1. In a sport called far-leaping, an athlete uses a long pole to cross a river.

Figure 1 shows an athlete far-leaping.

Figure 1

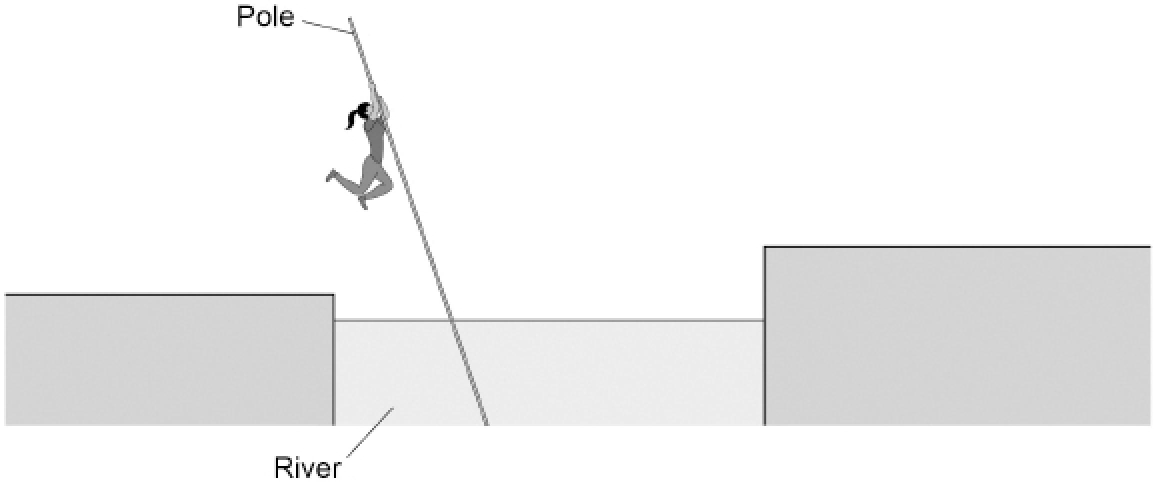
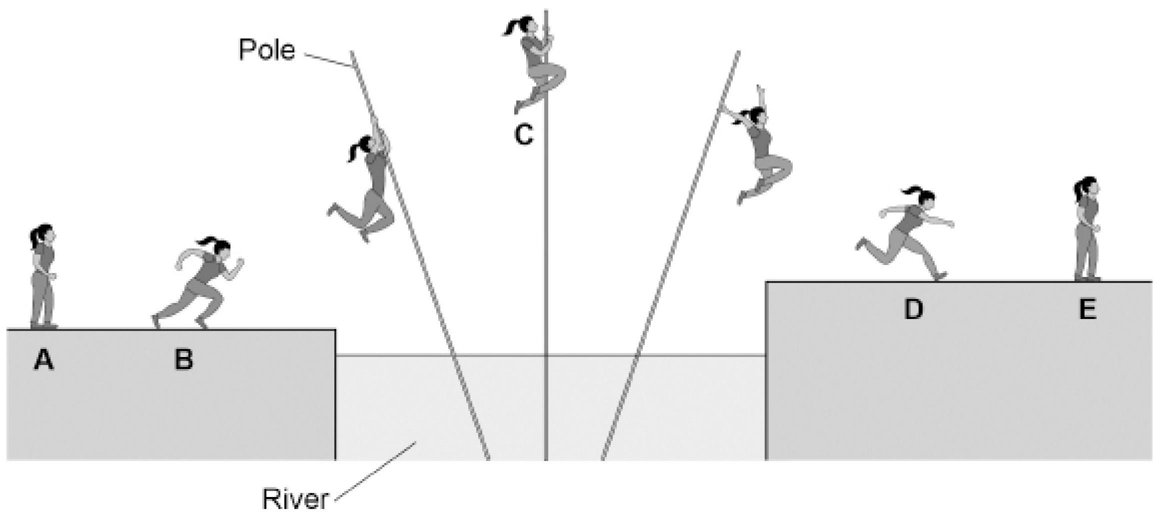


Figure 2 shows the athlete in different stages of far-leaping.

Figure 2



(a) Complete the sentence.

Choose answers from the box.

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

Between positions **A** and **B** the athlete speeds up. There is

an increase in the athlete's ________________________ energy and

a decrease in the athlete's ________________________ store of energy.

(2)

(b) Between positions **B** and **C** the athlete jumps to the pole and climbs up it.

Which statement describes a change in the athlete's energy between positions **B** and **C**?

Tick (✓) **one** box.

Elastic potential energy decreases. ☐

Elastic potential energy increases. ☐

Gravitational potential energy decreases. ☐

Gravitational potential energy increases. ☐

(1)

(c) The pole falls over from position **C**. The athlete lets go of the pole and lands at position **D**.

The change in height of the athlete between positions **C** and **D** is 3.0 m.

mass of athlete = 50 kg

gravitational field strength = 9.8 N/kg

Calculate the change in gravitational potential energy of the athlete between positions **C** and **D**.

Use the equation:

$$\text{change in gravitational potential energy} = \text{mass} \times \text{gravitational field strength} \times \text{change in height}$$

____

____

____

Change in gravitational potential energy = ________________ J

(2)

(d) The kinetic energy of the athlete at position **D** is 1600 J.

mass of athlete = 50 kg

Calculate the speed of the athlete at position **D**.

Use the equation:

$$\text{speed} = \sqrt{\frac{2 \times \text{kinetic energy}}{\text{mass}}}$$

Choose the unit from the box.

m/s	**J/kg**	**J/s**

____

____

____

____

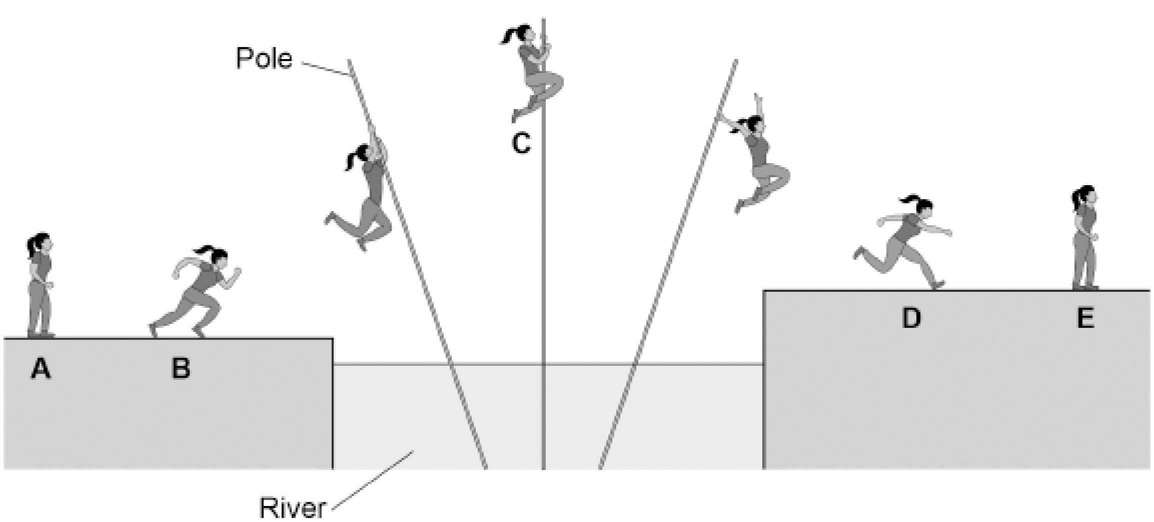
____

Speed = ___________ Unit ___________

(3)

Figure 2 is repeated below.

Figure 2



(e) At positions **A** and **E**, the athlete is standing still.

Why does the athlete have less energy in position **E** than in position **A**?

Tick (✓) **one** box.

Energy has been transferred from the athlete to the air.	☐
The air temperature has decreased.	☐
The height of the athlete above the water has increased.	☐

(1)

(f) Athletes have a large power output when they are far-leaping.

What is meant by the power of an athlete?

Tick (✓) **one** box.

The rate at which the athlete transfers energy.	☐
The size of the maximum force exerted by the athlete.	☐
The total energy transferred by the athlete.	☐

(1)

(g) A second athlete crossed the same river by far-leaping.

The second athlete had less power than the first athlete when running between position **A** and position **B**.

Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

less than	**the same as**	**more than**

Two factors that could explain why the second athlete had less power than the first athlete are:

1. The time taken by the second athlete to run between position **A** and position **B** was ____________________ the first athlete.

2. The work done by the second athlete was ____________________ the first athlete.

(2)

(Total 12 marks)

2. The photograph below shows a sailing boat crossing an ocean.

There is a wind turbine on the boat.

(a) The wind turbine generates electricity to charge a battery on the boat.

Name one **other** renewable energy resource that could be used on the boat to generate electricity.

____

(1)

(b) The boat also has a generator that burns a fossil fuel.

The battery can be charged by either the wind turbine **or** the generator.

Give **two** reasons why this is useful.

1 ____

____

2 ____

____

(2)

(c) Explain **one** environmental impact of using fossil fuels to generate electricity.

____

____

____

____

(2)

(d) The kinetic energy of the boat is 81 kJ.

mass of boat = 8000 kg

Calculate the speed of the boat.

____

____

____

____

____

____

____

Speed = ________________ m/s

(4)

(e) As the boat passes over a wave, the gravitational potential energy of the boat increases by 19 600 J.

mass of boat = 8000 kg

gravitational field strength = 9.8 N/kg

Calculate the change in height of the centre of mass of the boat as it passes over the wave.

___

___

___

___

___

___

Change in height = _______________ m

(3)

(Total 12 marks)

3. **Figure 1** shows a mobile phone with its battery removed.

Figure 1

A student measured the potential difference across the battery and then put the battery into the phone.

(a) What is the equation linking current (*I*), potential difference (*V*) and resistance (*R*)?

Tick (✓) **one** box.

$I = V R$ ☐

$R = I V$ ☐

$V = I R$ ☐

$V = I_2 R$ ☐

(1)

(b) The current in the electronic circuit in the mobile phone was 0.12 A.

The potential difference across the battery was 3.9 V.

Calculate the resistance of the electronic circuit in the mobile phone.

____

____

____

____

____

____

Resistance = _______________ Ω

(3)

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

____

(1)

(d) The battery was fully charged when it was put into the mobile phone.

The battery discharged when the mobile phone was switched on.

The average power output of the battery as it discharged was 0.46 watts.

The time taken to fully discharge the battery was 2500 minutes.

Calculate the energy transferred by the battery.

____

____

____

____

____

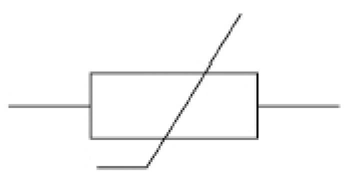
Energy transferred = _______________ J

(3)

The mobile phone includes a sensor to monitor the temperature of the battery.

Figure 2 shows the circuit symbol for a component used in the sensor.

Figure 2



(e) What component does the circuit symbol shown in **Figure 2** represent?

____

(1)

(f) The temperature of the component in **Figure 2** increases.

The potential difference across the component remains constant.

Explain what happens to the current in the component.

____

____

____

____

(2)

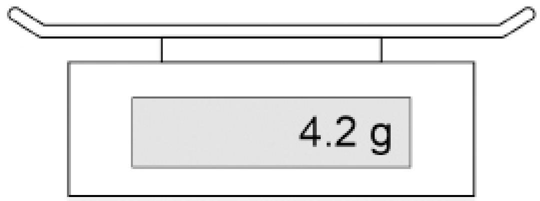
(Total 11 marks)

4. A student determined the density of a cube made of bronze.

The student used a balance to measure the mass of the bronze cube.

Figure 1 shows the balance before the cube was added.

Figure 1



(a) What type of error is shown on the balance?

____

(1)

(b) How could the student get a correct value for the mass of the cube from the balance?

____

____

(1)

(c) The student measured the length of the bronze cube using Vernier callipers and then using a micrometer.

Table 1 shows the results.

Table 1

Equipment	**Length in mm**
Vernier callipers	20.1
Micrometer	20.14

Complete the sentence.

The results in **Table 1** show that the Vernier callipers and the micrometer have a different ____________________.

(1)

The student wanted to determine the density of a bronze coin.

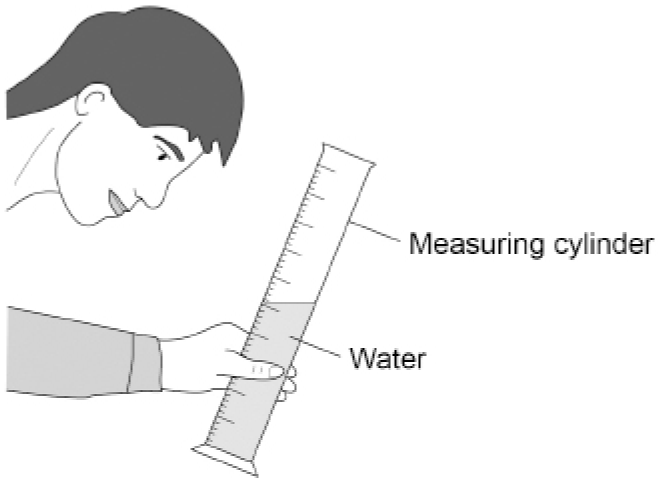
The student had several identical coins.

The volume of each coin was very small.

(d) The student added water to a measuring cylinder.

Figure 2 shows the student reading the volume of water in the measuring cylinder.

Figure 2



Give **two** changes the student should make to increase the accuracy of the volume measurement.

1 ____

____

2 ____

____

(2)

(e) Describe how the student could use a displacement method to determine an accurate value for the volume of a single coin.

____

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____

____

____

____

(3)

(f) Old penny coins were made from a disc of bronze.

New penny coins are made from a disc of a different metal.

Figure 3 shows a disc of metal.

Figure 3

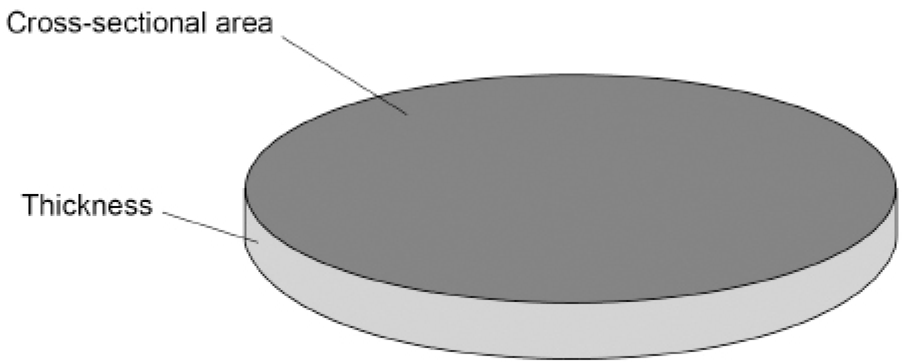

Table 2 shows information about the discs used to make each coin.

Table 2

Disc	**Mass in g**	**Density in g/cm^3**	**Thickness in cm**
Old penny	3.6	8.9	0.16
New penny	3.6	**X**	0.17

The discs used to make the old and the new coins have the **same** cross-sectional area.

Calculate value **X** in **Table 2**.

Give your answer to 2 significant figures.

The volume of a disc can be calculated using the equation:

volume of a disc = cross-sectional area × thickness

___

___

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Density (2 significant figures) = ________________ g/cm^3

(5)

(Total 13 marks)

5. A scientist had a balloon which was filled with air.

(a) Which statement describes how air particles move?

Tick (✓) **one** box.

At random speeds in random directions ☐

At random speeds in the same direction ☐

At the same speed in random directions ☐

At the same speed in the same direction ☐

(1)

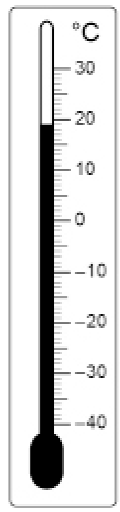
The temperature of the air was 19 °C

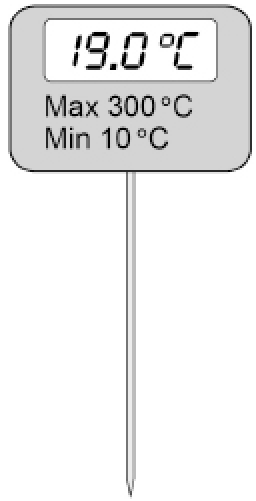
The scientist dipped the balloon into liquid nitrogen.

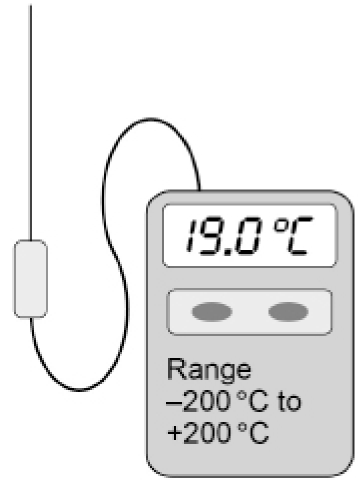
The temperature of the liquid nitrogen was −196 °C

(b) Which thermometer could be used to measure the temperature of the liquid nitrogen?

Tick (✓) **one** box.







☐ ☐ ☐

(1)

(c) The scientist wore special insulating gloves when putting the balloon into the liquid nitrogen.

Suggest why.

____

____

(1)

(d) When the balloon was put into liquid nitrogen the temperature of the air in the balloon decreased.

Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

decreased	**stayed the same**	**increased**

As the air in the balloon cooled down, the speed of the particles

________________. This is because the kinetic energy of the

particles ________________.

(2)

(e) The air in the balloon had a mass of 0.00320 kg

The temperature of the air in the balloon decreased by 215 °C

The change in thermal energy of the air in the balloon was 860 J

Calculate the specific heat capacity of the air in the balloon.

Use the Physics Equations Sheet.

____

____

____

____

____

____

Specific heat capacity = ________________ J/kg°C

(3)

(f) The liquid nitrogen boiled.

What happens to the temperature of nitrogen as it boils?

Tick (✓) **one** box.

Temperature decreases ☐

Temperature increases ☐

Temperature stays the same ☐

(1)

The scientist recorded measurements to calculate the specific latent heat of vaporisation of nitrogen.

(g) What is meant by vaporisation?

Tick (✓) **one** box.

A change of state from liquid to gas	☐
A change of state from solid to gas	☐
A change of state from solid to liquid	☐

(1)

(h) The mass of nitrogen that vaporised was 0.0072 kg

1440 J of energy was transferred to the nitrogen as it vaporised.

Calculate the specific latent heat of vaporisation of nitrogen.

Use the Physics Equations Sheet.

___

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Specific latent heat of vaporisation = ____________ J/kg

(3)

(Total 13 marks)

6. Different radioactive isotopes emit different types of nuclear radiation.

A polonium-210 (Po) nucleus emits an alpha particle (α) and turns into a lead (Pb) nucleus.

This can be represented by the equation:

$$^{210}_{84}\text{Po} \longrightarrow {}^{A}_{Z}\text{Pb} + \alpha$$

(a) What is the value of A in the equation?

Tick (✓) **one** box.

A = 206 ☐ A = 208 ☐ A = 210 ☐ A = 211 ☐

(1)

(b) What is the value of Z in the equation?

Tick (✓) **one** box.

Z = 80 ☐ Z = 82 ☐ Z = 85 ☐ Z = 86 ☐

(1)

(c) A strontium-89 nucleus (Sr) emits a beta particle (β) and turns into an yttrium nucleus (Y).

This can be represented by the equation:

$$^{89}_{38}\text{Sr} \longrightarrow ^{A}_{Z}\text{Y} + \beta$$

What are the values of A and Z in the equation?

A = ____________________________

Z = ____________________________

(2)

(d) Gamma radiation is another type of nuclear radiation.

What does gamma radiation consist of?

Tick (✓) **one** box.

High energy neutrons ☐

Electromagnetic waves ☐

Particles with no charge ☐

Positively charged ions ☐

(1)

(e) Explain the differences between the properties of alpha, beta and gamma radiations.

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(6)

(Total 11 marks)

7. Scientists are developing a rocket aeroplane designed to travel much faster than jet aeroplanes.

(a) The rocket aeroplane must accelerate along a runway to take off.

What would happen to the air resistance acting on the rocket aeroplane as it accelerates?

____

____

(1)

(b) An upward force called lift will act on the wings of the rocket aeroplane when it moves.

Complete the sentence.

Choose the answer from the box.

less than	**denatured**	**the same as**

As the rocket aeroplane starts to accelerate along the runway, the lift force on the wings will be ________________________________ the weight of the rocket aeroplane.

(1)

(c) During the first 14 seconds the average speed of the rocket aeroplane on the runway will be 35 m/s.

Calculate the distance that the rocket aeroplane will travel during the first 14 seconds.

Use the equation:

distance travelled = average speed × time

___

___

___

Distance travelled = ________________ m

(2)

(d) Write down the equation which links distance (*s*), force (*F*) and work done (*W*).

___

(1)

(e) When the rocket aeroplane travels a distance of 270 m on the runway the engines will do 54 000 000 J of work.

Calculate the average force exerted by the engines.

___

___

___

___

___

Average force = ________________ N

(3)

(f) The rocket aeroplane will fly at a greater height than a jet aeroplane.

The height that an aeroplane flies at affects the radiation dose a passenger will receive each hour.

The table below shows the speed of each aeroplane and the radiation dose a passenger will receive each hour.

Aeroplane	**Speed in metres per second**	**Radiation dose each hour in millisieverts**
Rocket aeroplane	8000	0.006
Jet aeroplane	250	0.003

Exposure to ionising radiation has risks and possible consequences.

Evaluate the risks and possible consequences of flying in a rocket aeroplane and in a jet aeroplane.

Assume the same journey is made in each aeroplane.

Use values from the table above.

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____

(6)

(Total 14 marks)

8. A student made water waves in a ripple tank.

(a) Describe how the frequency and wavelength of the water waves in the ripple tank can be measured accurately.

____

____

____

____

____

____

____

____

(4)

The student recorded values for the frequency and the wavelength of waves in the ripple tank.

Table 1 and **Table 2** show the results.

Table 1

Reading	**1**	**2**	**3**
Frequency in hertz	9.8	9.4	9.3

Table 2

Reading	**1**	**2**	**3**
Wavelength in cm	1.7	2.2	2.1

(b) Determine the mean wave speed.

____

____

____

____

____

____

____

Mean wave speed = ________________ m/s

(4)

(c) What is the advantage of taking repeat readings and then calculating a mean?

____

____

(1)

(d) The speed of the wave is affected by the depth of the water in the ripple tank.

The deeper the water the faster the wave.

Explain how the depth of the water affects the wavelength of the wave if the frequency is constant.

____

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____

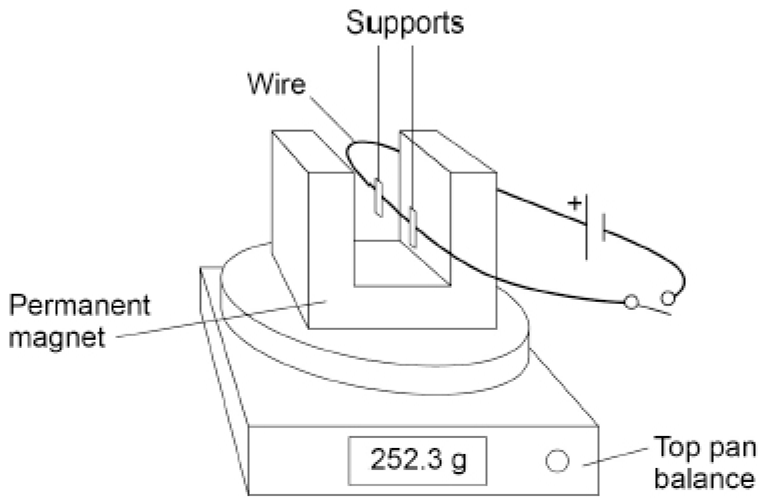
(2)

(Total 11 marks)

9. A student clamped a wire between the poles of a permanent magnet.

The student investigated how the force on the wire varied with the current in the wire.

The diagram below shows the equipment used.



The top pan balance was used to determine the force on the wire.

(a) When the switch was closed the reading on the top pan balance increased.

Explain why the increased reading showed that there was an upward force on the wire.

____

____

____

____

(2)

(b) The table below shows the readings on the top pan balance with the switch open and with the switch closed.

Switch	Mass in grams
Open	252.3
Closed	254.8

Explain how the values in the table above can be used to determine the size of the force on the wire.

____

____

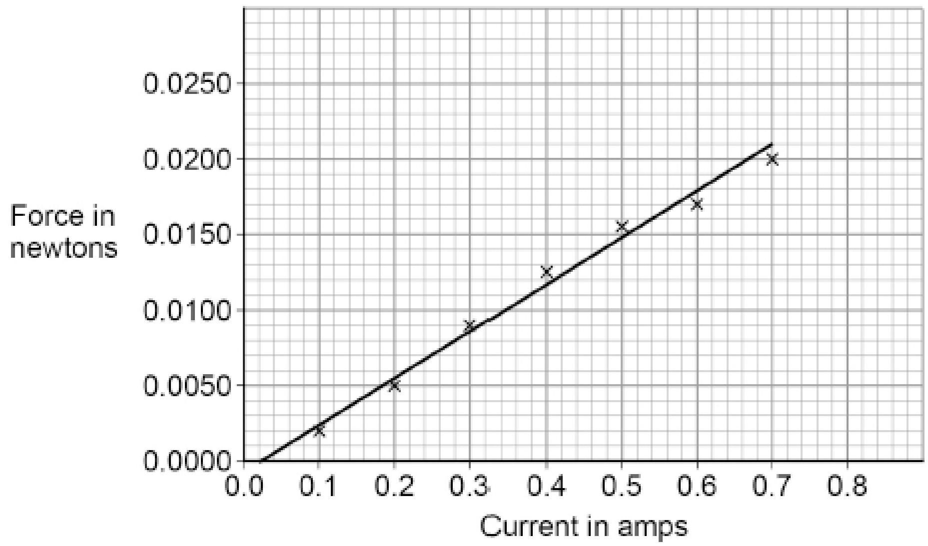
____

____

(2)

(c) The student varied the current in the wire and calculated the force acting on the wire.

The graph below shows the results.



The length of the wire in the magnetic field was 0.125 m

Determine the magnetic flux density.

____

____

____

____

____

____

____

Magnetic flux density = ________________ T

(4)

(Total 8 marks)

Mark schemes

1. (a) kinetic

answers must be in this order 1

chemical 1

(b) gravitational potential energy increases 1

(c) $E_p = 50 \times 9.8 \times 3.0$ 1

$E_p = 1470$ (J)

allow 1500 (J) 1

(d) speed = $\sqrt{2 \times \frac{1600}{50}}$ 1

speed = 8

allow 8.0 1

m/s 1

(e) energy has been transferred from the athlete to the air 1

(f) the rate at which the athlete transfers energy 1

(g) more than

answers must be in this order 1

less than 1

[12]

2. (a) solar

allow biofuel / biodiesel allow wave power 1

(b) sometimes there is no wind (but the battery can still be charged using the generator)

allow if the generator breaks then the turbine can still generate electricity

1

when there is wind less fuel is burned

allow a disadvantage of burning fossil fuel

1

(c) carbon dioxide

1

increases global warming

OR

sulfur dioxide or NOx emissions (1)

increases acid rain (1)

OR

particulates or NOx emissions (1)

can harm living organisms (1)

allow increases the greenhouse effect

1

(d) 81 kJ = 81 000 J

1

$81000 = 0.5 \times 8000 \times v^2$

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

1

$$v = \sqrt{\frac{81\,000}{0.5 \times 8000}}$$

allow a correct re-arrangement using an incorrectly/not converted value of energy

1

v = 4.5 (m/s)

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

1

(e) 19600 = 8000 × 9.8 × Δh

1

$$\Delta h = \frac{19\,600}{8000 \times 9.8}$$

1

Δh = 0.25 m

1

[12]

3. (a) *V* = *I R*

1

(b) 3.9 = 0.12 × R

1

$$R = \frac{3.9}{0.12}$$

1

R = 32.5 (Ω)

allow R = 33 (Ω)

1

(c) energy = power × time

or

E = P t

1

(d) time = 150 000s

1

energy = 0.46 × 150 000

allow a substitution using an incorrectly/not converted value of time

1

energy = 69 000 (J)

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

1

(e) thermistor

1

(f) the current will increase

1

(because) the resistance decreases

1

[11]

4. (a) zero error

allow systematic error

1

(b) reset the balance to zero g

allow subtract the reading shown on the balance from the reading taken

1

(c) resolution

this answer only

1

(d) place the measuring cylinder on a horizontal surface

1

view with eye in line with the level of the water

allow read from the bottom of the meniscus

1

(e) add several coins to the measuring cylinder

allow a minimum of 5 coins if a number of coins is given

1

measure the change in the water level in the measuring cylinder

1

divide by the number of coins added

1

(f) $8.9 = \frac{3.6}{\text{area} \times 0.16}$

allow $8.9 = \frac{3.6}{\text{volume}}$

1

$\text{area} = \frac{3.6}{8.9 \times 0.16}$

allow area = 2.5(28…) (cm^2)

1

$\text{density} = \frac{3.6}{2.528 \times 0.17}$

allow $\frac{3.6}{\text{their calculated area} \times 0.17}$

1

density = 8.37… (g/cm^3)

allow a correct calculation using their calculated area

1

density = 8.4 g/cm^3

this mark can only be scored for a correct rounding of a value of density calculated using correct equations

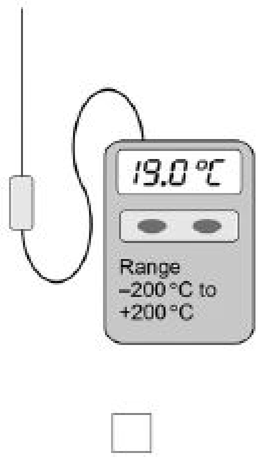
1

[13]

5. (a) at random speeds in random directions

1

(b) 3rd thermometer ticked



1

(c) to prevent (frost/cold) burns

allow to prevent frostbite

or

to prevent injury from the cold nitrogen

1

(d) decreased

1

decreased

1

(e) 860 = 0.00320 × c × 215

1

$c = \frac{860}{0.00320 \times 215}$

1

c = 1250 (J/kg°C)

1

(f) temperature stays the same

1

(g) a change of state from liquid to gas

1

(h) $1440 = 0.0072 \times L$ **1**

$L = \frac{1440}{0.0072}$ **1**

L = 200 000 (J/kg) **1**

[13]

6. (a) A = 206 **1**

(b) Z = 82 **1**

(c)

numbers must be in this order

89 **1**

39 **1**

(d) electromagnetic waves **1**

(e) **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

alpha radiation

- an alpha particle is the same as a helium nucleus
- alpha is the least penetrating
- alpha is stopped by paper or skin
- alpha has the shortest range in air
- alpha will travel a few cm in air
- because alpha is most ionising
- because alpha has a charge of +2

beta radiation

- a beta particle is an electron (emitted from the nucleus)
- beta penetrates less than gamma and more than alpha
- beta is stopped by a thin sheet of aluminium
- beta has a shorter range than gamma
- beta will travel up to 1m in air
- because beta is more ionising that gamma and less ionising than alpha
- because beta has a charge of -1

gamma radiation

- gamma radiation is an electromagnetic wave
- gamma is the most penetrating
- gamma is reduced/stopped by several cm of lead or thick concrete
- gamma has the largest range in air
- gamma will travel very large distances in air
- because gamma is least ionising
- because is uncharged

to access level 3 the answer should compare alpha, beta and gamma radiation and provide some explanation of their properties

[11]

7. (a) (air resistance) increases

1

(b) less than

1

(c) $s = 35 \times 14$

1

$s = 490$ (m)

1

(d) work done = force × distance

or

$W = Fs$

1

(e) $54\,000\,000 = F \times 270$

1

$$F = \frac{54\,000\,000}{270}$$

1

$F = 200\,000$ (N)

1

(f) **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.

4−6

Level 1: Relevant features are identified and differences noted.

1−3

No relevant content

0

Indicative content

- distance travelled is the same for each aeroplane
- time in the air is much greater for jet aeroplane
- speed of rocket plane is much greater
- speed of rocket plane is 32 times greater
- radiation dose each hour greater for rocket aeroplane
- radiation dose each hour is 2 times greater for rocket aeroplane
- overall radiation dose is less for rocket plane
- dose in jet aeroplane is 16 times greater overall
- much higher risk in jet aeroplane
- increased risk of skin cancer
- increased risk of gene mutation and cancer

To access level 2, there must be a relevant calculation.

[14]

8. (a) **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 necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced. 1–2

No relevant content 0

Indicative content

Wavelength

- place a metre rule at the side of the screen perpendicular to the wave fronts
- use the metre rule to measure the length of the screen
- take a photograph of the shadow on the screen
- count the number of complete waves on the screen
- determine the wavelength by dividing the length of the by the number of complete waves

or

- place a metre rule at the side of the screen perpendicular to the wave fronts
- take a photograph of the shadow on the screen
- use the metre rule to measure the distance between two wave front

Frequency

- count the number of waves that pass a given point
- time how long it takes for the waves to pass that point using a stop clock
- frequency is number of waves divided by time taken

or

- put a stop clock on the screen
- use a digital video camera to record the waves passing a point
- replay in slow motion and count the number of waves passing a point in 1 second

There must be a description of both frequency and wavelength measurement to access level 2

(b) mean f = 9.5 Hz

1

mean λ = 0.020 m

1

v = 9.5 × 0.020

allow a correct substitution of an incorrect value of mean frequency and/or wavelength

1

v = 0.19 (m/s)

allow a correct calculation using an incorrect value of mean frequency and/or wavelength

1

or

v = 9.8 × 0.017
and
v = 9.4 × 0.022
and

v = 9.3 × 0.021 (2)

$v = \frac{(1.67 + 2.07 + 1.95)}{3}$ (1)

v = 0.19 (m/s) (1)

*allow a maximum of **2** marks if a single pair of values is used*

(c) reduces the effect of random errors

allow anomalous readings can be discarded before calculating a mean

1

(d) deeper water means longer wavelength

1

because

v increases and f is constant

allow for a fixed frequency period is constant

1

[11]

9. (a) the downward force on the balance increased

allow when there is a current in the wire there is a magnetic field around the wire (which causes a magnetic force)

1

therefore the wire must experience an equal and opposite force (which is upwards)

1

(b) calculate the difference between the two mass readings

allow 254.8 – 252.3 = 2.5

1

convert to kg **and** multiply by gravitational field strength

allow (2.5 / 1000) × 9.8 = 0.02375 (N)

1

(c) gradient = $\frac{(0.0210 - 0.0)}{(0.70 - 0.02)}$

1

gradient = 0.031

allow answer correctly given to any number of significant figures

1

0.031 = B × 0.125

allow correct substitution using correctly calculated value given to any number of significant figures

1

B = 0.25 T

allow answer correctly given to any number of significant figures

any rounding must be correct for subsequent marks to be awarded.

*max **2** marks if a pair of readings from the graph are used instead of gradient calculation*

1

[8]