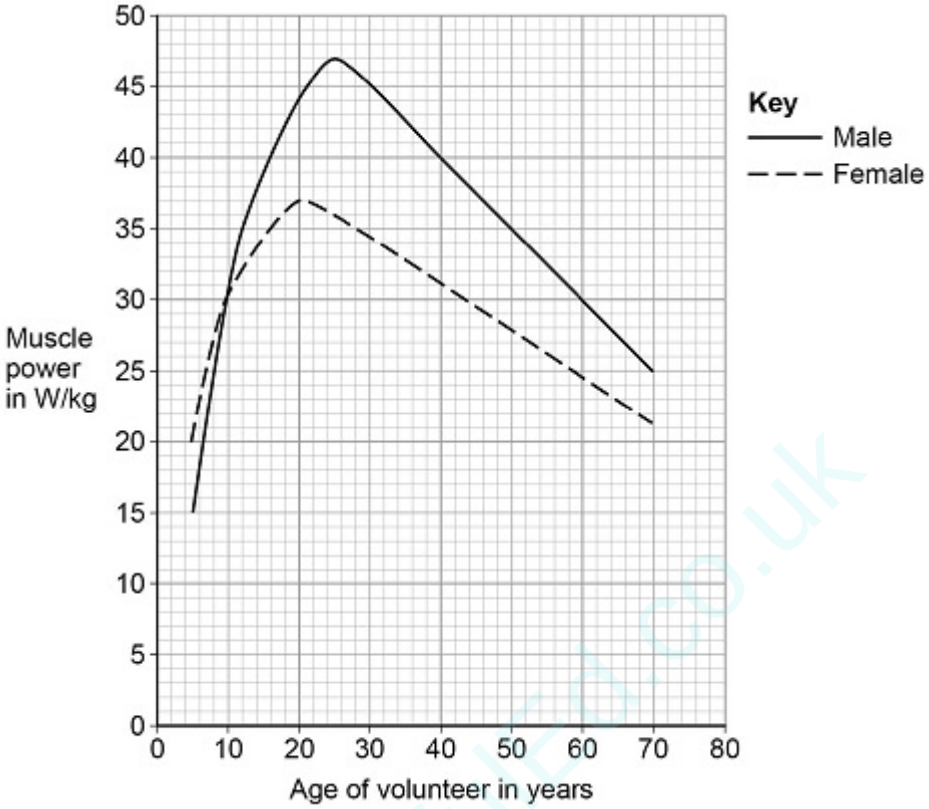
_____

Jump height = _____ m

(3)

Figure 2 shows the scientist's results.

Figure 2



(d) Compare the muscle power of males with the muscle power of females.

Use data from **Figure 2** in your answer.

(4)

(e) The muscle power of each volunteer was measured five times.

The highest muscle power reading was recorded instead of calculating an average.

Suggest **one** reason why.

_____

_____

_____

_____

(1)

(Total 12 marks)

Q16.

Light bulbs are labelled with a power input.

(a) What does power input mean?

Tick (✓) **one** box.

The charge transferred each second by the bulb.	☐
The current through the bulb.	☐
The energy transferred each second to the bulb.	☐
The potential difference across the bulb.	☐

(1)

(b) Write down the equation which links current, potential difference and power.

_____

(1)

(c) A light bulb has a power input of 40 W

The mains potential difference is 230 V

Calculate the current in the light bulb.

_____

_____

_____

Current = _____ A

(3)

The following table shows information about three different light bulbs.

Light bulb	Total power input in watts	Useful power output in watts	Efficiency
P	6.0	5.4	0.90
Q	40	2.0	0.05
R	9.0	**X**	0.30

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

_____

(1)

(e) Calculate the value of **X** in the table above.

_____

_____

_____

_____

X = _____ W

(3)

(f) In addition to power input, light bulbs should also be labelled with the rate at which they emit visible light.

Suggest why.

_____

_____

_____

_____

(2)

(Total 11 marks)

Mark schemes

Q1.

(c) $P = 12^2 \times 15$

1

$P = 2160$ (W)

1
1

Q2.

(a) other energy resources = 95 (%)

1

hydroelectric = 5 (%)

1

(c) energy = power × time
or
$E = P \times t$

1

(d) $t = 3600$ (s)

1

$E = 3000 \times 3600$

allow a correct substitution using an incorrectly/not converted value for t

1

$E = 10\,800\,000$ (J)
or
$E = 1.08 \times 10^7$ (J)

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

allow a correct answer given to 2 s.f.

1

(e) the level of the water in the river varies
or
the amount of rainfall varies

1

and is lower in the summer months

allow specified months or range of months eg April to September

1

MP2 dependent on scoring MP1

[10]

Q3.

(b) 3 kW = 3000 W

1

$$3000 = \frac{2.16 \times 10^7}{t}$$

all subsequent marks can score using an incorrectly / not converted value of P

1

$$t = \frac{2.16 \times 10^7}{3000}$$

1

t = 7200 (s)

1

$t = 7.2 \times 10^3$ (s)

allow an answer given in standard form from a calculation using data given in the question

1

(c) in the summer the power output from the hydroelectric generator is lower but the solar power output would be greater

*allow power output of hydroelectric generator depends on rainfall **and** power output of solar power system depends on light intensity*

1

so less variation in total power output (which improves the reliability of the supply)

allow electricity supply for total power output

1

allow reference to specific months eg April to September

[11]

Q4.

(b) energy transferred = power × time

1

(c) 162 000 000 = 7200 × t

1

$$t = \frac{162\,000\,000}{7200}$$

1

t = 22 500 (s)

1

Q5.

(a) h = 1.75 (m)

1

$E_p = 60 \times 9.8 \times 1.75$

allow a correct substitution using an incorrectly / not converted value of h

1

E_p = 1029 (J)

allow a correct calculation using an incorrectly / not converted value of h

1

$$P = \frac{1029}{1.40}$$

allow a correct substitution using their calculated value of E_p

1

P = 735 (W)

allow an answer consistent with their value for E_p

1

(b) girl increases her kinetic energy (as well as increasing her gravitational potential energy)

1

some energy is wasted in her muscles
or
some energy transferred as thermal energy (to surroundings)

allow some energy transferred due to air resistance
ignore unqualified references to friction
ignore references to sound

1

(c) the boy's mass was greater than the girl's mass

1

[8]

Q6.

(a) risk of electric shock (if someone touched the case)

allow risk of electrocution (if someone touched the case)

1

(b) 2530 = I × 230

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

1

$$I = \frac{2530}{230}$$

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

1

I = 11 (A)

this answer only

*an answer of 0.011 (A) scores **2** marks*

*an answer of 11 (A) scores **3** marks*

1

(c) E = 2530 × 14

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

1

E = 35 420 (J)

this answer only

1

35 420 = m × 4200 × 70

allow their calculated E = m × 4200 × 70

1

$$m = \frac{35\,420}{4200 \times 70}$$

$$\textit{allow } m = \frac{\textit{their calculated } E}{4200 \times 70}$$

1

m = 0.12 (kg)

allow an answer that is consistent with their calculated value of E

1

[9]

Q7.

(a) gravitational potential

1

kinetic

1

chemical

1

(b) flying drones may damage aircraft
or
falling drones may injure people
or
damage buildings / vehicles

allow any sensible suggestion of a hazard caused by a flying / falling drone

1

(c) energy transferred = power × time

allow E = Pt

1

(d) t = 25 × 60 = 1500 (s)

1

E = 65 × 1500

1

E = 97 500 (J)

an answer of 97 500 (J) scores 3 marks

allow 2 marks for an answer of 1625 (J)

1

[8]

Q8.

(b) mass of air passing the turbine blades is halved which decreases kinetic energy by a factor of two

1

(wind speed is halved) decreasing kinetic energy by a factor of four

1

so kinetic energy decreases by a factor of eight

1

allow power output for kinetic energy throughout

(c) $388\,000 = 0.5 \times 13\,800 \times v^2$

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

1

$$v^2 = \frac{(2 \times 388\,000)}{13\,800}$$

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

or

$$v^2 = \frac{388\,000}{(0.5 \times 13\,800)}$$

or

$v^2 = 56.2$

1

v = 7.50 (m/s)

an answer that rounds to 7.50 (m/s) only

1

[9]

Q9.

(a) chemical

1

equal to

allow the same as

1

in this order only

(b) $\text{power} = \frac{\text{work done}}{\text{time}}$

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

1

(c) $200 = \frac{W}{1800}$

1

W = 200 × 1800

1

W = 360 000 (J)

1

*an answer of 360 000 (J) scores **3** marks*

(d) 11 − 9.5 = 1.5 (m/s)

allow a change in speed between 1.2 and 1.5 (m/s)

1

$\left(\frac{1.5}{9.5}\right) \times 100 = 15.8\,(\%)$

allow an answer consistent with their change in speed
*an answer of 16 (%) scores **2** marks*

1

*an answer that rounds to 15.8 (%) scores **2** marks*

(e) maximum speed is lower

1

because maximum power output of cyclist is constant

allow maximum force on pedals is constant

1

(but) additional work is done (against gravity)

*do **not** accept additional work done against friction or air resistance*

or
gravitational potential energy (of cyclist) is increased

1

[11]

Q10.

(b) low(er)

1

hot(ter)

allow warm(er)

1

(d) $\frac{4\,030\,000}{4\,070\,000}$

1

0.99

*an answer of 99% scores **2** marks*
*an answer of 99 or 0.99% scores **1** mark*

1

*an answer of 0.99 scores **2** marks*
*allow an answer that rounds to 0.99 for **2** marks*

(e) power = energy transferred / time

allow $P = E / t$

1

(f) $5000 = \frac{4\,070\,000}{t}$

1

$t = \frac{4\,070\,000}{5000}$

1

t = 814

1

seconds

other units of time must be consistent with numerical value

1

*an answer of 814 seconds scores **4** marks*
*an answer of 13.57 minutes scores **4** marks*

Q11.

(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]

Q12.

(a) potential

1

(b) (i) 13 200

*allow **1** mark for correct substitution, ie 660 × 20 provided no subsequent step shown*

2

(ii) 16.5

allow 1 mark for correct

or

$\frac{\text{their (b)(i)}}{800}$ correctly calculated

substitution, ie $\frac{13\,200}{800}$ ***or*** $\frac{\text{their (b)(i)}}{800}$

provided no subsequent step shown

2

[5]

Q13.

(a) $P = \frac{120\,000}{8.0}$

1

P = 15 000 (W)

1

*an answer of 15 000 (W) scores **2** marks*

(b) energy is transferred in heating the surroundings

1

friction causes energy to be transferred in non-useful ways

1

(d) gravitational potential energy = mass × gravitational field strength × height

allow $E_p = m\ g\ h$

1

Q14.

(a) tape measure
or
metre rule

allow ruler

ignore metre stick

1

(c) $P = \frac{1800}{1.44}$

1

P = 1250 (W)

1

(d) stop-clock C

1

Q15.

(a)

*an answer of 0.50 scores **3** marks*
*allow a correct answer that rounds to 0.50 for **3** marks*

$$41 = \frac{9.8 \times h}{0.12}$$

1

$$h = \frac{41 \times 0.12}{9.8}$$

1

h = 0.50 (m)

1

(d) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear.

3–4

Level 1: Relevant features are identified and differences noted.

1–2

No relevant content

0

Indicative content

- males have a greater muscle power than females for most of their lives
- males have a greater muscle power than females above 9/10 years old
- males have a lower muscle power than females below 9/10 years old
- there is a similar pattern for males and females as age increases
- males have a peak muscle power at 25 years old whereas females have a peak muscle power at 20/21 years old
- at 9/10 years old males have the same muscle power as females
- peak muscle power for males (47 W/kg) is greater than peak muscle power for females (37 W/kg)
- the rate of increase of muscle power is greater for males than females (between 5 and 25 years old)
- the rate of decrease of muscle power is greater for males than females.

Ignore comments relating to strength

(e) any **1** from:

- maximum height reached is a better indicator of maximum muscle power

  allow maximum time in the air for maximum height reached / jumped
- maximum / peak muscle power was being investigated, not mean / average muscle power
- volunteer may not use maximum effort on the first try
- performance may improve with practice
- performance may get worse with tiredness

1

Q16.

(a) The energy transferred each second to the bulb.

1

(b) power = potential difference × current
or

P = VI

1

(c)

*an answer of 0.17 (A) scores **3** marks*

40 = I × 230

1

$$I = \frac{40}{230}$$

1

I = 0.17 (A)

*a correct answer that rounds to 0.17 (A) scores **3** marks*

1

(d)

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

1

(e)

*an answer of 2.7 (W) scores **3** marks*

$$0.30 = \frac{\text{useful power output}}{9.0}$$

1

useful power output = 0.30 × 9.0

1

useful power output = 2.7 (W)

1

(f) bulbs also transfer thermal energy

allow light bulbs emit infrared radiation as well as visible light
ignore so people know how bright the bulb is

1

the efficiency of the light bulb also needs to be considered

allow the cost to power the light bulb depends on the efficiency

allow to see how much energy is wasted

1

[11]