PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



EXAM QUESTION PACK

TOPIC 1: WORKING AS A PHYSICIST

SCORE	PERCENTAGE
/715	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions and mark schemes in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question or mark scheme material in this pack. Pearson has not endorsed, approved or been involved in the production of it. Pearson, Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson publishes its past papers and mark schemes free of charge. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of the following is a base SI unit?

☒ **A** ampere

☒ **B** coulomb

☒ **C** joule

☒ **D** newton

(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Which of the following are the base units for impulse?

☒ **A** kg m s^{-1}

☒ **B** kg m s^{-2}

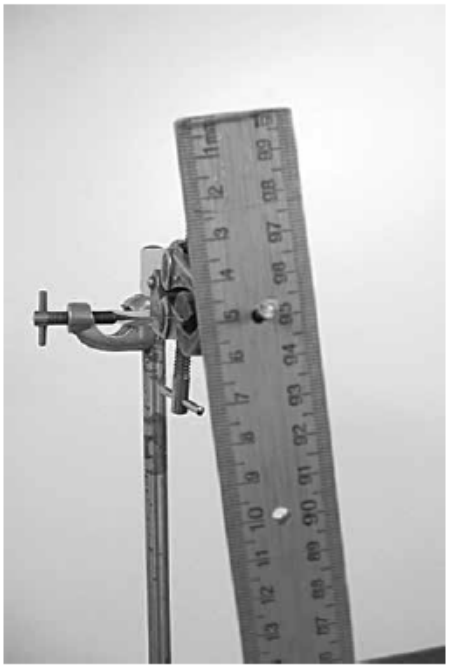
☒ **C** N m

☒ **D** N s

(Total for question = 1 mark)

Q3.

A metre rule has a small hole drilled at the 5 cm mark. The rule is hung on a horizontal pin passing through the hole.



The rule is rotated through a small angle and released. It then oscillates about the pin as a pendulum with a time period *T*.

(i) Describe how to use a stopwatch to determine a value for *T*.

(2)

.....

.....

.....

.....

(ii) State **two** reasons why repeating the readings will improve the results for *T*.

(2)

.....

.....

.....

.....

(Total for question = 4 marks)

Q4.

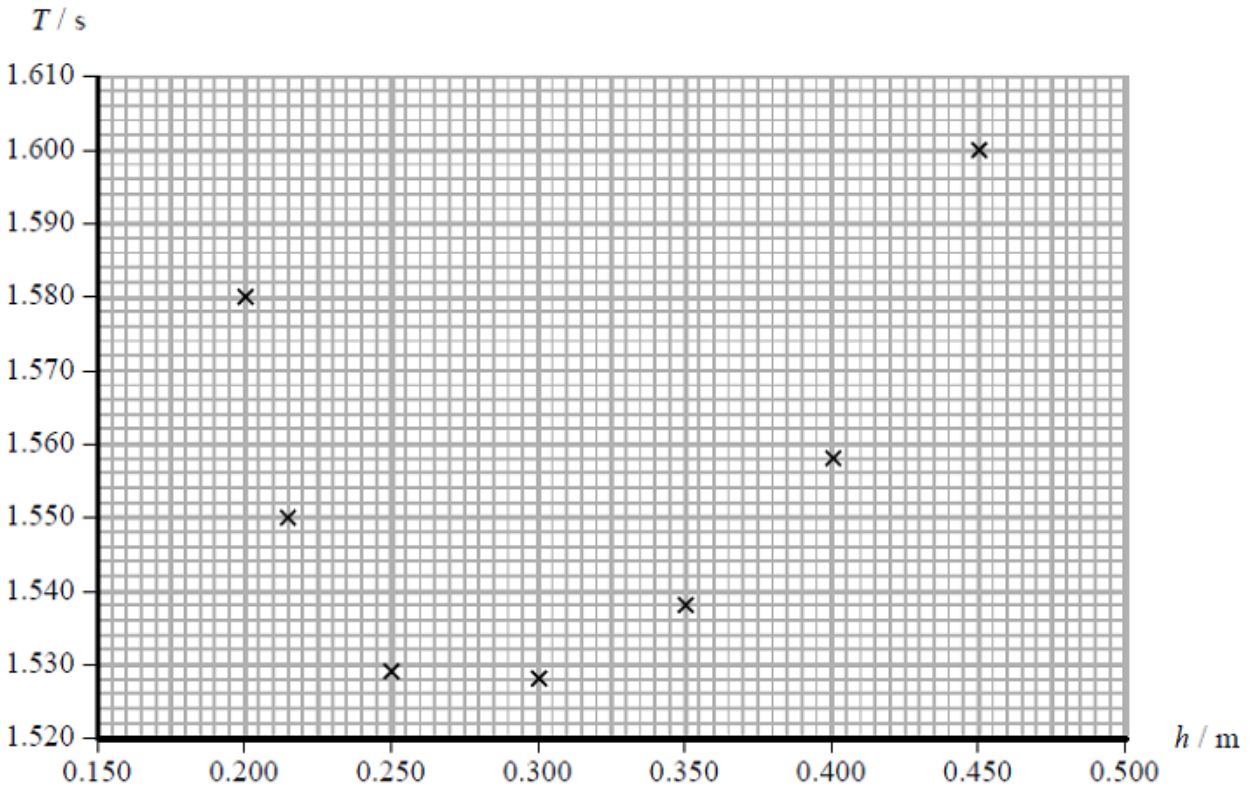
A metre rule has a small hole drilled at the 5 cm mark. The rule is hung on a horizontal pin passing through the hole.



(a) There are six more holes drilled at intervals down the rule. The rule is hung from each hole and the distance h from the pin to the 50 cm mark is recorded.

T is determined for each value of h and a graph of T against h is plotted.

h/m	T/s
0.450	1.601
0.400	1.558
0.350	1.538
0.300	1.528
0.250	1.529
0.215	1.550
0.200	1.580



(i) Draw a line of best fit on the graph.

(1)

(ii) Use your line to determine the value of h that would produce the smallest value of T.

Record these values.

(2)

h = ... T = ...

(b) The graph of T against h does **not** produce a straight line.

The variables T and h are related by

$T^2h = 4\pi^2h^2/g + C$

where C is a constant.

Describe a graphical method to determine a value for C and state the unit for C.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q5.

The photograph shows a tea cup on a saucer.



© Inter Ikea Systems B.V.

A student notices that walking with this sort of tea cup when it is filled with tea is particularly difficult to do without spilling it.

While walking, the tea starts to oscillate from side to side in the cup, rapidly increasing in amplitude and spilling over the edge.

The student develops the hypothesis that spillage occurs most when the frequency of the steps taken by a person matches the natural frequency of oscillation of tea in the cup.

*(i) Devise an experiment to investigate the hypothesis.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Describe how the measurements taken will be used to come to a conclusion.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q6.

A series of experiments was carried out in the 1970s to investigate the structure of protons using the linac at Stanford, USA.

An electron leaves the accelerator with a momentum of 20 GeV / c.

(i) Explain, with reference to base units, why GeV / c can be used as a unit of momentum.

(2)

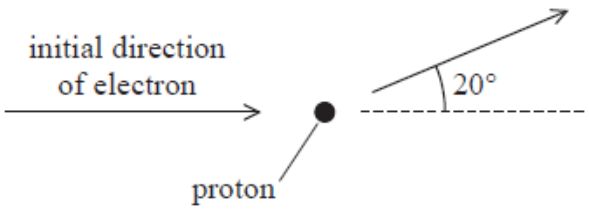
.....

.....

.....

.....

(ii) An electron with initial momentum 20 GeV / c collides with a stationary proton. After the collision the electron is deflected by an angle of 20° as shown and its momentum is 9.1 GeV / c. The momentum of the proton after the collision is 11.9 GeV / c.



Deduce whether the law of conservation of momentum is obeyed.

(3)

.....

.....

.....

.....

.....

.....

(iii) The collisions between electrons and the protons in these experiments are sometimes inelastic.

State what is meant by an inelastic collision.

(1)

.....

(Total for question = 6 marks)

Q7.

The joule can be expressed in SI base units as

☒ **A** kg m s^{-2}

☒ **B** kg m^2 s^{-1}

☒ **C** kg m^2 s

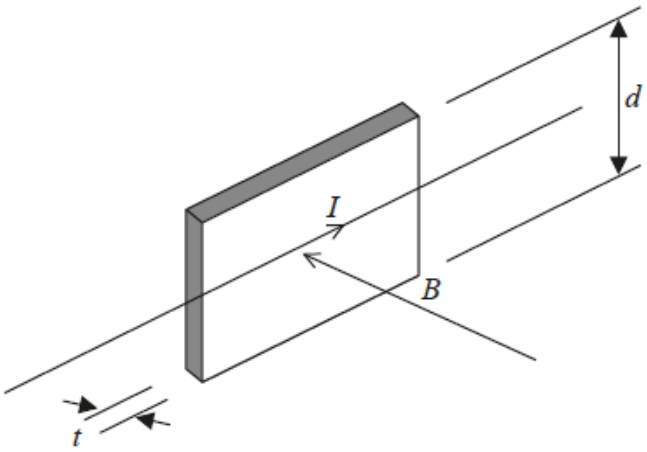
☒ **D** kg m^2 s^{-2}

(Total for question = 1 mark)

Q8.

Tiny sensors in smartphones could be used to determine the position of the phone on the Earth's surface by measuring the Earth's magnetic flux density.

A current I and a magnetic field of flux density B are applied to a slice of semiconductor as shown. The slice has thickness t and depth d.



Electrons collect at the top edge of the slice and the bottom edge becomes positively charged. As a result a potential difference known as a Hall voltage V_{HALL} develops.

Show that the units are the same on each side of the equation

$$V_{HALL} = \frac{BI}{nte}$$

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q9.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of the following is a unit of magnetic flux?

☒ **A** N C^{-1}

☒ **B** T m^{-2}

☒ **C** V s

☒ **D** Wb m^2

(Total for question = 1 mark)

Q10.

Select the row of the table that correctly identifies a derived unit and a base unit.

	Derived unit	Base unit
☒ **A**	ampere	joule
☒ **B**	coulomb	kilogram
☒ **C**	joule	coulomb
☒ **D**	kilogram	ampere

(Total for question = 1 mark)

Q11.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of the following lenses would produce a real image of an object placed 15 cm away from the lens?

☒ **A** converging, focal length = 10 cm

☒ **B** converging, focal length = 20 cm

☒ **C** diverging, focal length = 10 cm

☒ **D** diverging, focal length = 20 cm

(Total for question = 1 mark)

Q12.

Which of the following is a possible unit for rate of change of momentum?

☒ **A** kg m s^{-1}

☒ **B** kg m s^{-2}

☒ **C** N s

☒ **D** N s^{-1}

(Total for question = 1 mark)

Q13.

Electric field strength can have the unit of

☒ **A** V m

☒ **B** V C^{-1}

☒ **C** N m^{-1}

☒ **D** N C^{-1}

(Total for question = 1 mark)

Q14.

Show that the unit of magnetic flux density (Tesla) in SI base units is kg A^{-1} s^{-2}.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q15.

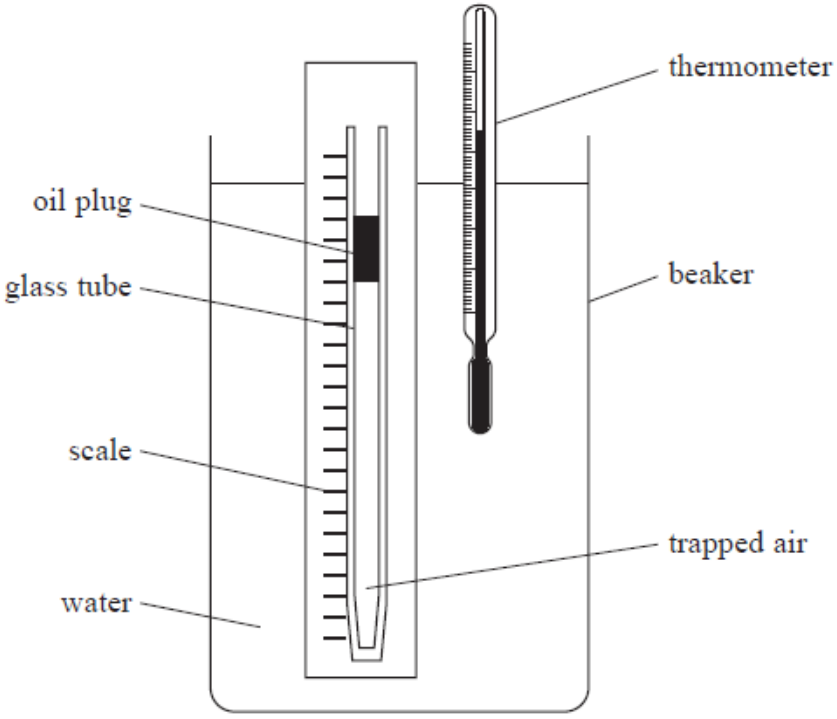
The SI unit for mass is the kilogram. However, particle physicists often use the alternative unit

- ☒ **A** MeV
- ☒ **B** MeV/c
- ☒ **C** MeV/c^2
- ☒ **D** MeV^2/c^2

(Total for question = 1 mark)

Q1.

A student investigated how the volume of a fixed mass of air varies with the temperature of the air. She used the apparatus shown.



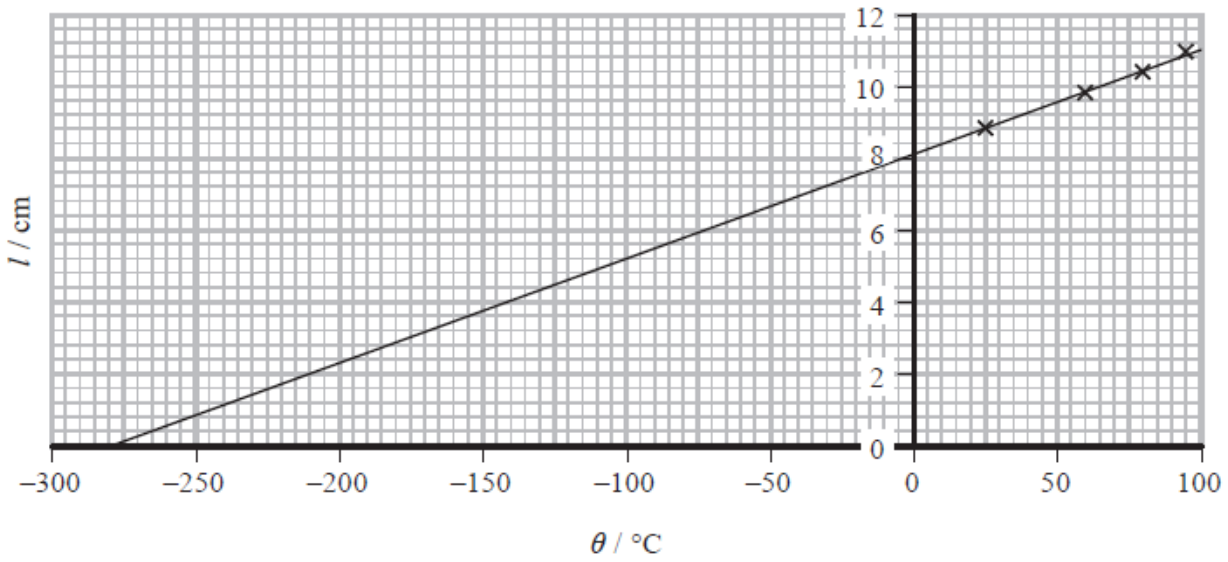
A glass tube was sealed at one end. A plug of oil trapped a length *l* of air in the tube. The water in the beaker was heated to a temperature θ. The corresponding value of *l* was measured. This was repeated for a range of temperatures.

The thermometer had a resolution of 0.5 °C. The scale had mm divisions.

The student's results are shown in the table.

θ / °C	*l* / cm
24	8.8
60	9.8
78.5	10.3
95.5	10.9

The student plotted a graph of *l* against θ as shown.



(i) Explain the significance of the intercept on the *x*-axis.

(3)

.....

.....

.....

.....

.....

.....

(ii) The student wrote a report of the investigation in her lab book. In the conclusion she wrote:

"In this investigation uncertainties were minimised by selecting measuring instruments with a high resolution. The points lie on a perfect straight line, indicating that the investigation is accurate."

Discuss the student's conclusion.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

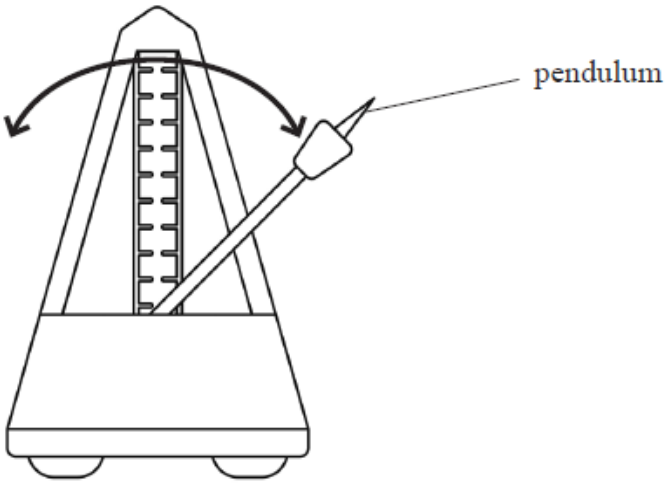
.....

.....

(Total for question = 7 marks)

Q2.

The diagram shows a metronome, which includes an inverted pendulum, used by musicians to set a tempo. The pendulum oscillates with simple harmonic motion and makes a loud click at regular intervals.



(Source: Getty Images)

A faulty metronome stopped making a clicking noise. A student tried to check the accuracy of the period *T* of the metronome, using a stopwatch. The student timed the pendulum as it moved from one extreme of the oscillation to the other.

Explain how the procedure used by the student to determine *T* could have been improved.

(5)

.....

.....

.....

.....

.....

.....

.....

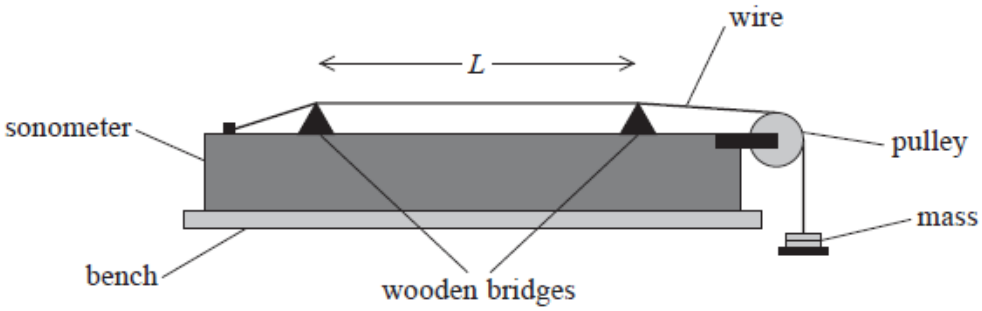
.....

(Total for question = 5 marks)

Q3.

A student used a sonometer to investigate the properties of a stretched wire. The sonometer is a long hollow wooden box.

A steel wire is attached to one end of the box and rests on two wooden bridges. The wire is placed under tension T by hanging a mass from the end of the wire, as shown.



The student placed the base of a vibrating tuning fork in contact with the wire, at one of the bridges. This set the wire into oscillation. He adjusted the position of the other bridge until a single-loop standing wave was produced on the wire between the bridges.

The student repeated this for a series of tuning forks with different frequencies f. For each fork he measured the distance L between the bridges.

The steel wire, of mass per unit length μ, was placed under tension T by hanging a mass of 2.10 kg from the end of the wire.

(i) State one safety precaution that should be taken when carrying out the investigation.

(1)

.....

(ii) The student plotted a graph of L^2 against $1/f^2$.

Show that the gradient of this graph is equal to $\frac{T}{4\mu}$

(3)

.....

.....

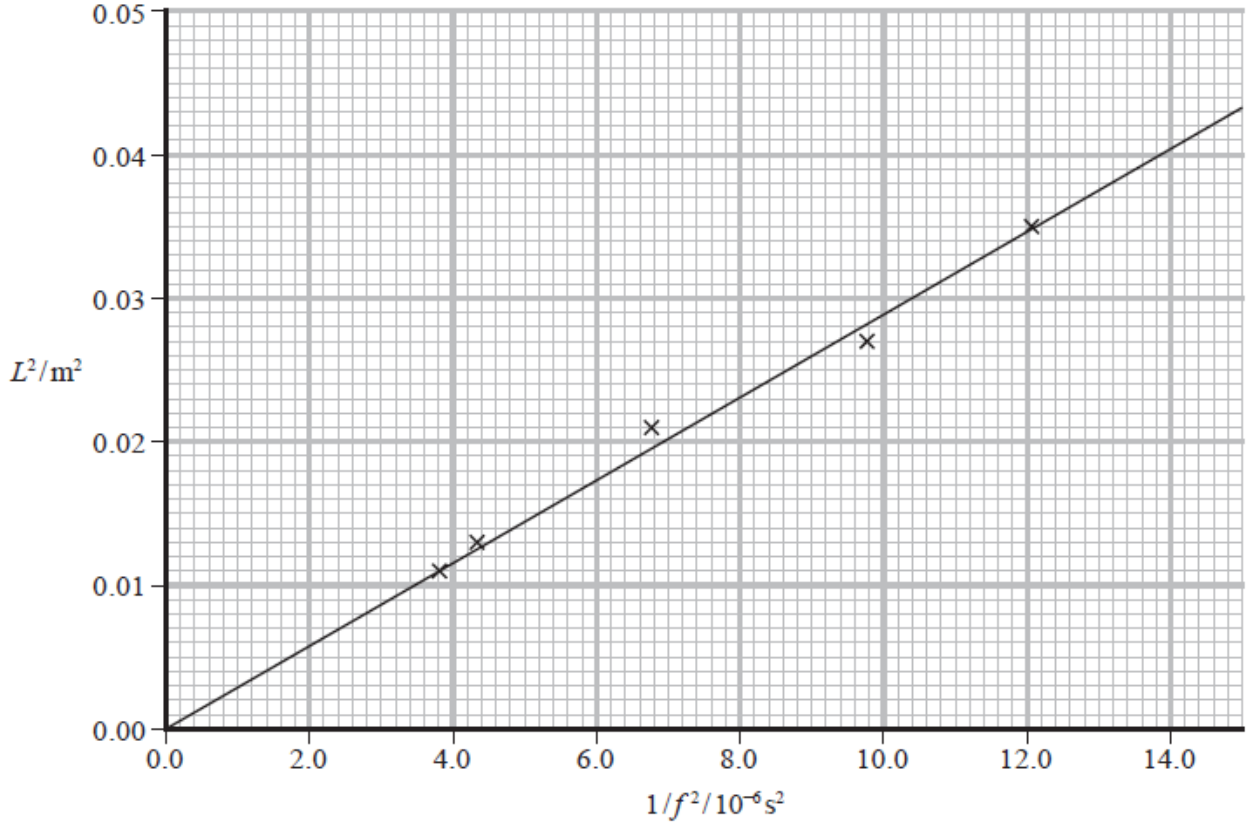
.....

.....

.....

.....

(iii) The student's graph is shown below.



The value of μ for different standard wire gauge (SWG) steel wire is shown in the table.

SWG	μ / g m^{-1}
22	3.15
24	1.95
26	1.31

Deduce which wire the student used in the investigation.

(4)

.....

.....

.....

.....

.....

.....

(Total for question = 8 marks)

Q4.

The student then found a value of μ for a brass wire, using a different method.

(i) He measured the diameter d of the wire using a micrometer.

Explain one technique the student should use when measuring d.

(2)

.....

.....

.....

.....

(ii) The student obtained the following data.

d / mm			
0.55	0.59	0.57	0.58

The stated value of μ for the brass wire used by the student was 2.14×10^{-3} kg m^{-1}.

Deduce whether the student's data supports this value for μ.

density of brass = 8700 kg m^{-3} ± 200 kg m^{-3}

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

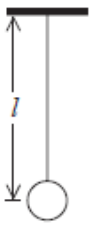
.....

.....

(Total for question = 8 marks)

Q5.

A student is using a simple pendulum to determine a value for the acceleration of free fall *g*.



She measures the length *l* of the pendulum four times with a metre rule and records the following values.

l / cm			
l_1	l_2	l_3	l_4
85.5	86.0	87.5	85.5

She calculates the mean length l_m of the pendulum using the following method:

$$l_m = \frac{85.5 + 86.0 + 87.5 + 85.5}{4} = 86.1 \text{ cm}$$

(i) Calculate a more accurate value for l_m.

(2)

.....

.....

.....

.....

l_m = ...

(ii) Determine the time period of the oscillations of this pendulum, using your calculated value for l_m.

(2)

.....

.....

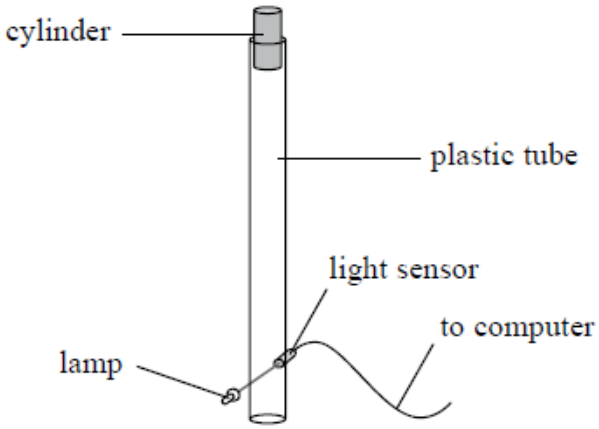
.....

Time period of oscillations = ...

(Total for question = 4 marks)

Q6.

A student uses a lamp and a light sensor as a light gate connected to a data logger and computer to determine the speed of a falling object. He drops a small cylinder through a clear plastic tube. The light gate and data logger measure the time of fall of the cylinder and the speed is calculated.



The student repeats the experiment five times and records the results in a table.

Speed/m s^{-1}	Mean speed/m s^{-1}
4.52 4.59 4.43 4.63 4.58	4.55

Explain **one** advantage of using a light gate and data logger in this experiment.

(2)

.....

.....

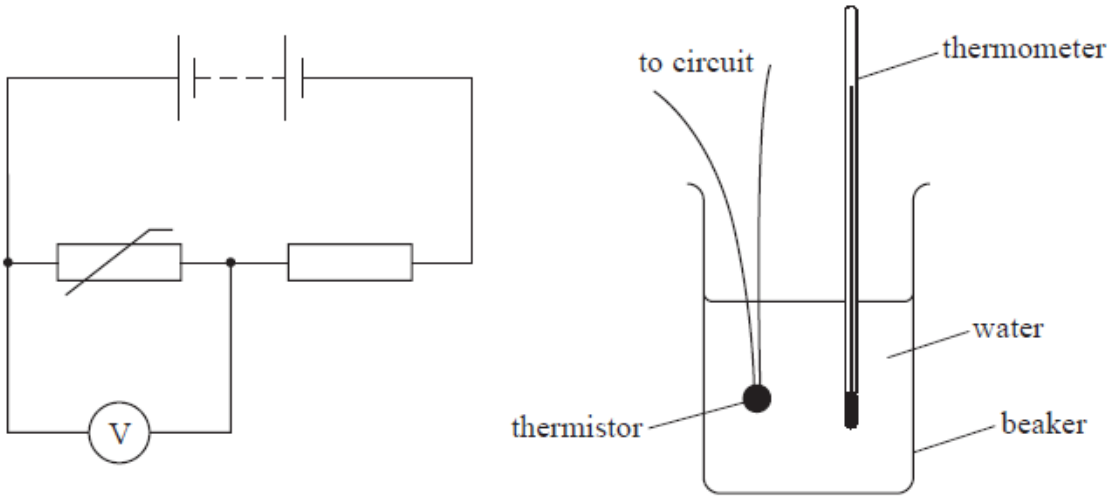
.....

.....

(Total for question = 2 marks)

Q7.

A student carried out an experiment to calibrate a thermistor. She connected the thermistor in series with a resistor and a power supply as shown. Then she placed the thermistor in a beaker of hot water and used a thermometer to record the temperature θ of the water.



The student recorded θ and corresponding values of the reading V on the voltmeter as the water cooled.

Over a limited temperature range V varies with θ according to the expression

$$V = V_0 e^{-b\theta}$$

where b and V_0 are constants.

(i) Explain why a graph of ln V against θ would give a straight line.

(2)

.....

.....

.....

.....

(ii) The student's data is shown in the table below.

θ/°C	V/V	
89.0	1.9	
74.0	2.9	
53.5	4.9	
32.5	9.1	
18.5	12.6	
3.5	18.7	

Plot a graph of ln V against θ on the grid opposite. Use the column provided to show any

processed data.

(5)

(iii) Determine values for b and $V_{0.}$

(4)

.....

.....

.....

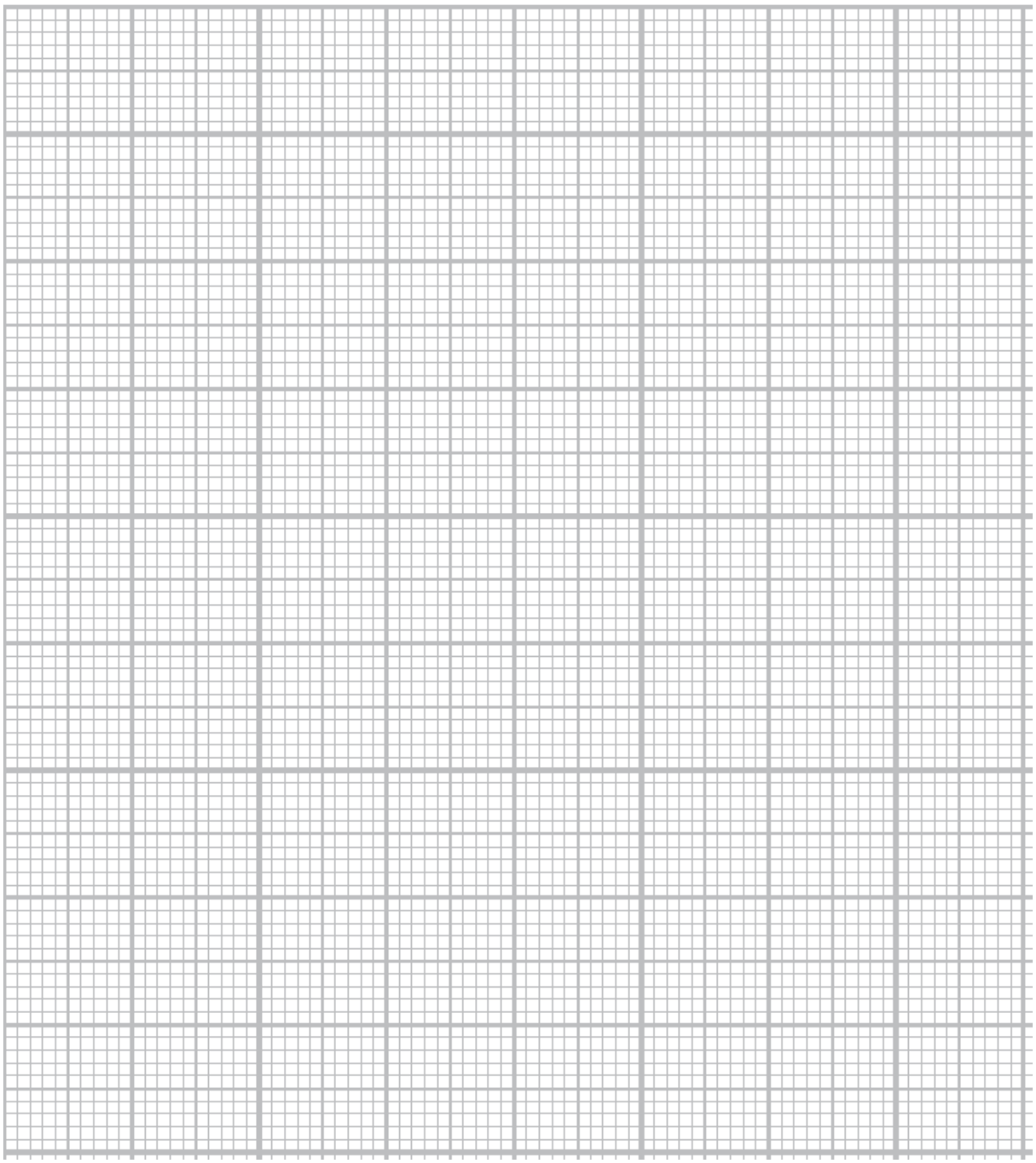
.....

.....

.....

b = ...

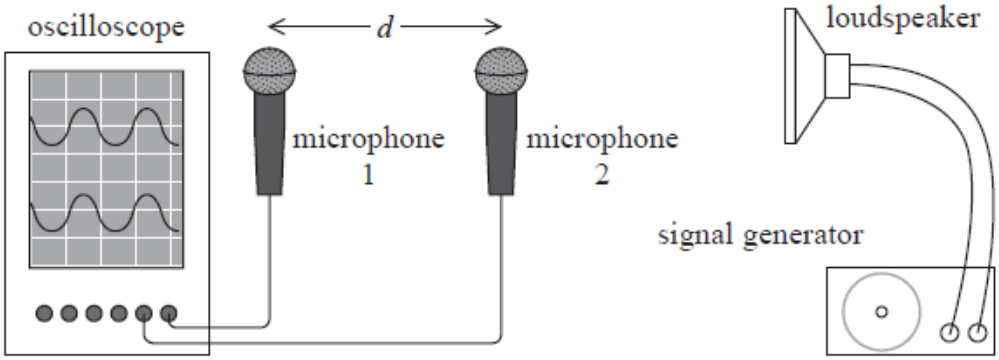
V_0 = ...



(Total for question = 11 marks)

Q8.

In an experiment to determine the speed of sound in air a student connected two microphones to an oscilloscope, as shown.



The microphones detect sound from the loudspeaker, converting it to an electrical signal. The signal is displayed on the oscilloscope screen.

Both microphones were initially positioned the same distance from the loudspeaker. The two signals were in phase on the oscilloscope screen. The student slowly moved microphone 2 towards the loudspeaker, until the two signals on the oscilloscope were in phase again. He then measured the distance *d* between the microphones to determine the wavelength λ of the sound waves.

d = 20.5cm

Comment on the student's experimental technique to determine *λ*.

(2)

.....

.....

.....

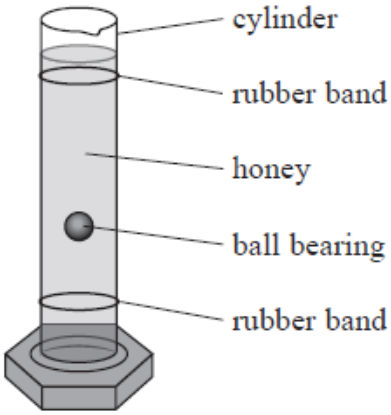
.....

.....

(Total for question = 2 marks)

Q9.

A student carried out an experiment to determine the viscosity of some honey. He filled a tall glass cylinder with honey as shown, and timed a ball bearing as it fell through the honey.



The student placed rubber bands near the top and bottom of the cylinder. He started a stopwatch when the ball bearing passed the first band and stopped the stopwatch when the ball bearing passed the second band. He repeated this several times to determine a mean time.

Criticise the student's method.

(2)

.....

.....

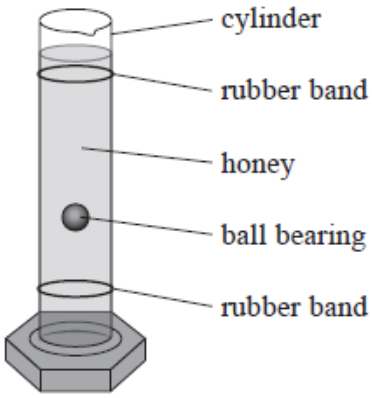
.....

.....

(Total for question = 2 marks)

Q10.

A student carried out an experiment to determine the viscosity of some honey. He filled a tall glass cylinder with honey as shown, and timed a ball bearing as it fell through the honey.



The student placed rubber bands near the top and bottom of the cylinder. He started a stopwatch when the ball bearing passed the first band and stopped the stopwatch when the ball bearing passed the second band. He repeated this several times to determine a mean time.

The time *t* for the sphere to fall through a distance of 25.0 cm is shown in the table.

t / s			
6.40	6.35	6.36	6.38

(i) Show that the mean velocity v of the ball bearing is about 0.04 m s^{-1}.

(3)

.....

.....

.....

(ii) The student had three different types of honey available.

Viscosity η is given by the following expression

$$\eta = \frac{2r^2 g\left(\rho_B - \rho_H\right)}{9v}$$

radius *r* of ball bearing = 5.50 × 10^{-3} m

density of ball bearing ρ_B = 7750 kg m^{-3}

density of honey ρ_H = 1360 kg m^{-3}

Viscosity (at 20 °C) / Pa s		
Honey A	Honey B	Honey C
10.6	12.5	13.6

Deduce which honey the student used.

(2)

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q11.

A student used a Geiger-Müller (GM) tube to determine the activity of a radium source. Radium emits α, β, and γ radiation.

He positioned the source 20 cm from the GM tube, as shown, and recorded the count for 1 minute. He repeated the measurement and calculated a mean count.



The student recorded the following results.

Count 1	Count 2	Mean count
183	178	181

Criticise the student's method for determining the count at this position.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q12.

A student used a Geiger-Müller (GM) tube to determine the activity of a radium source. Radium emits α, β, and γ radiation.

He positioned the source 20 cm from the GM tube, as shown, and recorded the count for 1 minute. He repeated the measurement and calculated a mean count.



The student recorded the following results.

Count 1	Count 2	Mean count
183	178	181

From his results the student determined that the activity of the source was 3.0 Bq.

Comment on his value for the activity of the source.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q13.

Small electrical devices are often powered by electric cells; different devices use different types of cell.

The cells normally used in a television remote control have an e.m.f. of 1.5 V.

(i) Describe a procedure to determine the internal resistance and e.m.f. of an electrical cell. You should include a circuit diagram.

(3)

.....

.....

.....

.....

.....

.....

(ii) Describe how you would use your results to find a value for the e.m.f. and internal resistance of the cell.

(3)

.....

.....

.....

.....

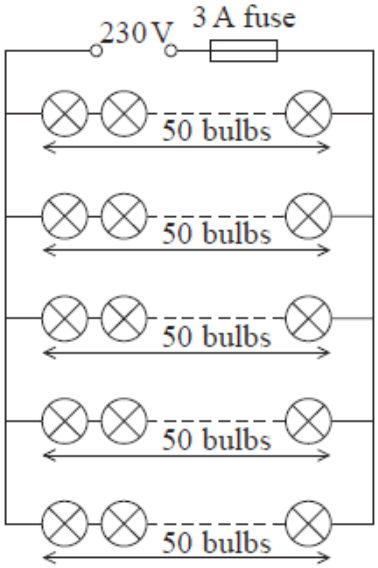
.....

.....

(Total for question = 6 marks)

Q14.

A set of festive lights is made up of five parallel strands of filament bulbs. Each strand contains 50 bulbs in series as shown.



(a) When a bulb is working normally its resistance is 8.0 Ω. If the filament of the bulb breaks, the lamp is designed to still conduct and its resistance becomes 3.0 Ω.

(i) The filament of one bulb on a strand breaks.
By considering the effect this has on the remaining bulbs in that strand, explain why it is recommended that broken bulbs are replaced as soon as possible.

(3)

.....

.....

.....

.....

.....

.....

(ii) The set of festive lights are fitted with a 3 A fuse. Five bulbs in one strand break.

Determine whether the fuse blows.

(3)

.....

.....

.....

.....

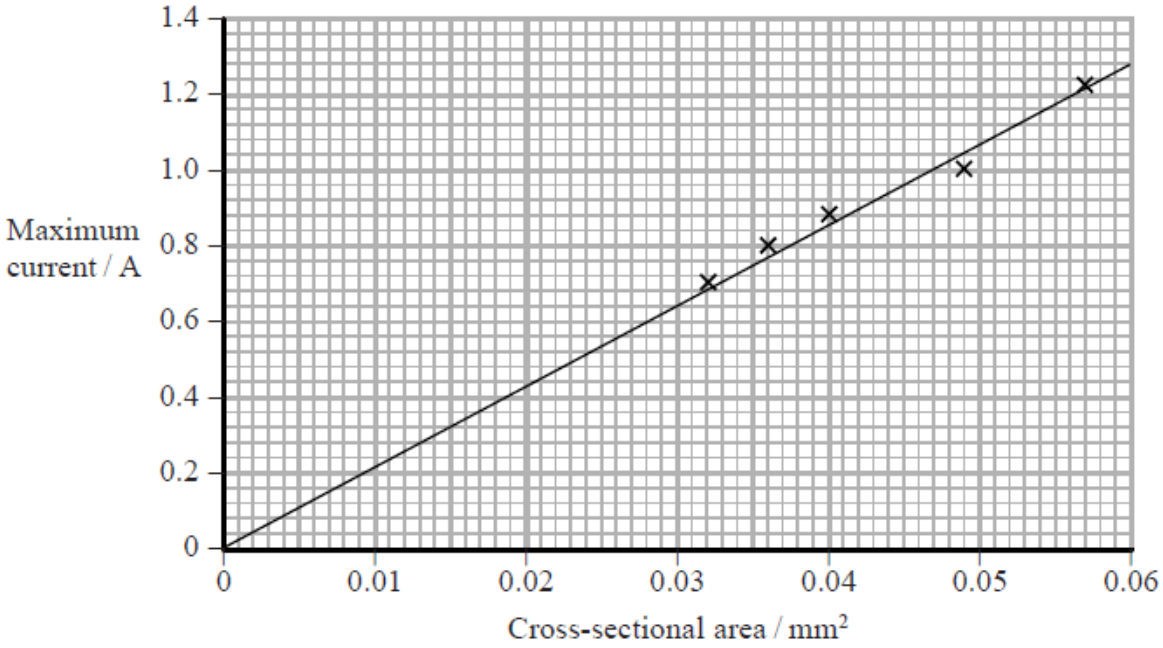
.....

.....

(b) A student investigates how the cross-sectional area of a fuse wire affects the current at

which the fuse blows. She uses pieces of wire of the same material and length, but different cross-sectional areas. She steadily increases the current through each piece of wire and records the maximum current through the wire before it breaks.

She then plots a graph of maximum current against cross-sectional area.



(i) Describe how the student should determine the cross-sectional area of the wire.

(3)

.....

.....

.....

.....

.....

.....

(ii) State the relationship between the maximum current and the cross-sectional area of the wire.

(1)

.....

.....

(iii) The student chooses a piece of wire, of the same material and length as used in the investigation. The piece of wire has a diameter of 0.40 mm.

Use the graph to determine whether the piece of wire is suitable to use as the 3A fuse wire for the set of festive lights.

(4)

.....

.....

.....

.....

.....

.....

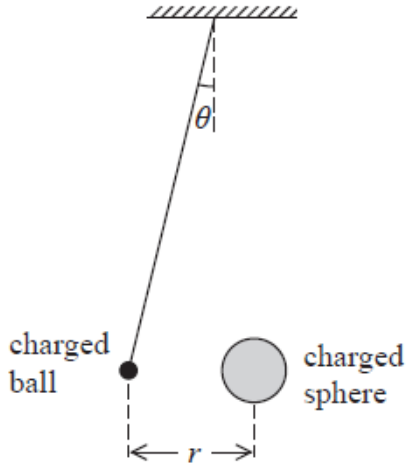
.....

.....

(Total for question = 14 marks)

Q15.

A student carries out an experiment to investigate the force acting between two charged objects. A lightweight negatively-charged ball is freely suspended from the ceiling by an insulating thread. The ball is repelled by a negatively-charged sphere that is placed near it on an insulated support.
The angle of deflection is θ and r is the distance between the centres of the ball and the sphere.



(a) (i) Draw a free-body force diagram for the suspended ball.

(2)

(ii) The weight of the suspended ball is W.

Show that the force of repulsion F on the suspended ball is given by

$$F = W \tan \theta$$

(2)

.....

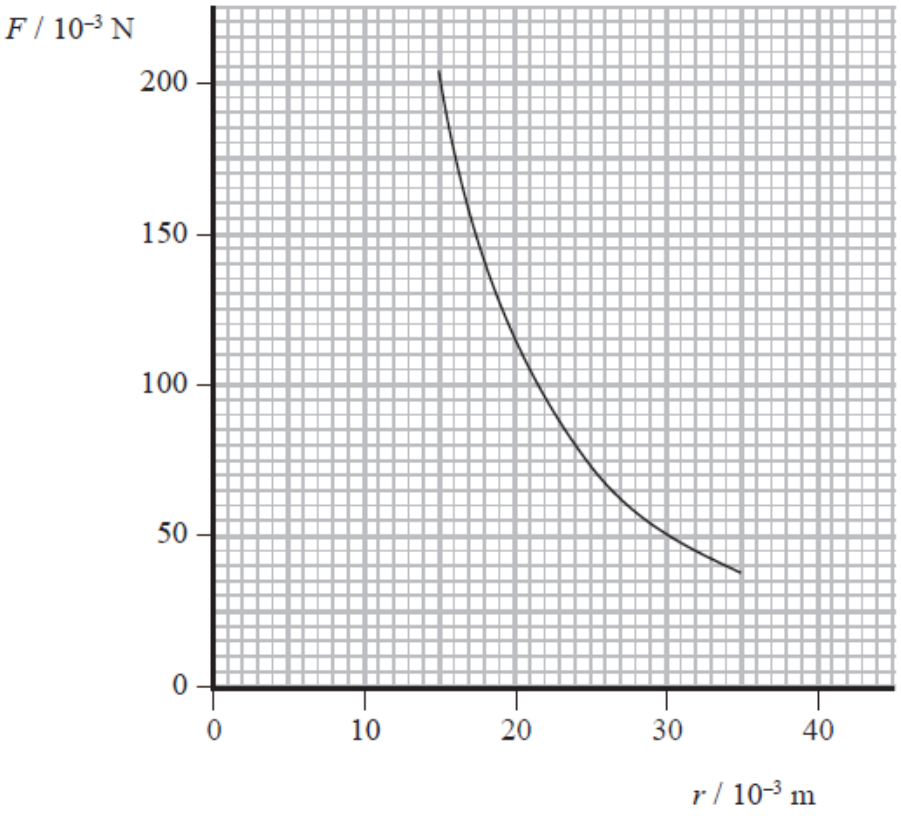
.....

.....

.....

.....

(b) (i) The student can increase the magnitude of the force by moving the sphere towards the suspended ball.
She takes pairs of measurements of r and θ and calculates the magnitude of the force F. She then plots a graph of F against r.



Use readings from the graph to demonstrate that the relationship between *F* and *r* obeys an inverse square law.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) The charge on the sphere is 100 times greater than the charge on the ball.

Calculate the charge on the ball.

(3)

.....

.....

.....

.....

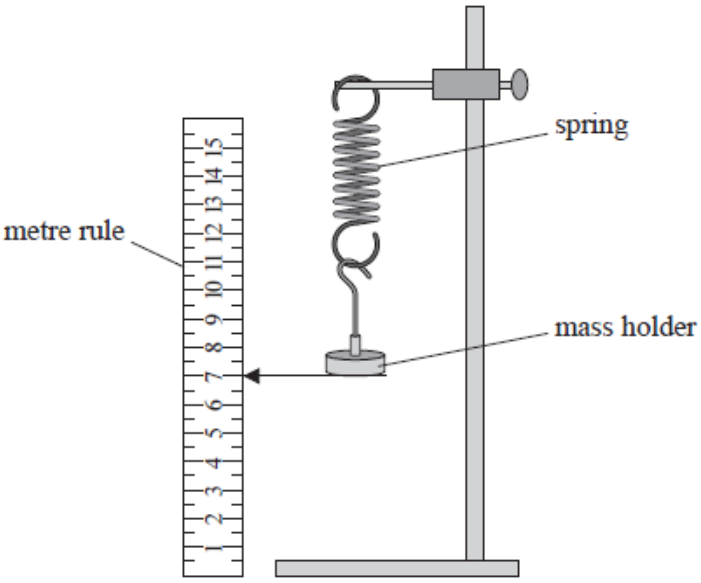
.....

Charge = ...

(Total for question = 11 marks)

Q16.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached.



The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

The student produced the following table.

Mass added / g	Extension / cm	Stretching force / N
50	1.9	0.49
70	3	0.69
90	3.5	0.9
110	4.5	1.08
130	5.3	1.28
150	5.8	1.47

Criticise the student's table.

(2)

.....

.....

.....

.....

.....

(Total for question = 2 marks)

Q17.

A student carries out an experiment to investigate the stretching of a liquorice lace.

(a) The student fixes one end of the lace to a support and adds different masses to the end of it, measuring the extension each time with a metre rule. His results are shown in the table.

Mass/kg	Force/N	Extension/m
0.03	0.294	0.005
0.04	0.392	0.0075
0.06	0.589	0.011
0.07	0.687	0.012

Criticise the recording of these results.

(3)

.....

.....

.....

.....

.....

.....

(b) Describe how the student should measure the extension of the lace to make his results as accurate as possible.

(2)

.....

.....

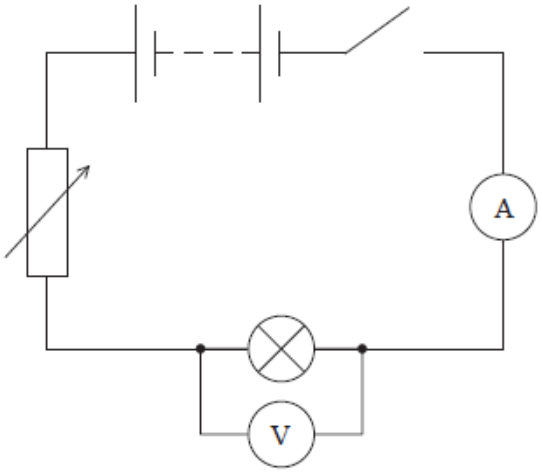
.....

.....

(Total for question = 5 marks)

Q18.

A student set up the circuit shown and measured the current *I* through the filament lamp for a range of values of potential difference (p.d.) *V*.



The student's data is shown in the table.

V / V	*I* / A
3.0	0.6
4.0	0.75
6.0	1.00
8.0	1.20
10.0	1.35
12.0	1.5

Criticise the student's recording of the data.

(1)

.....

.....

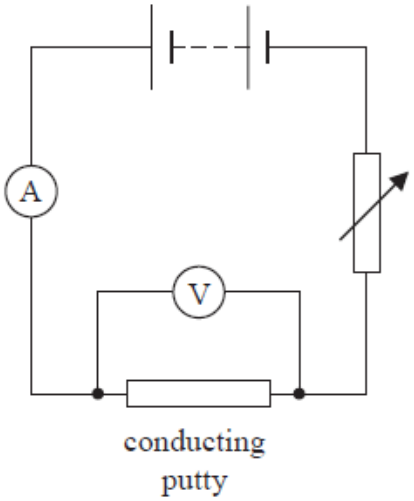
(Total for question = 1 mark)

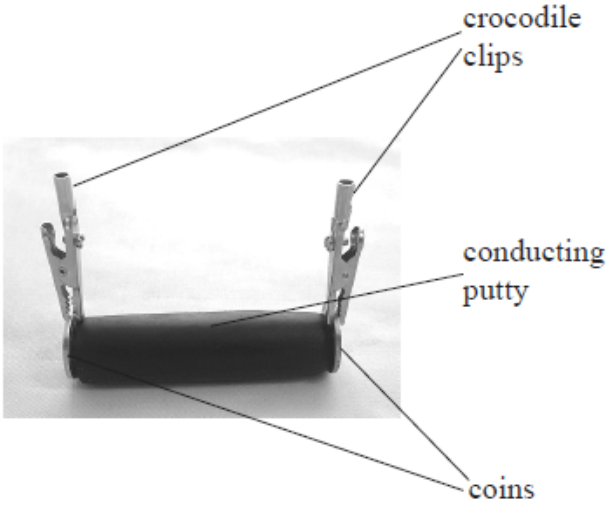
Q19.

Conducting putty is a material that is a relatively good conductor and can be easily moulded into different shapes.

A student decides to investigate how the resistance *R* of a cylinder of conducting putty depends upon the cross-sectional area *A* of the cylinder.

(a) She sets up the circuit shown and keeps the length *l* of the cylinder constant at 7.5 cm. She uses the ammeter and voltmeter readings to determine the resistance of cylinders of different cross-sectional areas.



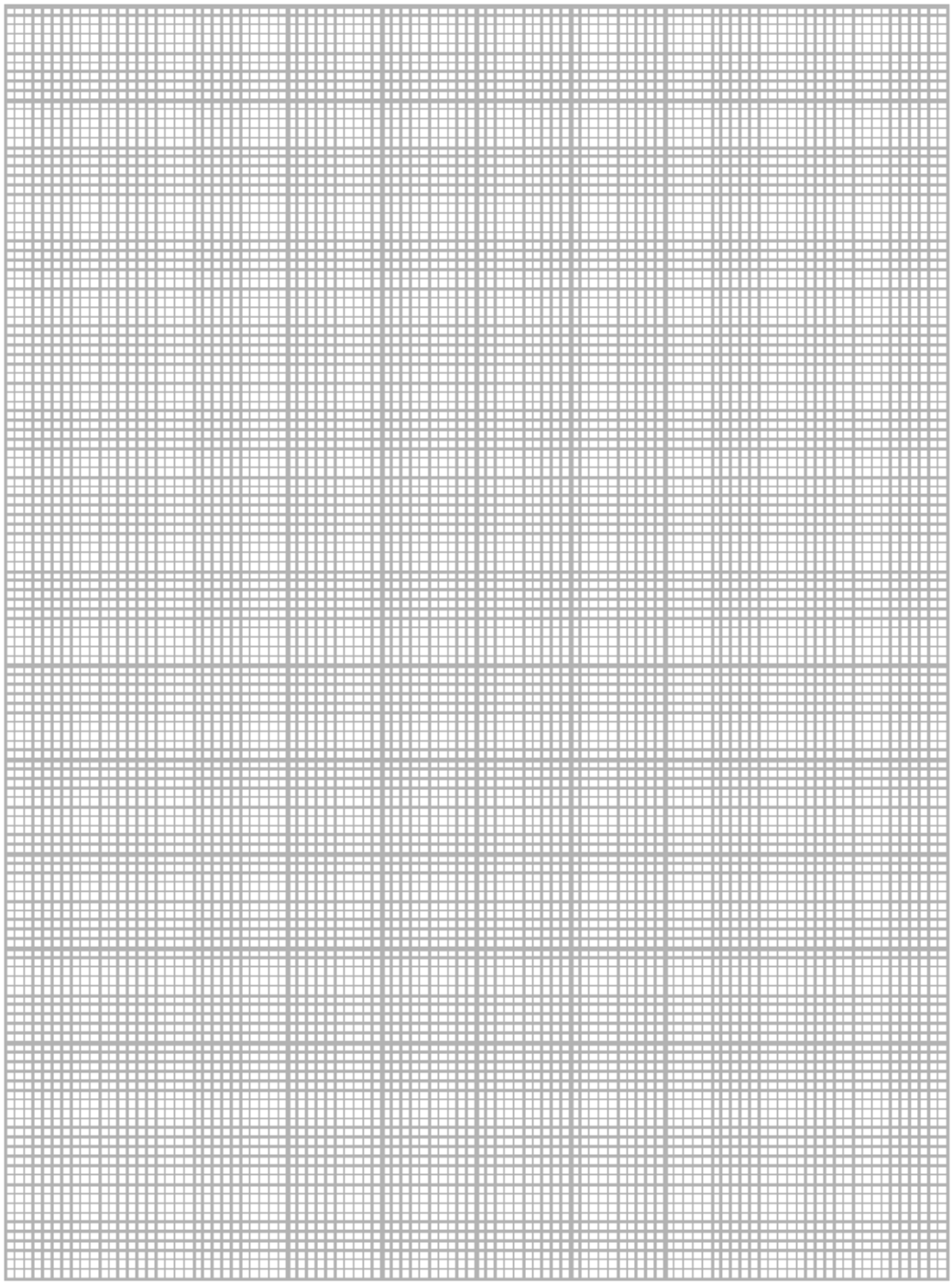


The student's results are shown in the table.

Diameter / cm	Resistance / Ω	(l / A) / m^{-1}
0.4	56.0	1490
1.0	37.5	968
1.5	16.7	430
2.0	9.44	242
2.5	6.00	155

(i) Plot a graph of *R* against *l*/*A*.

(4)



(ii) Use your graph to determine a value for the resistivity of the putty.

(2)

.....

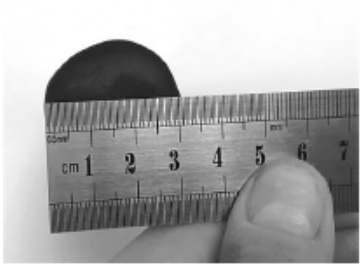
.....

.....

Resistivity = ...

(b) The photographs show how the student obtained measurements for the length and diameter of a cylinder.





The student records the following readings:

length = 90 mm; diameter = 31 mm

Identify two problems with this method of determining the dimensions of the cylinder and for each problem identify a solution.

(4)

1

.....

.....

.....

.....

2

.....

.....

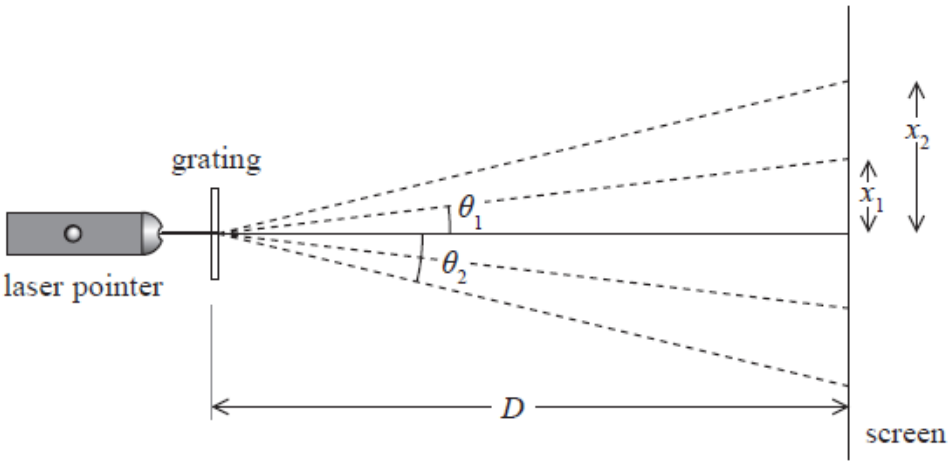
.....

.....

(Total for question = 10 marks)

Q20.

A student is using a diffraction grating to determine the wavelength of the light emitted by a laser pointer. The light from the laser pointer is directed so that it is normal to the plane of the grating. The diffracted light is viewed on a screen a distance *D* from the grating.



The diagram shows the first two diffracted orders where x_1 and x_2 are the distances of the maxima for these orders from the central maximum of the diffraction pattern.

(a) Before carrying out the experiment, the student carries out a risk assessment to ensure that the experimental procedure is safe.

Explain one precaution that should be taken.

(2)

.....

.....

.....

.....

(b) The student measures the distances from the central maximum of the diffraction pattern for various diffracted orders n, using a metre rule.

n	x_n / cm	θ / °	sin θ
0	0	0.00	0.000
1	35.5	11.4	0.20
2	74		
3	126.5	35.9	0.586
4	211	50.4	0.771

(i) Criticise the results that are recorded.

(1)

.....

.....

.....

(ii) Complete the data for the 2nd order maximum.

D = 1.750 m

(2)

.....

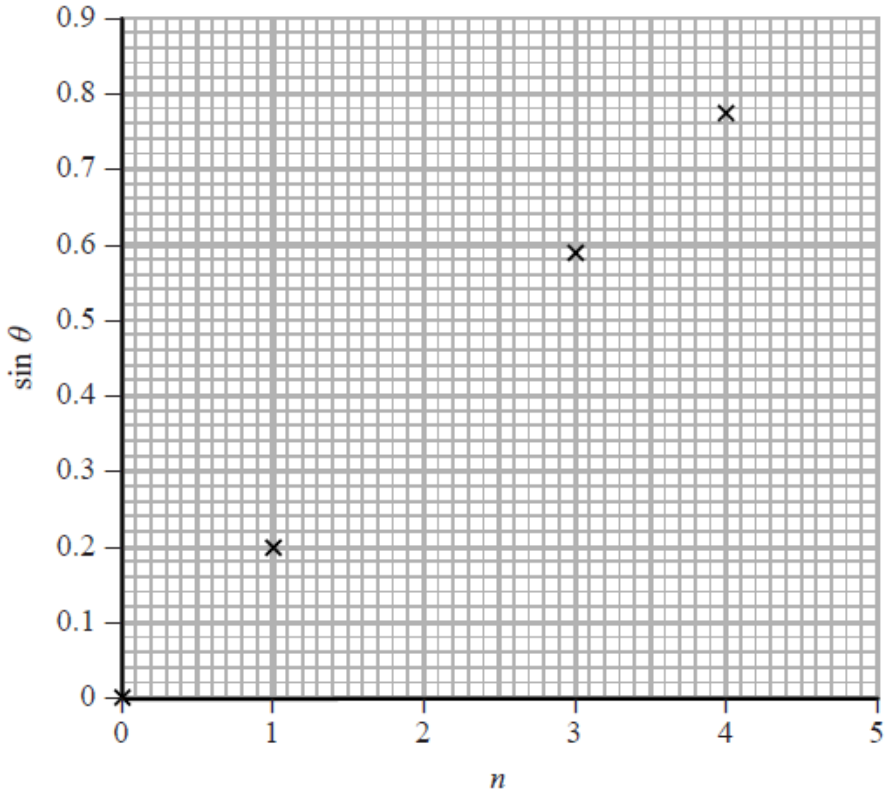
.....

.....

.....

(iii) Add your data to the axes and draw a line of best fit.

(1)



(iv) Use your graph to determine a value for the wavelength of the laser light.
The grating has 300 lines per mm

(5)

.....

.....

.....

.....

.....

.....

.....

.....

Wavelength = ...

(c) State and justify two modifications to the experimental method which would have improved the accuracy of the value obtained for the wavelength.

(4)

.....

.....

.....

.....

.....

.....

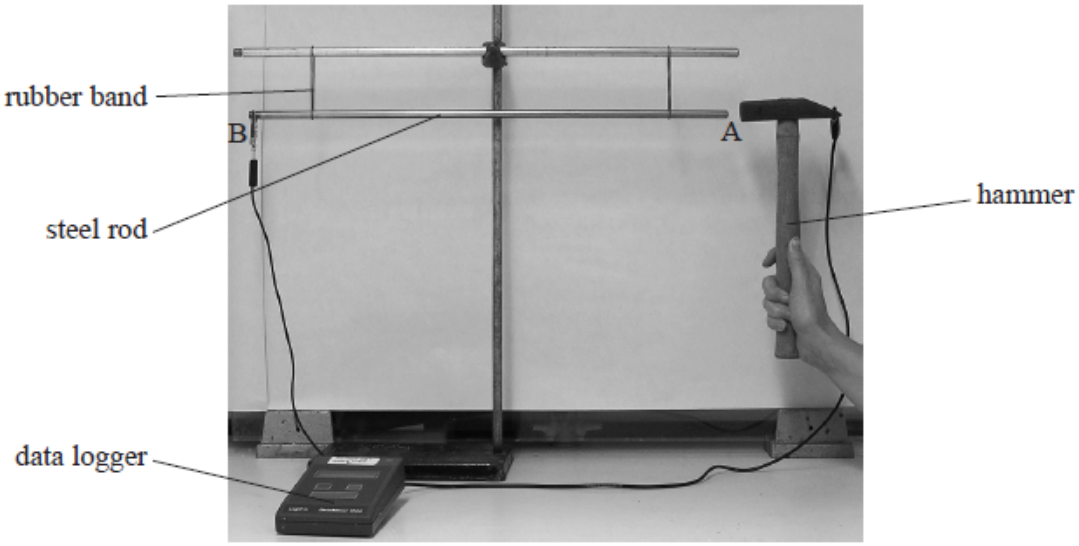
.....

.....

(Total for question = 15 marks)

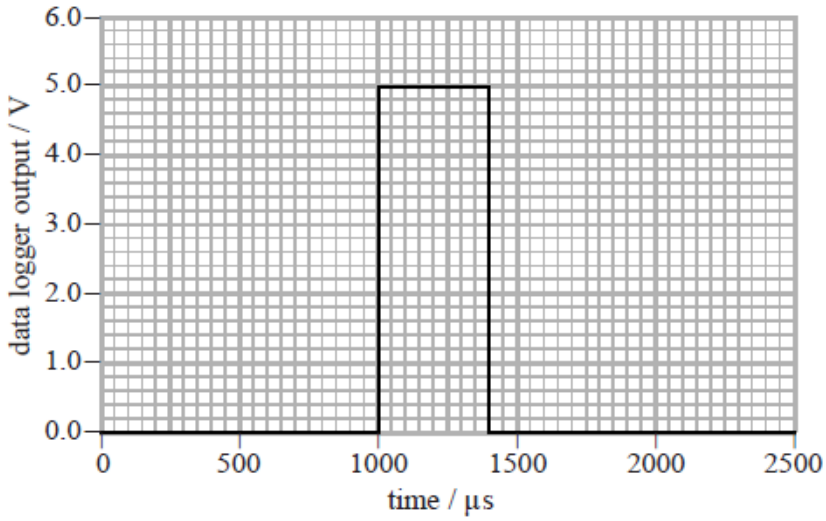
Q1.

A teacher is demonstrating how to measure the speed of sound in a steel rod. The equipment comprises a hanging steel rod and a hammer connected to a data logger as shown.



The rod is tapped at A with the hammer. A compression pulse travels to B and is reflected back. When the reflection reaches A the hammer loses contact with the rod.
Whilst the hammer is in contact with the rod the output from a 5 V supply is recorded by the data logger.

The graph shows the output from the data logger for one hammer tap.



Explain why a data logger is appropriate for this demonstration.

(2)

.....

.....

.....

.....

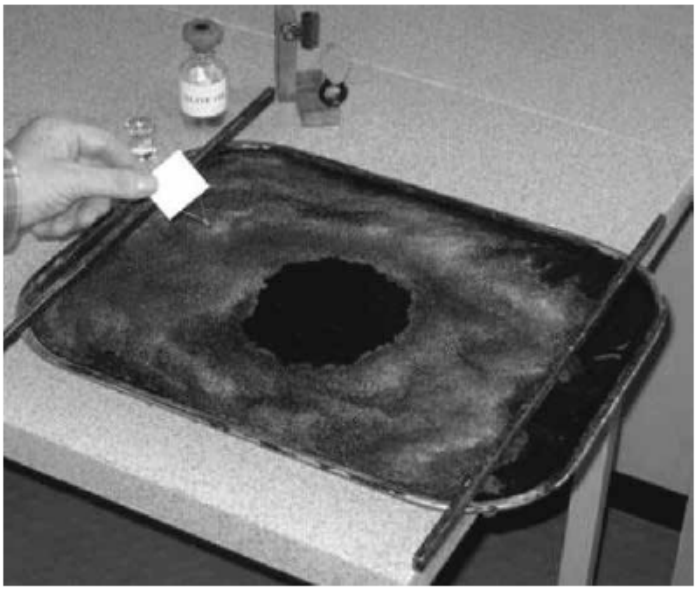
(Total for question = 2 marks)

Q2.

When a drop of oil is placed on the surface of water it spreads out to form a thin film 1 molecule thick. A student uses this phenomenon to determine the size of an oil molecule.

She dips a wire loop into the oil so that a small, spherical oil drop forms. She uses a millimetre scale to measure the diameter of this oil drop.

The student fills a tray with water and scatters a fine powder on the water surface. The oil drop is placed on the water surface and spreads out to form a thin film, approximately circular, as shown in the photograph.



© Images taken from www.practicalphysics.org,
a Nuffield Foundation and Institute of Physics website

The student uses a metre rule to measure the diameter of the circular thin film.
She records the following measurements:

diameter of oil drop = 0.5 mm
diameter of thin film = 250 mm

The student now equates the volume of oil as a drop to the volume of the film.

Evaluate the student's method and suggest refinements that would improve the accuracy of determining the size of the molecule.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

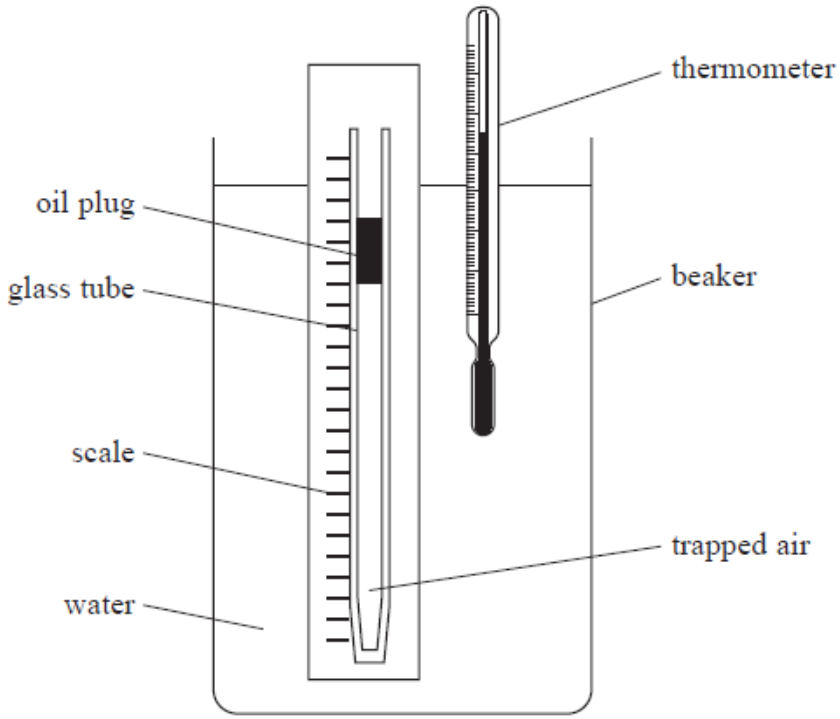
.....

.....

(Total for question = 6 marks)

Q3.

A student investigated how the volume of a fixed mass of air varies with the temperature of the air. She used the apparatus shown.



A glass tube was sealed at one end. A plug of oil trapped a length *l* of air in the tube. The water in the beaker was heated to a temperature θ. The corresponding value of *l* was measured. This was repeated for a range of temperatures.

The thermometer had a resolution of 0.5 °C. The scale had mm divisions.

The student's results are shown in the table.

θ / °C	l / cm
24	8.8
60	9.8
78.5	10.3
95.5	10.9

(i) Criticise the student's results.

(3)

.....

.....

.....

.....

.....

(ii) Explain two possible sources of error in this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(iii) Describe two improvements that would increase the accuracy of measurements obtained in this investigation.

(2)

.....

.....

.....

.....

(Total for question = 9 marks)

Q4.

A spring is made from loops of thick steel wire as shown.



There are two extra loops, one on each end of the spring.

The student measured the diameter *d* of the steel wire and obtained a value of 2.52 mm.

(i) Explain which instrument he used to measure the diameter.

(2)

.....

.....

.....

(ii) Estimate the percentage uncertainty in the student's value for *d*.

(1)

.....

.....

% uncertainty in *d* = ...

(iii) The student used a balance to measure the mass *m* of the spring.

He obtained a value of 32.0 ± 0.5 g.

Estimate the percentage uncertainty in the mass of the spring.

(1)

.....

.....

% uncertainty in *m* = ...

(iv) The student calculated the density ρ of the steel using the equation

$$\rho = \frac{m}{V}$$

Calculate the percentage uncertainty in his value for the density of steel.

(1)

.....

.....

% uncertainty in value for density of steel = ...

(v) Determine whether the data collected leads to a value for the density of steel in agreement with the standard value.

density of steel = 7 800 kg m^{-3}

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

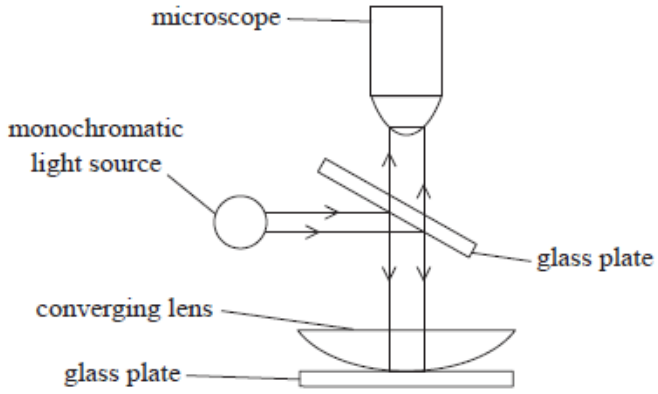
Q5.

A method to determine the wavelength of light using a converging lens was first proposed by Sir Isaac Newton.

A converging lens is placed on a plane glass plate. The lens is illuminated from above with a parallel beam of monochromatic light, as shown.

Some of the light is reflected from the upper surface of the lower glass plate and some from the

lower surface of the lens. Interference between these two reflected waves produces circular fringes. The pattern is viewed through a microscope.



Side view of apparatus



Pattern seen through microscope

The diameter D of each circular fringe, numbered N from the centre, is measured using the microscope. The data obtained from such an experiment is shown.

N	D / mm		
1	5.13		
2	7.08		
3	8.71		
4	10.23		
5	11.48		

The relationship between N and D is of the form $D = pN^q$ where p and q are constants.

Determine p and q for this data using a graphical method. Use the additional columns for your processed data.

(8)

.....

.....

.....

.....

.....

.....

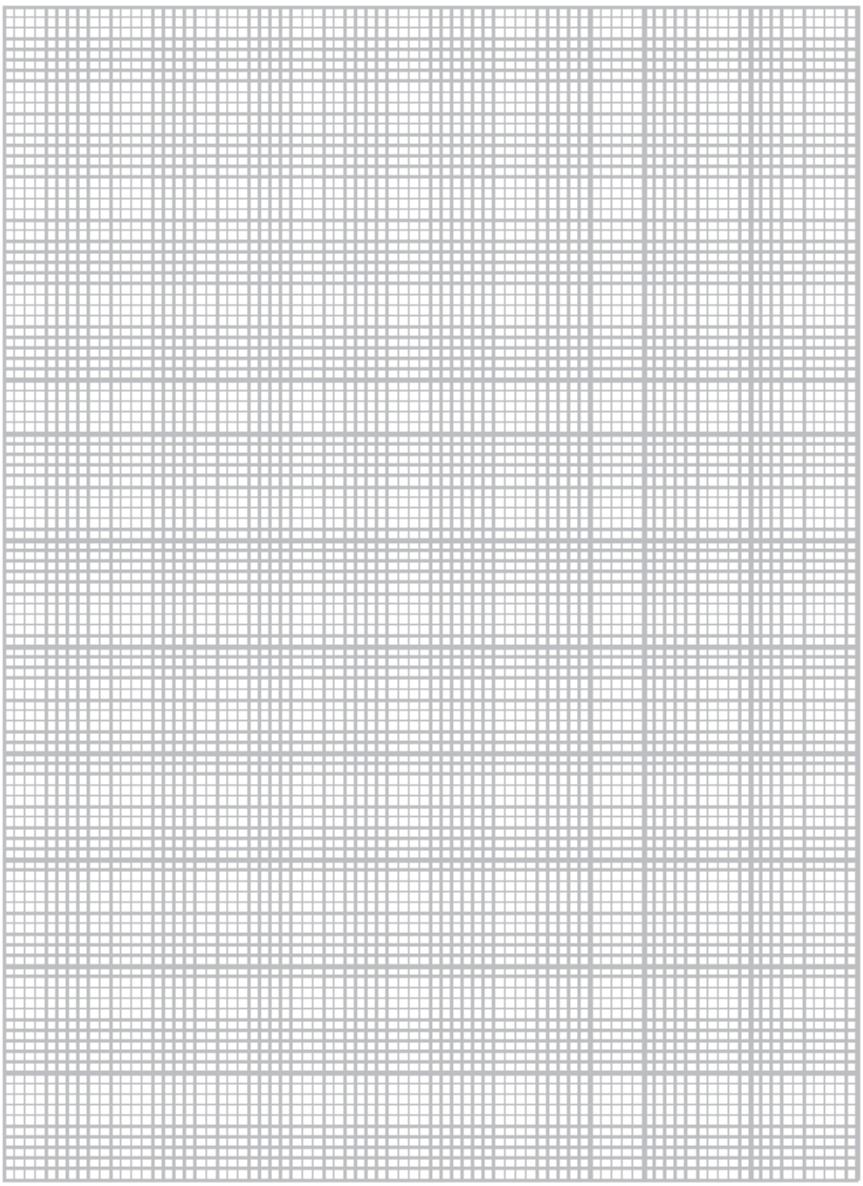
.....

.....

.....

p = ...

q = ...



(Total for question = 8 marks)

Q6.

Photograph 1 shows a toy known as a popper. It is a hollow hemisphere made of rubber.



Photograph 1

When the top of the popper is pushed down, it changes shape as in Photograph 2.



Photograph 2

It remains in this shape for two to three seconds. It then returns to its original shape and is launched from the surface, rising nearly a metre.

The initial speed of the popper can be determined using only a metre rule to measure the maximum height reached by the popper.

(i) Describe how the maximum height measurement can be used to determine the launch speed.

(3)

.....

.....

.....

.....

.....

.....

(ii) Comment on using the maximum height measurement as a means of determining an accurate value for the launch speed.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q7.

A student was given a box of identical glass microscope slides and asked to determine the density of the glass. She used a micrometer to measure the thickness of one of the slides. She repeated this measurement twice in different places and calculated a mean value for the thickness. The thickness of each slide was approximately 1 mm.

In her report she wrote

> *"My value for the mass of the glass slides was precise, because I measured the mass using an electronic balance which was accurate to the nearest 0.01g. I reduced the effect of random error by repeating the measurement several times."*

Comment on this statement.

(4)

.....

.....

.....

.....

.....

.....

.....

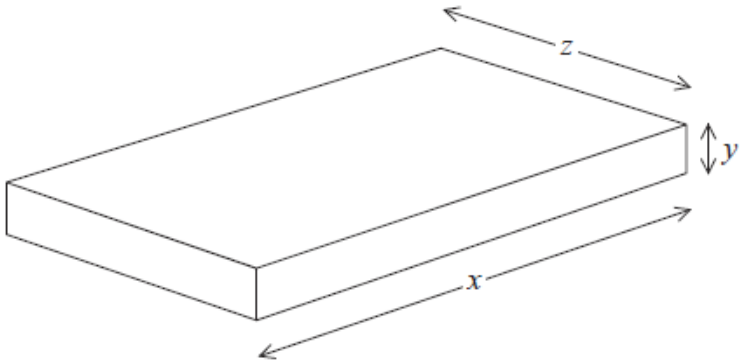
.....

(Total for question = 4 marks)

Q8.

A student carries out measurements to determine the density of glass. The student has 20 glass microscope slides available.

The approximate dimensions of one slide are shown.



$x \approx 75\,\text{mm}$
$y \approx 1\,\text{mm}$
$z \approx 25\,\text{mm}$

(a) The density is calculated using the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Describe how the student can determine an accurate value for the density of the glass. Your answer should include the measuring instruments required.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(b) State one precaution that the student should take to ensure the measurements are accurate.

(1)

.....

.....

(Total for question = 5 marks)

Q9.

A student was given a box of identical glass microscope slides and asked to determine the density of the glass. She used a micrometer to measure the thickness of one of the slides. She repeated this measurement twice in different places and calculated a mean value for the thickness. The thickness of each slide was approximately 1 mm.

Explain how she should have measured the thickness of the slides in order to minimise the percentage uncertainty.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q10.

The photograph shows a vase made of uranium glass. Uranium glass is radioactive.



Uranium glass usually contains a maximum of 2% uranium. Uranium glass made in the early part

of the 20th century can contain up to 25% uranium.

A student carried out an investigation to determine the percentage of uranium in the glass.

The student measured the count rate by placing a Geiger Muller (GM) tube against the vase at a single position. This value was used to calculate the decay rate for the whole vase.

(i) Show that the decay constant for uranium is about 5×10^{-18} s^{-1}

half-life of uranium = 1.41×10^{17} s

(2)

.....

.....

.....

.....

(ii) Calculate the percentage of uranium, by mass, in the glass.

area of GM tube window = 6.36×10^{-5} m^2
surface area of vase = 0.0177 m^2
background count rate = 525 counts in 10 minutes
count rate when GM tube next to vase = 3623 counts in 5 minutes
mass of vase = 149 g
mass of uranium atom = 238 u

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Percentage of uranium = ...

(iii) The uranium decays by emitting alpha particles.

Criticise the method used to determine the percentage of uranium in the vase.

(2)

.....

.....

.....

.....

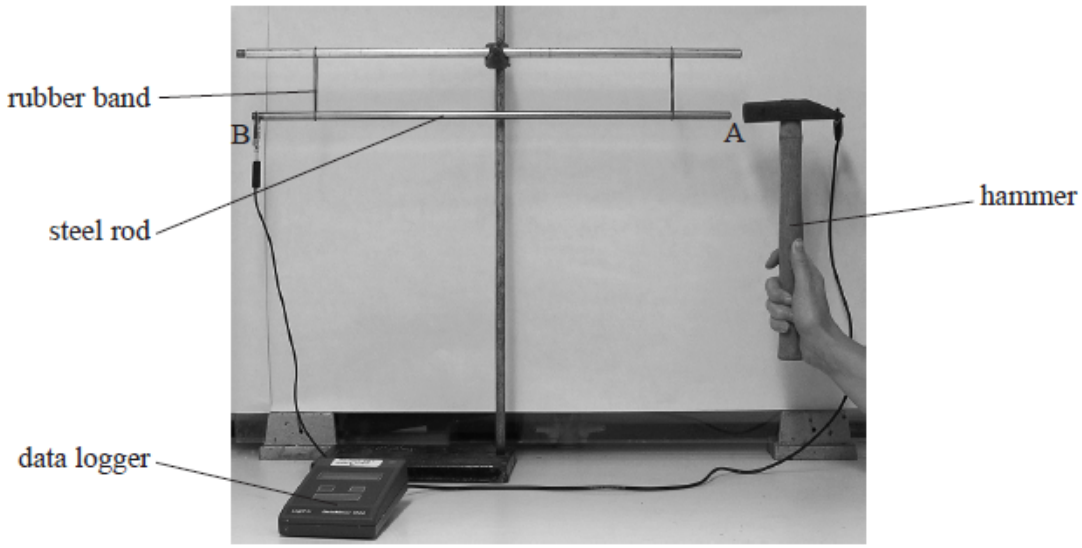
.....

.....

(Total for question = 10 marks)

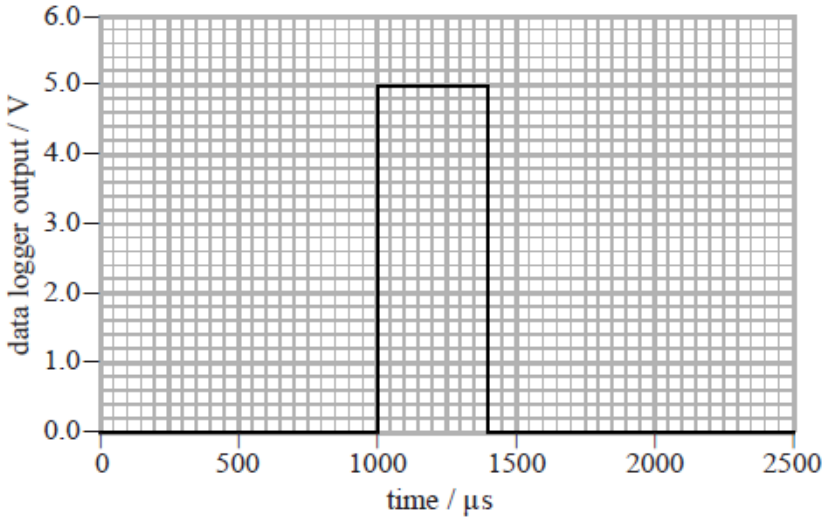
Q11.

A teacher is demonstrating how to measure the speed of sound in a steel rod. The equipment comprises a hanging steel rod and a hammer connected to a data logger as shown.



The rod is tapped at A with the hammer. A compression pulse travels to B and is reflected back. When the reflection reaches A the hammer loses contact with the rod.
Whilst the hammer is in contact with the rod the output from a 5 V supply is recorded by the data logger.

The graph shows the output from the data logger for one hammer tap.



(i) Use the graph to show that the speed of the pulse in the rod is about 6000 m s^{-1}.

length of steel rod = 1.18 m

(3)

.....

.....

.....

.....

(ii) The speed of sound v in the rod depends on the Young modulus E and the density ρ of the material of the rod as given by the equation

$$v = \sqrt{\frac{E}{\rho}}$$

Calculate the Young modulus of steel.

ρ_{steel} = 7850 kg m^{-3}

(2)

.....

.....

.....

.....

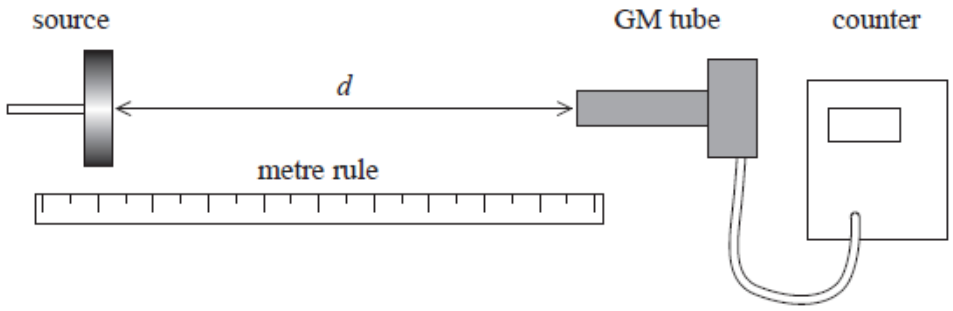
.....

Young modulus of steel = ...

(Total for question = 5 marks)

Q12.

A student investigated the way in which gamma radiation spreads out from a source.
He placed a cobalt-60 source in a source holder and set up a Geiger-Müller (GM) tube a short distance *d* away. He connected the GM tube to a counter as shown.



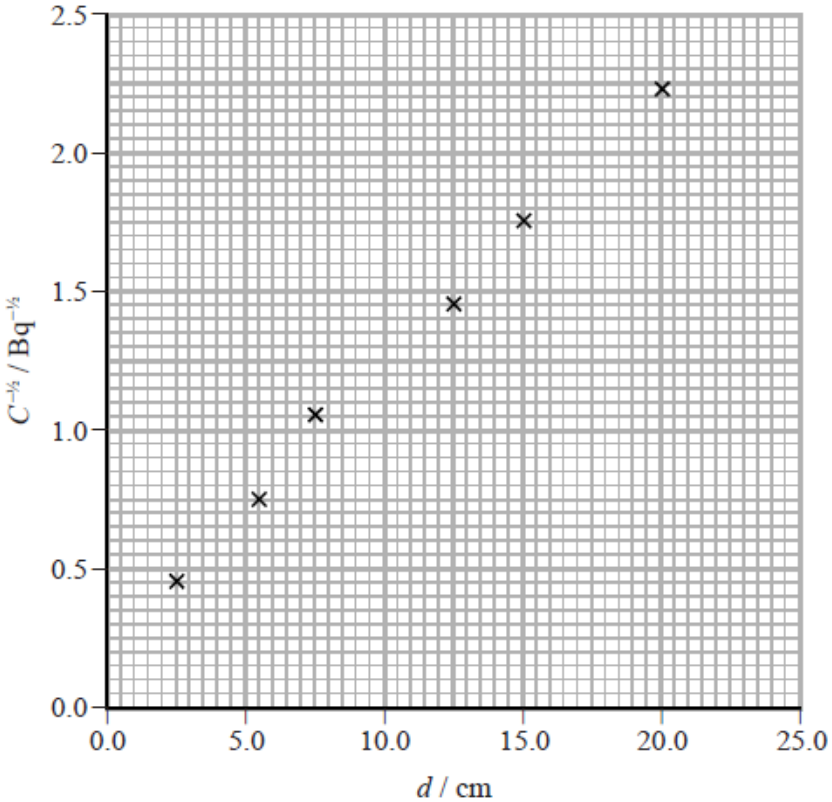
The student recorded the count for 2 minutes.

The variation in the intensity of gamma radiation with distance from a point source should obey an inverse square law. If this is the case, then the count rate *C* should vary with *d* according to the equation

$$C = \frac{K}{4\pi d^2}$$

where *K* is a constant.

The student plotted $\frac{1}{\sqrt{C}}$ against *d* and obtained the following graph.



(i) Draw a line of best fit on the graph.

(1)

(ii) The student concluded that the graph was consistent with the gamma radiation intensity obeying an inverse square law.

Discuss the extent to which the data obtained supports the student's conclusion.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q13.

A student investigated the rate at which a hot liquid transfers thermal energy to the surroundings. He placed hot water in a Pyrex beaker and measured the temperature of the water using a liquid-in-glass thermometer.

He obtained the following data for the temperature θ of the water at times t. He measured t using a stopwatch.

t / s	θ / °C		
0	95		
120	87		
240	81		
360	76		
480	71		

temperature of surroundings = 23 °C

Theory suggests that a liquid transfers internal energy to the surroundings at a rate proportional to the temperature difference $\Delta\theta$ between the liquid and the surroundings.

This leads to the expression

$$\Delta\theta = \Delta\theta_0 e^{-bt}$$

where b is a constant and $\Delta\theta_0$ is the initial temperature difference.

(a) Explain why a graph of ln $\Delta\theta$ against t should be a straight line.

(2)

.....

.....

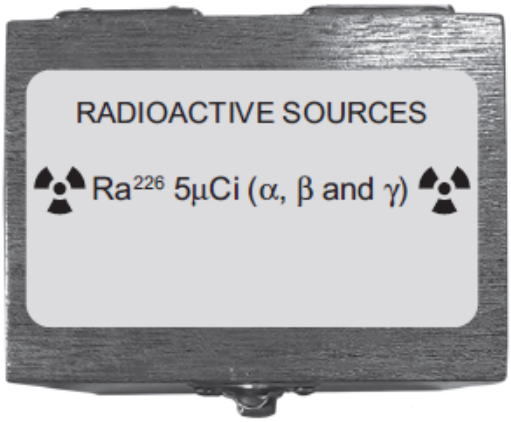
.....

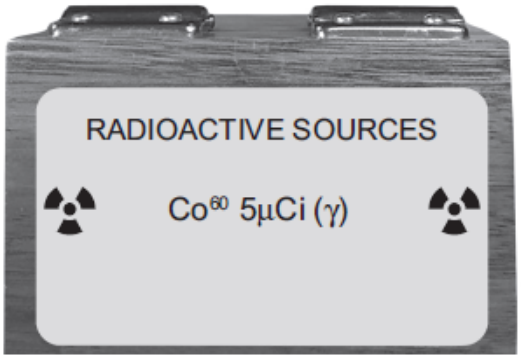
.....

(Total for question = 2 marks)

Q14.

The photograph shows the containers of two radioactive sources kept in a school.





The sources are tested every year and a record of the activity of the sources has to be kept.

The school has incomplete records. The table shows the test entries for cobalt for 2015 and for a year X, which is the year the source was purchased.

Year	Background: counts in 60 s	Source: counts in 60 s
X	22	12227
2015	15	322

The school records show that sources were purchased in 1980, 1987 and 1995, but there is no record of which source was purchased in which year.

(i) Determine the age of the cobalt source in order to establish in which year the school purchased this source.

half-life of Co 60 = 5.3 years

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Year = ...

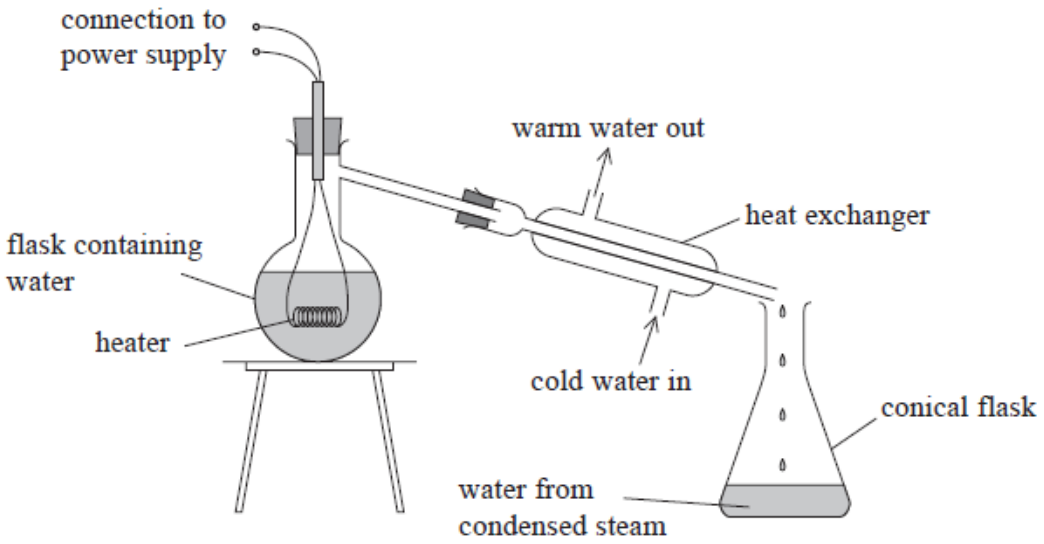
(ii) Explain a factor that may affect the reliability of this date.

(2)

.....

Q15.

The apparatus shown can be used to determine a value for the specific latent heat of vaporisation of water.



(a) In one experiment the current in the heater was 8.20 A, and the potential difference across the heater was 230 V.

(i) Show that the power of the heater was about 2 kW.

(2)

.....

.....

.....

(ii) There was 0.655 kg of water in the flask at an initial temperature of 22.5 °C.

The heater was switched on, and the water in the flask was heated to boiling point.

Calculate the minimum time taken for the water to be heated to 100.0 °C.

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

(3)

.....

.....

.....

.....

.....

Minimum time taken for water to be heated = ...

(b) The heater was left on and water continued to boil in the flask. The water was allowed to boil for a few minutes. The conical flask was then placed under the heat exchanger and water was collected in it.

(i) Give a reason why the water was left boiling for a few minutes before the conical flask was put in place.

(1)

.....

.....

.....

.....

(ii) Water with a mass of 95.0 g was collected in a time of 125 s.

Calculate the rate of energy transfer in the heat exchanger.

specific latent heat of vaporisation of water = 2.26 × 10^6 J kg^{-1}

(3)

.....

.....

.....

.....

.....

Rate of energy transfer in the heat exchanger = ...

(iii) Discuss your answers to (a)(i) and (b)(ii).

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 12 marks)

Q16.

A spring is made from loops of thick steel wire as shown.



There are two extra loops, one on each end of the spring.

A student determined the length of steel used to make the spring by using vernier calipers to measure the width *w* of the spring.

The length of wire *l* on each loop is given by $l = \pi w$

The student obtained the following values for *w*.

w / mm	15.3	15.2	15.4	15.3

(i) Calculate *l*.

(3)

.....

.....

.....

.....

.....

.....

.....

l = ...

(ii) Estimate the percentage uncertainty in your value for *l*.

(2)

.....

.....

.....

.....

% uncertainty in *l* = ...

(iii) Calculate the total length *L* of wire used to make the spring.

(2)

.....

.....

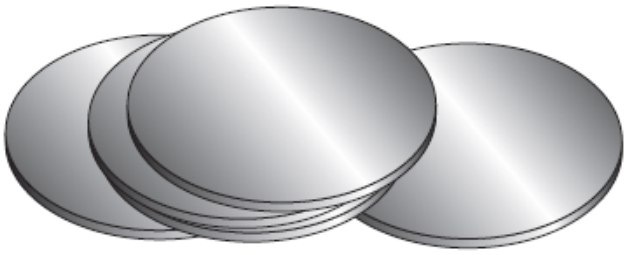
.....

L = ...

(Total for question = 7 marks)

Q17.

A student is investigating the properties of steel. He has fifty steel discs available.



Each disc has a diameter $d \approx 1.3$ cm and a thickness $t \approx 2$ mm.

State a suitable measuring instrument that could be used with a single disc to measure t.

(1)

.....

.....

(Total for question = 1 mark)

Q18.

A student released a ping pong ball in front of a metre rule and used a phone camera to record the motion of the ball as it fell. The phone camera captures 60 images per second, which may be played back one image at a time.

This experiment could have been attempted using a stopwatch to measure the time as the ping pong ball fell.

Explain an advantage of using a phone camera rather than a stopwatch.

(2)

.....

.....

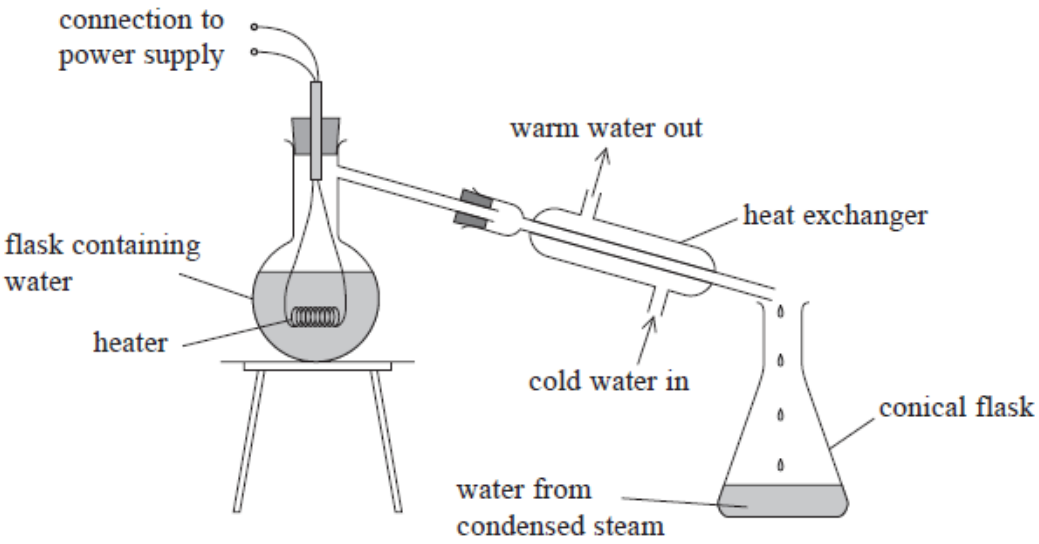
.....

.....

(Total for question = 2 marks)

Q19.

The apparatus shown can be used to determine a value for the specific latent heat of vaporisation of water.



State how the apparatus could be modified to minimise the effect of a significant source of error.

(1)

.....

.....

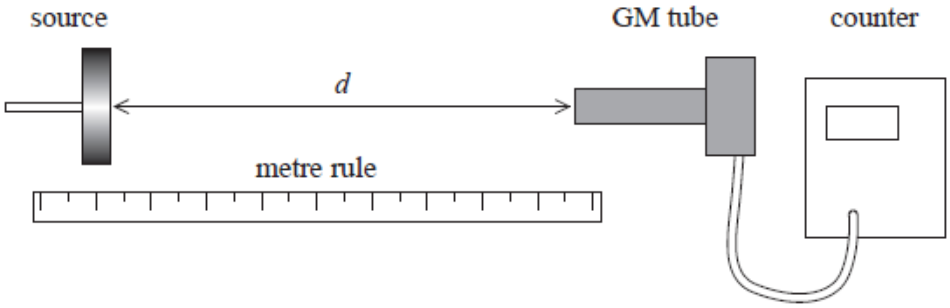
.....

.....

(Total for question = 1 mark)

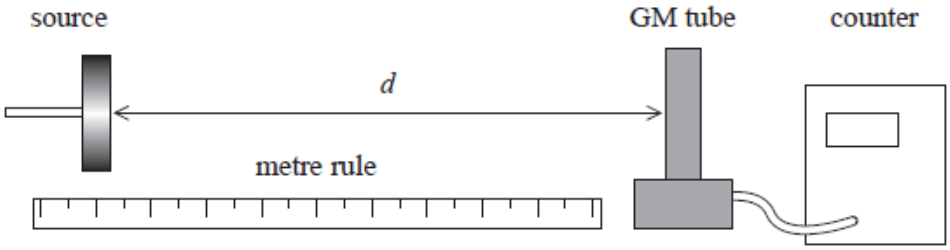
Q20.

A student investigated the way in which gamma radiation spreads out from a source.
He placed a cobalt-60 source in a source holder and set up a Geiger-Müller (GM) tube a short distance *d* away. He connected the GM tube to a counter as shown.



The student recorded the count for 2 minutes.

His teacher turned the GM tube through 90° so that the side of the tube faced the source as shown below.



(i) Explain why this arrangement could lead to more accurate data.

(2)

.....

.....

.....

.....

.....

(ii) Explain another modification to the experimental method which would improve the accuracy of the data.

(2)

.....

.....

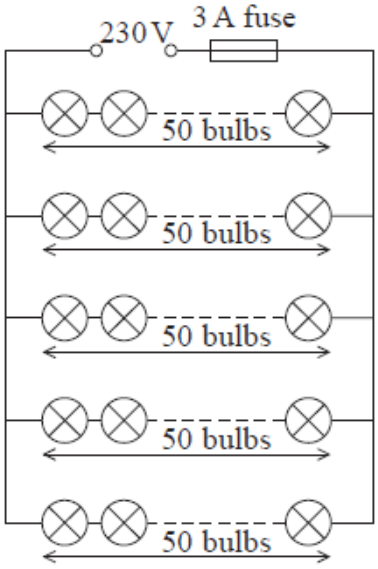
.....

.....

(Total for question = 4 marks)

Q1.

A set of festive lights is made up of five parallel strands of filament bulbs. Each strand contains 50 bulbs in series as shown.



(a) When a bulb is working normally its resistance is 8.0 Ω. If the filament of the bulb breaks, the lamp is designed to still conduct and its resistance becomes 3.0 Ω.

(i) The filament of one bulb on a strand breaks.
By considering the effect this has on the remaining bulbs in that strand, explain why it is recommended that broken bulbs are replaced as soon as possible.

(3)

.....

.....

.....

.....

.....

.....

(ii) The set of festive lights are fitted with a 3 A fuse. Five bulbs in one strand break.

Determine whether the fuse blows.

(3)

.....

.....

.....

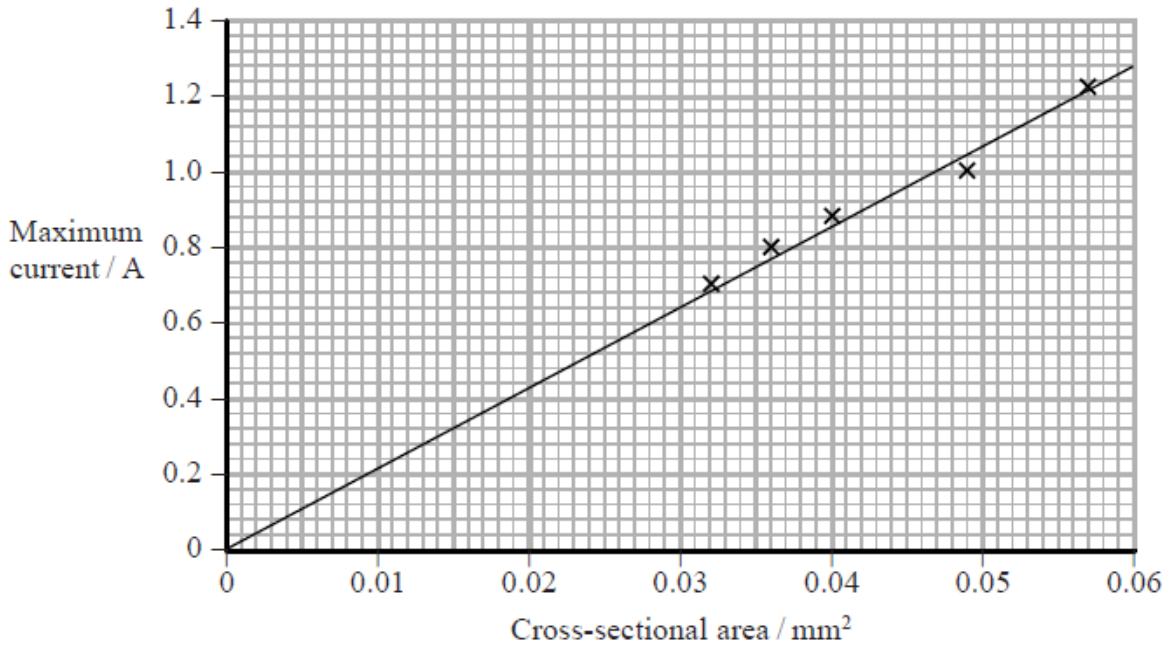
.....

.....

.....

(b) A student investigates how the cross-sectional area of a fuse wire affects the current at which the fuse blows. She uses pieces of wire of the same material and length, but different cross-sectional areas. She steadily increases the current through each piece of wire and records the maximum current through the wire before it breaks.

She then plots a graph of maximum current against cross-sectional area.



(i) Describe how the student should determine the cross-sectional area of the wire.

(3)

.....

.....

.....

.....

.....

.....

(ii) State the relationship between the maximum current and the cross-sectional area of the wire.

(1)

.....

.....

(iii) The student chooses a piece of wire, of the same material and length as used in the investigation. The piece of wire has a diameter of 0.40 mm.

Use the graph to determine whether the piece of wire is suitable to use as the 3A fuse wire for the set of festive lights.

(4)

.....

.....

.....

.....

.....

.....

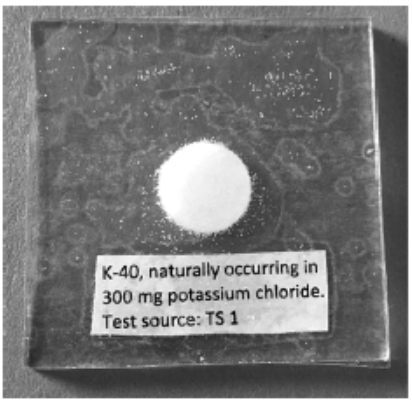
.....

.....

(Total for question = 14 marks)

Q2.

A school science department keeps a sample of potassium chloride to use as a test source for Geiger-Müller tubes.



Potassium contains 0.012% of the unstable isotope potassium-40.

A teacher makes some measurements using the potassium chloride test source to determine whether a Geiger-Müller tube is sufficiently efficient at detecting β radiation.

(i) The potassium chloride sample has a mass of 300 mg.

Show that the number of nuclei of potassium-40 in the sample is about 3×10^{17}.

number of potassium nuclei in 1 g of potassium chloride = 8.1×10^{21}

(2)

.....

.....

.....

.....

(ii) Show that the activity of this sample is about 5 Bq.

half-life of potassium-40 = 1.25×10^{9} years

(3)

.....

.....

.....

.....

.....

.....

(iii) With no sample in front of the Geiger-Müller tube, a count rate of 15 counts per minute is recorded. When the potassium chloride test sample is placed next to the Geiger-Müller tube 176 counts are recorded in a period of 10 minutes.

A detector is considered efficient if it detects at least 7.5% of beta emissions from the source.

Determine whether this Geiger-Müller tube can be considered efficient.

(3)

.....

.....

.....

.....

.....

.....

(iv) Explain a possible reason why only a low proportion of the decays are detected.

(2)

.....

.....

.....

.....

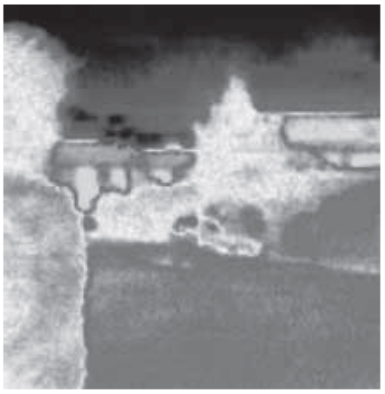
(Total for question = 10 marks)

Q3.

Infrared cameras are used to create images that show the infrared radiation emitted by objects.

The photographs show the same scene taken first with an ordinary camera and then with an infrared camera.





Deduce whether the objects shown in the photographs would be expected to have peak emissions at infrared wavelengths. Your answer should include a calculation.

(4)

longest wavelength of visible red light ≈ 700 nm

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q4.

Smartphones have built-in cameras. A lens on one side of the smartphone is used to form an image on sensors on the opposite side.

A smartphone camera is able to form clear images of objects at distances from the camera between 4.5 cm and infinity.

(a) Sketch a ray diagram to show the formation of a real image for an object close to the phone.

The diagram is not expected to be to scale.

(4)

(b) Estimate the thickness of a smartphone and use this value to determine the power of a lens that could be used to form a clear image for an object that is 4.5 cm away from the lens.

(3)

.....

.....

.....

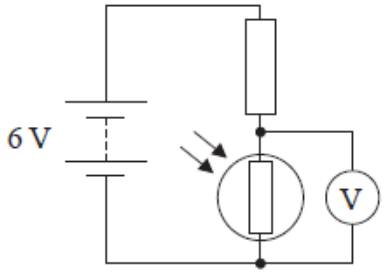
.....

Power = ...

(Total for question = 7 marks)

Q5.

A light-dependent resistor (LDR) and resistor are connected in series with a 6V battery as shown. A voltmeter measures the potential difference across the LDR.



In daylight the voltmeter reads 3.0V.

Which reading is most likely if the circuit is now in total darkness?

(1)

☒ **A** a little above 0 V

☒ **B** a little below 3 V

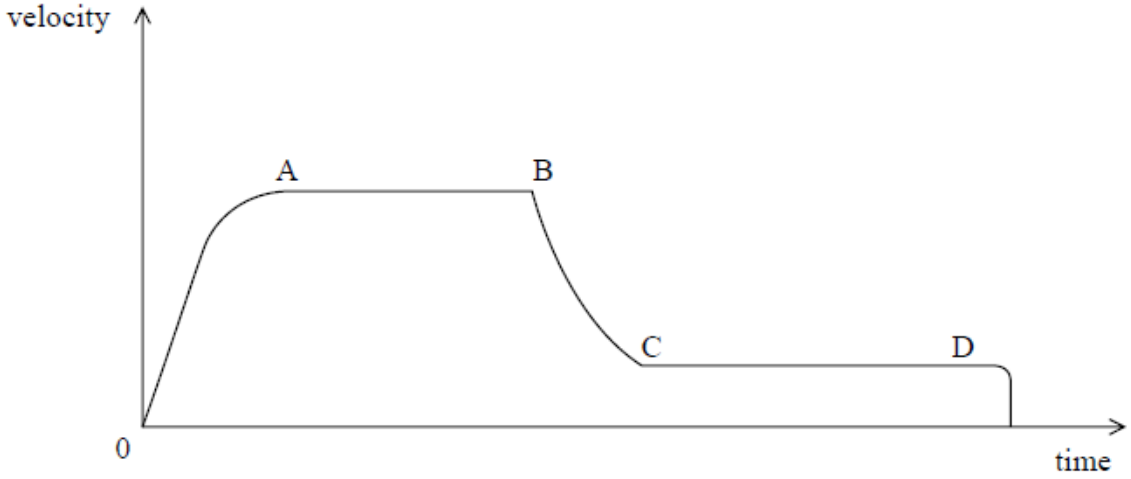
☒ **C** a little above 3 V

☒ **D** a little below 6 V

(Total for question = 1 mark)

Q6.

* The graph shows the velocity of a skydiver from the moment that she begins her freefall jump, until she lands on the ground.



Explain, in terms of the force acting, the shape of the graph from the point when the parachute opens until point D.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q1.

A practical physics textbook states that "measurements may give a precise value for the quantity being determined but this may not necessarily be an accurate value".

Describe what physicists mean by the terms accuracy and precision.

(2)

.....

.....

.....

.....

.....

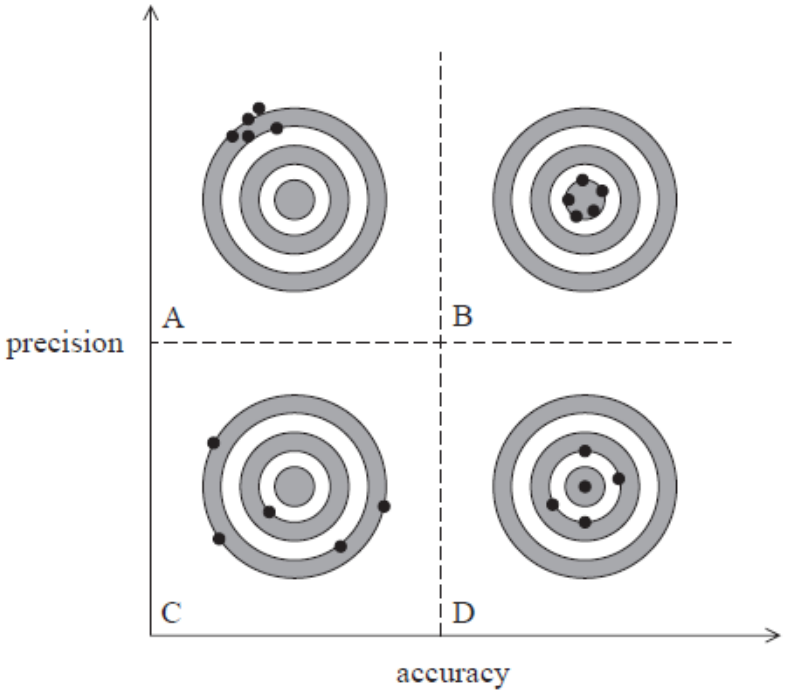
.....

(Total for question = 2 marks)

Q2.

A teacher is explaining the differences between accuracy and precision to her students.

She draws the following diagram, which shows different degrees of accuracy and precision. The circles represent targets A, B, C and D and the dots represent arrows hitting the targets.



Explain how targets A, B, C and D represent differing degrees of accuracy and precision.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

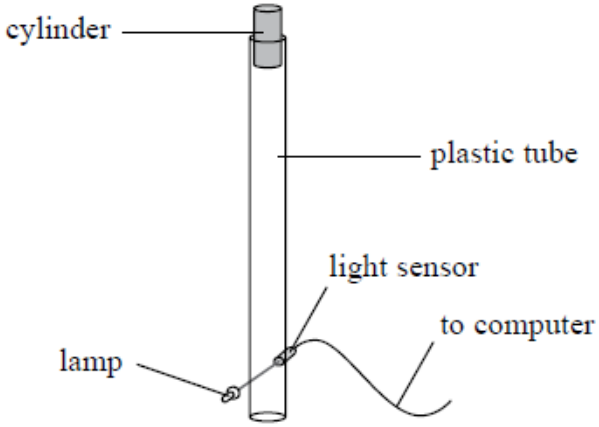
.....

.....

(Total for question = 4 marks)

Q3.

A student uses a lamp and a light sensor as a light gate connected to a data logger and computer to determine the speed of a falling object. He drops a small cylinder through a clear plastic tube. The light gate and data logger measure the time of fall of the cylinder and the speed is calculated.



The student repeats the experiment five times and records the results in a table.

Speed/m s^{-1}	Mean speed/m s^{-1}
4.52 4.59 4.43 4.63 4.58	4.55

Explain **one** advantage of using a light gate and data logger in this experiment.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q4.

A student used a Geiger-Müller (GM) tube to determine the activity of a radium source. Radium emits α, β, and γ radiation.

He positioned the source 20 cm from the GM tube, as shown, and recorded the count for 1 minute. He repeated the measurement and calculated a mean count.



The student recorded the following results.

Count 1	Count 2	Mean count
183	178	181

Criticise the student's method for determining the count at this position.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q5.

A student used a Geiger-Müller (GM) tube to determine the activity of a radium source. Radium emits α, β, and γ radiation.

He positioned the source 20 cm from the GM tube, as shown, and recorded the count for 1 minute. He repeated the measurement and calculated a mean count.



The student recorded the following results.

Count 1	Count 2	Mean count
183	178	181

From his results the student determined that the activity of the source was 3.0 Bq.

Comment on his value for the activity of the source.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q6.

Genuine crystal balls are made from clarified quartz rather than glass. A student was given a small crystal ball and wanted to know whether it was genuine.

The student measured the diameter of the crystal ball using vernier calipers with a resolution of 0.01 cm.
She measured the mass of the crystal ball using a balance with a resolution of 1 g.

The table gives the densities of clarified quartz and glass.

Material	Density / kg m^{-3}
Clarified quartz	2650
Glass	2590

Determine whether the crystal ball was genuine.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

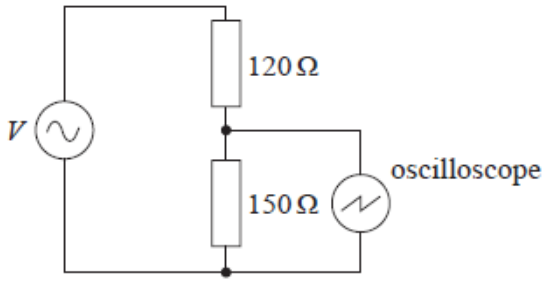
.....

(Total for question = 6 marks)

Q7.

A student connected the output from a source of alternating potential difference (p.d.) to a series resistor combination.

She connected an oscilloscope across the 150 Ω resistor as shown.



Another student suggested that a voltmeter would be more accurate than using an oscilloscope to determine the magnitude of the p.d.

Comment on this suggestion.

(3)

.....

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q8.

A student carries out an experiment to investigate the stretching of a liquorice lace.

(a) The student fixes one end of the lace to a support and adds different masses to the end of it, measuring the extension each time with a metre rule. His results are shown in the table.

Mass/kg	Force/N	Extension/m
0.03	0.294	0.005
0.04	0.392	0.0075
0.06	0.589	0.011
0.07	0.687	0.012

Criticise the recording of these results.

(3)

.....

.....

.....

.....

.....

.....

(b) Describe how the student should measure the extension of the lace to make his results as

accurate as possible.

(2)

.....

.....

.....

.....

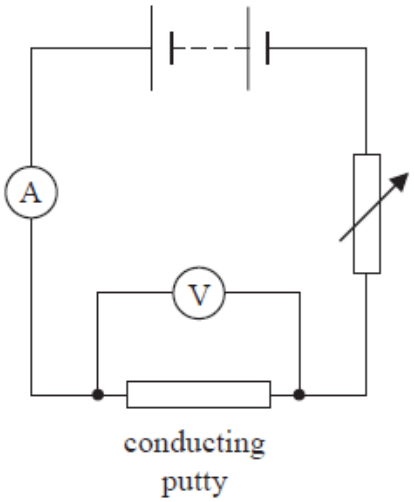
(Total for question = 5 marks)

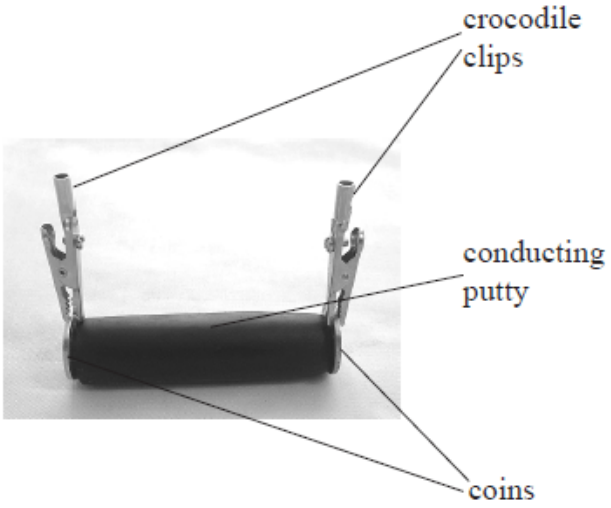
Q9.

Conducting putty is a material that is a relatively good conductor and can be easily moulded into different shapes.

A student decides to investigate how the resistance *R* of a cylinder of conducting putty depends upon the cross-sectional area *A* of the cylinder.

(a) She sets up the circuit shown and keeps the length *l* of the cylinder constant at 7.5 cm. She uses the ammeter and voltmeter readings to determine the resistance of cylinders of different cross-sectional areas.



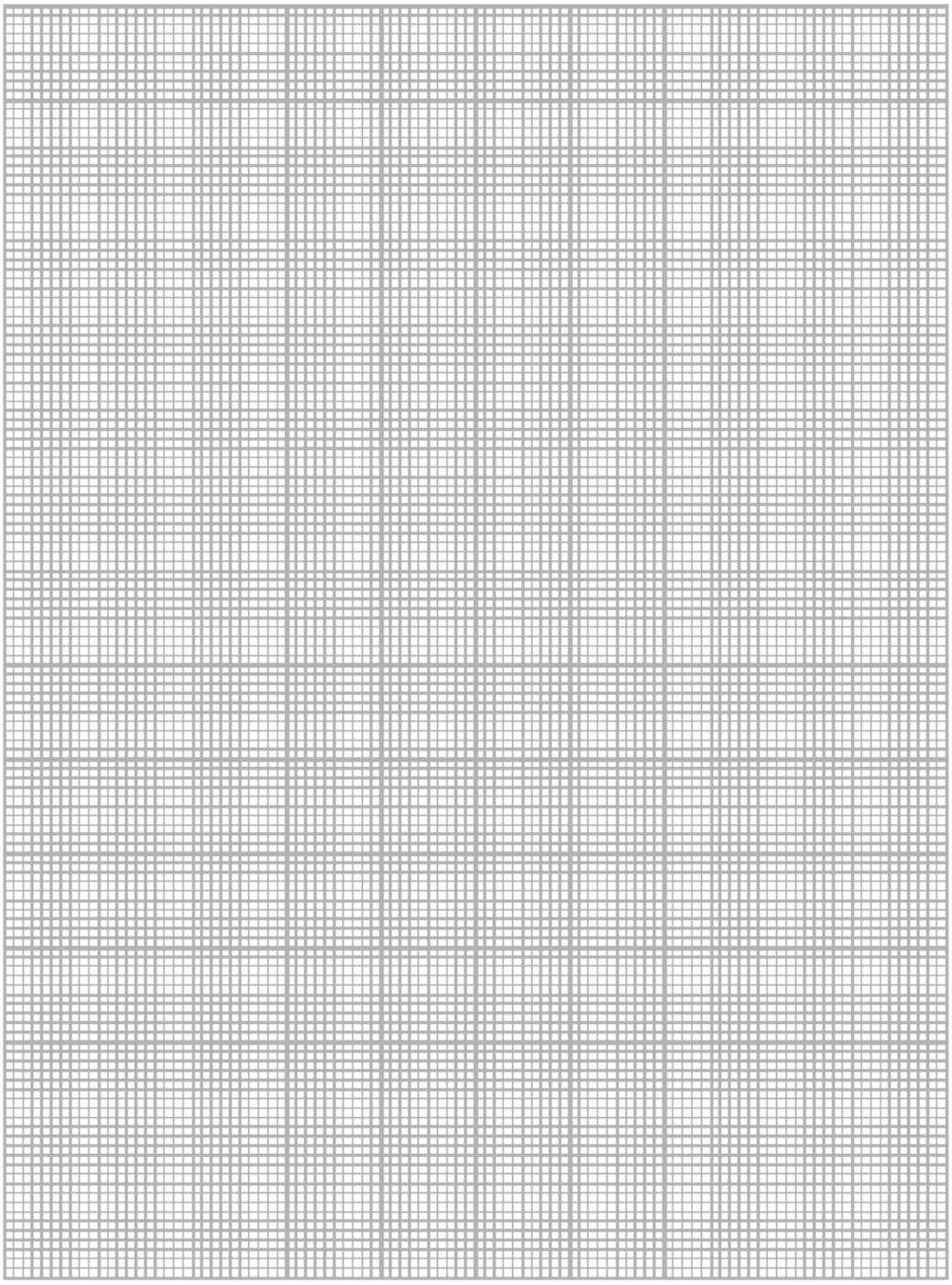


The student's results are shown in the table.

Diameter / cm	Resistance / Ω	(l / A) / m^{-1}
0.4	56.0	1490
1.0	37.5	968
1.5	16.7	430
2.0	9.44	242
2.5	6.00	155

(i) Plot a graph of R against l/A.

(4)



(ii) Use your graph to determine a value for the resistivity of the putty.

(2)

.....

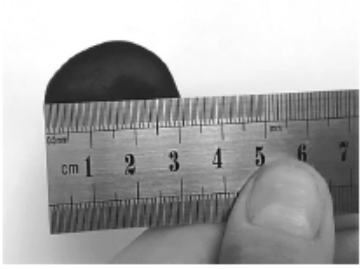
.....

.....

Resistivity = ...

(b) The photographs show how the student obtained measurements for the length and diameter of a cylinder.





The student records the following readings:

length = 90 mm; diameter = 31 mm

Identify two problems with this method of determining the dimensions of the cylinder and for each problem identify a solution.

(4)

1

.....

.....

.....

.....

2

.....

.....

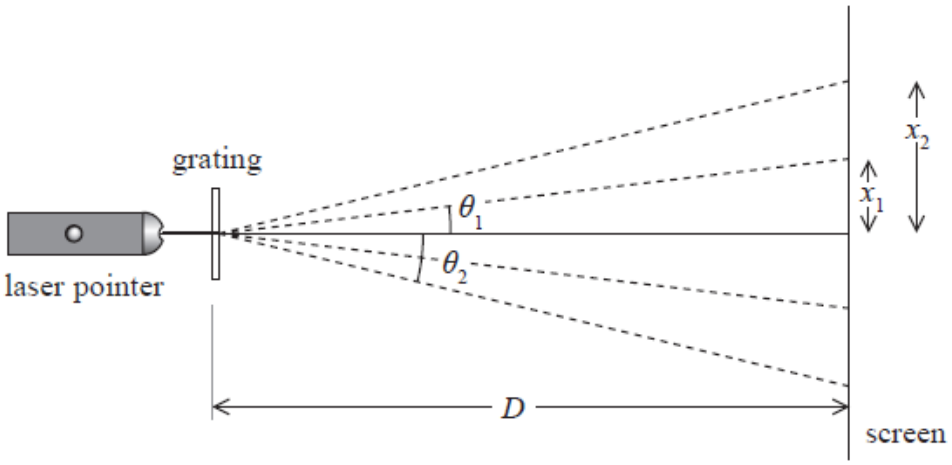
.....

.....

(Total for question = 10 marks)

Q10.

A student is using a diffraction grating to determine the wavelength of the light emitted by a laser pointer. The light from the laser pointer is directed so that it is normal to the plane of the grating. The diffracted light is viewed on a screen a distance *D* from the grating.



The diagram shows the first two diffracted orders where x_1 and x_2 are the distances of the maxima for these orders from the central maximum of the diffraction pattern.

(a) Before carrying out the experiment, the student carries out a risk assessment to ensure that the experimental procedure is safe.

Explain one precaution that should be taken.

(2)

.....

.....

.....

.....

(b) The student measures the distances from the central maximum of the diffraction pattern for various diffracted orders *n*, using a metre rule.

n	x_n / cm	θ / °	sin θ
0	0	0.00	0.000
1	35.5	11.4	0.20
2	74		
3	126.5	35.9	0.586
4	211	50.4	0.771

(i) Criticise the results that are recorded.

(1)

.....

.....

.....

(ii) Complete the data for the 2nd order maximum.

D = 1.750 m

(2)

.....

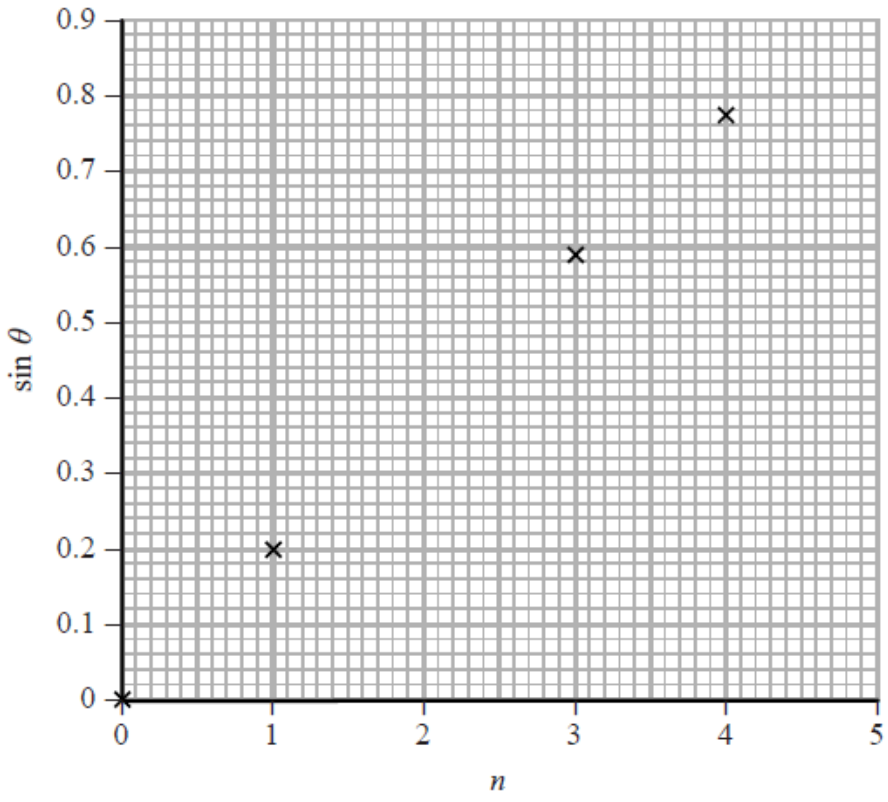
.....

.....

.....

(iii) Add your data to the axes and draw a line of best fit.

(1)



(iv) Use your graph to determine a value for the wavelength of the laser light.
The grating has 300 lines per mm

(5)

.....

.....

.....

.....

.....

.....

.....

.....

Wavelength = ...

(c) State and justify two modifications to the experimental method which would have improved the accuracy of the value obtained for the wavelength.

(4)

.....

.....

.....

.....

.....

.....

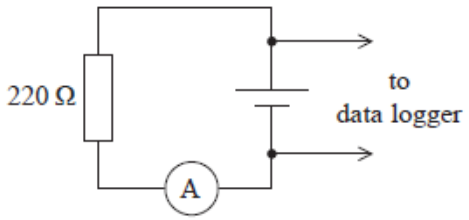
.....

.....

(Total for question = 15 marks)

Q11.

A student is investigating how the internal resistance of a dry cell varies over time. She sets up the circuit shown to draw current from the cell.



The student proposes to use a data logger to monitor the terminal potential difference (p.d.) of the cell over a period of time.

State why a data logger would be suitable to collect data in this investigation.

(1)

.....

.....

(Total for question = 1 mark)

Q12.

A physics textbook states that "when carrying out experimental measurements there will always be errors and uncertainties".

Describe what physicists mean by error and by uncertainty.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 2 marks)

Q13.

A spring is made from loops of thick steel wire as shown.



There are two extra loops, one on each end of the spring.

The student measured the diameter d of the steel wire and obtained a value of 2.52 mm.

(i) Explain which instrument he used to measure the diameter.

(2)

.....

.....

.....

(ii) Estimate the percentage uncertainty in the student's value for d.

(1)

.....

.....

% uncertainty in d = ...

(iii) The student used a balance to measure the mass m of the spring.

He obtained a value of 32.0 ± 0.5 g.

Estimate the percentage uncertainty in the mass of the spring.

(1)

.....

.....

% uncertainty in m = ...

(iv) The student calculated the density ρ of the steel using the equation

$$\rho = \frac{m}{V}$$

Calculate the percentage uncertainty in his value for the density of steel.

(1)

.....

.....

% uncertainty in value for density of steel = ...

(v) Determine whether the data collected leads to a value for the density of steel in agreement with the standard value.

density of steel = 7 800 kg m^{-3}

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q14.

A practical physics textbook states that "measurements may give a precise value for the quantity being determined but this may not necessarily be an accurate value".

The temperature of the air in a room is measured using a mercury-in-glass thermometer.

Describe how the value for the temperature may be precise but not accurate.

(2)

.....

.....

.....

.....

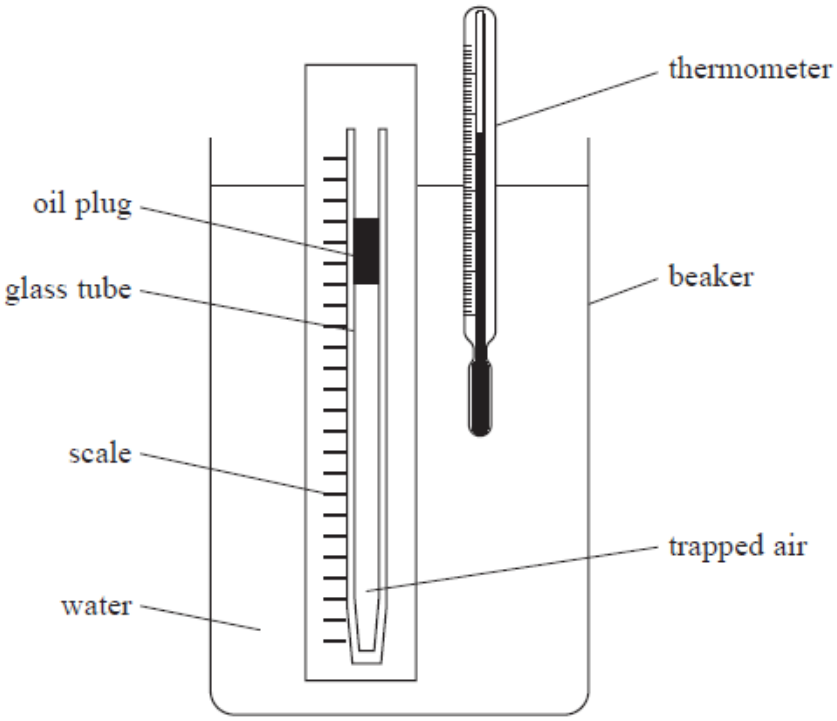
.....

.....

(Total for question = 2 marks)

Q15.

A student investigated how the volume of a fixed mass of air varies with the temperature of the air. She used the apparatus shown.



A glass tube was sealed at one end. A plug of oil trapped a length *l* of air in the tube. The water in the beaker was heated to a temperature θ. The corresponding value of *l* was measured. This was repeated for a range of temperatures.

The thermometer had a resolution of 0.5 °C. The scale had mm divisions.

The student's results are shown in the table.

θ / °C	*l* / cm
24	8.8
60	9.8
78.5	10.3
95.5	10.9

(i) Criticise the student's results.

(3)

.....

.....

.....

.....

.....

(ii) Explain two possible sources of error in this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(iii) Describe two improvements that would increase the accuracy of measurements obtained in this investigation.

(2)

.....

.....

.....

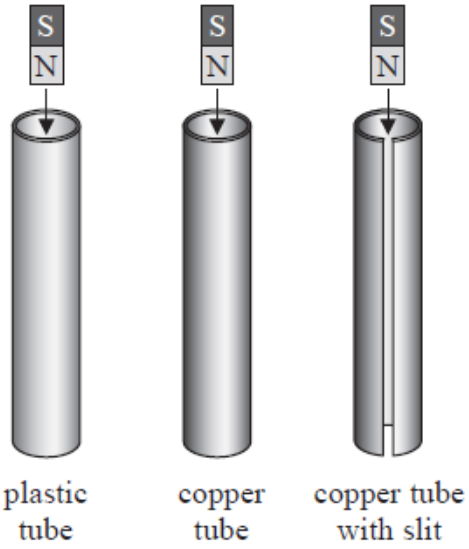
.....

(Total for question = 9 marks)

Q16.

A teacher carries out a demonstration to illustrate the laws of electromagnetic induction.
She uses three tubes of identical dimensions. One is made of plastic, one copper and one copper

with a slit cut into its length.



(a) The teacher releases a magnet from rest at the top of the plastic tube and it takes 0.45 s to fall through the tube.
Calculate the average acceleration of the magnet as it falls through the tube.

length of tube = 0.75 m

(2)

.....

.....

Average acceleration = ...

*(b) The teacher suggests that the magnet would take longer to fall through the copper tube as a consequence of the laws of electromagnetic induction.

Assess the validity of this suggestion.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Before the teacher releases the magnet through the copper tube with a slit along its length, she asks the class to consider how the time taken will compare with the time for the other copper tube. The class predicts that the time will be the same.

Explain, using electromagnetic induction, whether this prediction is correct.

(3)

.....

.....

.....

.....

.....

.....

(d) The times for the magnets to fall through the tubes were measured manually using an electronic timer.

Explain how suitable this is as a means of recording these times.

(2)

.....

.....

.....

.....

(Total for question = 13 marks)

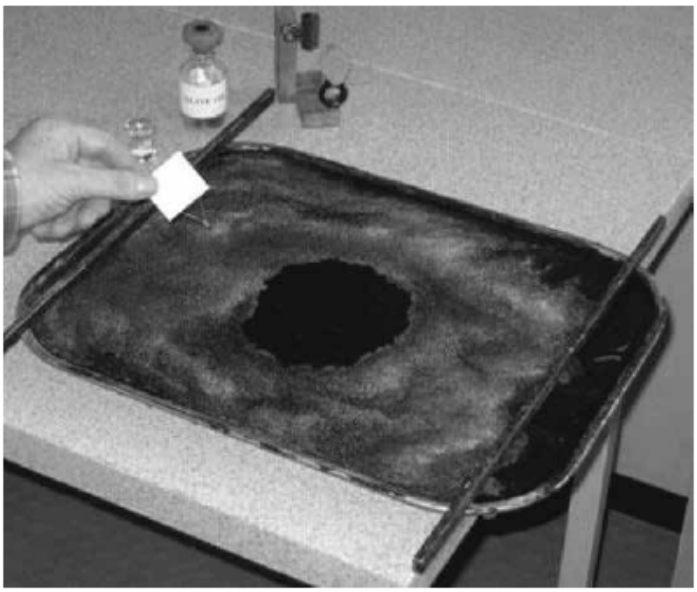
Q17.

When a drop of oil is placed on the surface of water it spreads out to form a thin film 1 molecule thick. A student uses this phenomenon to determine the size of an oil molecule.

She dips a wire loop into the oil so that a small, spherical oil drop forms. She uses a millimetre

scale to measure the diameter of this oil drop.

The student fills a tray with water and scatters a fine powder on the water surface. The oil drop is placed on the water surface and spreads out to form a thin film, approximately circular, as shown in the photograph.



© Images taken from www.practicalphysics.org,
a Nuffield Foundation and Institute of Physics website

The student uses a metre rule to measure the diameter of the circular thin film.
She records the following measurements:

diameter of oil drop = 0.5 mm
diameter of thin film = 250 mm

The student now equates the volume of oil as a drop to the volume of the film.

Evaluate the student's method and suggest refinements that would improve the accuracy of determining the size of the molecule.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

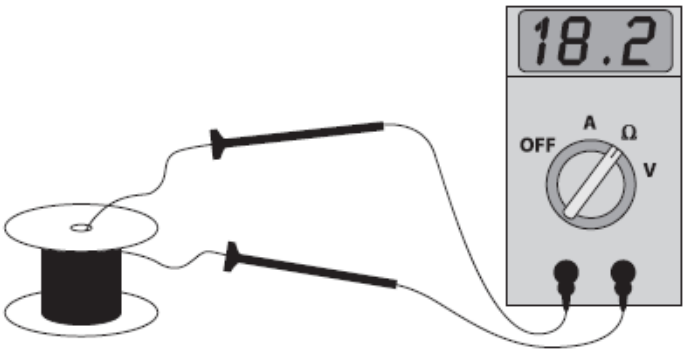
.....

(Total for question = 6 marks)

Q18.

A student carried out an experiment to determine the resistivity of nichrome wire.

He used an ohmmeter to measure the resistance of a length of nichrome wire as shown.



The diameter of the wire was measured as 0.27 mm ± 0.01 mm.
The length of the wire was measured as 1.25 m ± 0.05 m.

Determine which of the three measurements introduces the greatest uncertainty into the value for the resistivity.

Your answer should include calculations.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

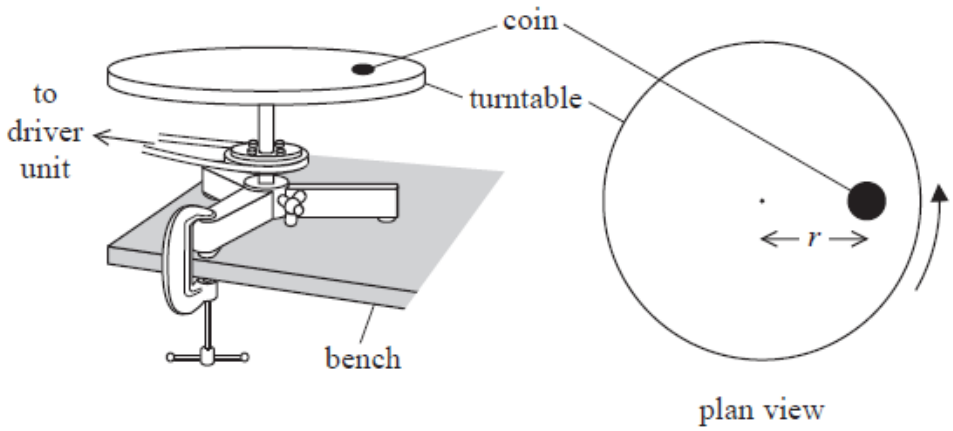
.....

(Total for question = 4 marks)

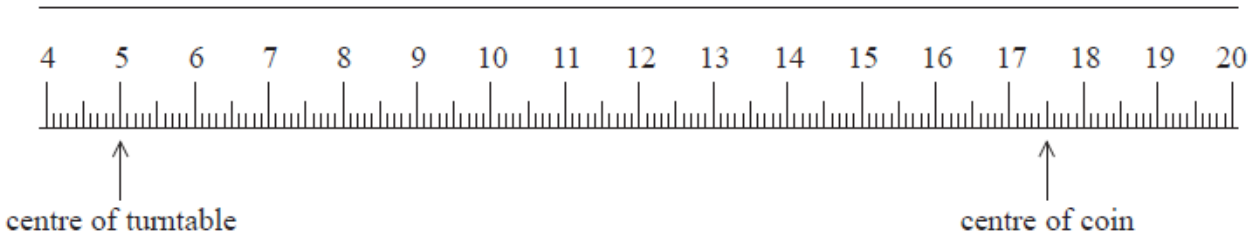
Q19.

A student was investigating the forces involved in circular motion.

He placed a small coin on a horizontal turntable as shown. The turntable was connected to a driver unit so that it could be rotated at a constant rate.



The student measured the distance *r* between the centre of the turntable and the centre of the coin, with a metre rule as shown.



Explain why the percentage uncertainty in the value of *r* is about 1%.
Your answer should include a calculation.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q20.

A physics textbook states that "when carrying out experimental measurements there will always be errors and uncertainties".

Give two reasons why a measurement may have an uncertainty.

(2)

.....

.....

.....

.....

.....

.....

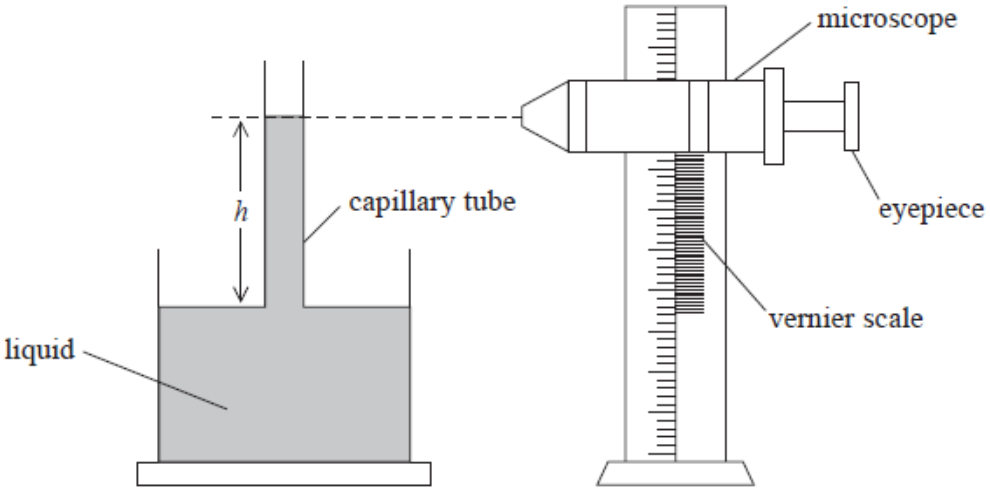
(Total for question = 2 marks)

by repeated measurements

Q1.

A student measured the height *h* of a liquid column in a capillary tube. She used a travelling microscope to make measurements of the positions of the top and bottom of the liquid column.

The travelling microscope consists of a simple microscope that can be moved vertically along a vernier scale.



The student used a capillary tube with an internal radius *r* equal to 0.10 mm and recorded the following readings from the vernier scale.

Bottom of liquid column / cm	Top of liquid column / cm
12.00	27.10

(i) State the uncertainty in each of these readings.

(1)

.....

(ii) Calculate the percentage uncertainty in the student's value of *h*.

(2)

.....

.....

.....

.....

Percentage uncertainty in *h* = ...

(iii) The student repeated the measurement of *h* for capillary tubes of different radii.

The table shows the student's final data.

r / mm	$1/r$	h / cm
0.09	11.1	16.56
0.10	10.0	15.1
0.12	8.3	12.6
0.15	6.7	10.33

Criticise the student's recording of the data.

(2)

.....

.....

.....

.....

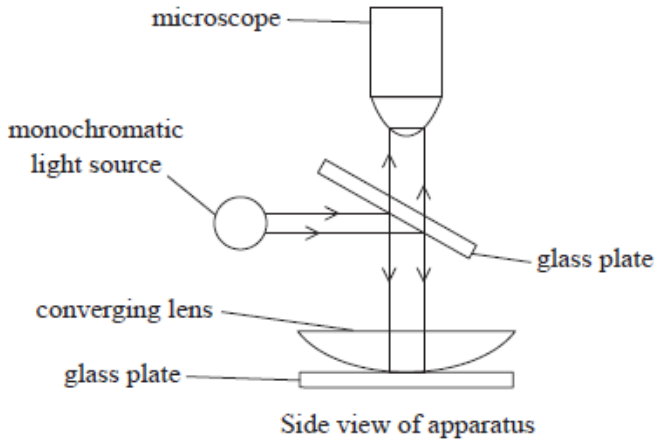
(Total for question = 5 marks)

Q2.

A method to determine the wavelength of light using a converging lens was first proposed by Sir Isaac Newton.

A converging lens is placed on a plane glass plate. The lens is illuminated from above with a parallel beam of monochromatic light, as shown.

Some of the light is reflected from the upper surface of the lower glass plate and some from the lower surface of the lens. Interference between these two reflected waves produces circular fringes. The pattern is viewed through a microscope.



Side view of apparatus



Pattern seen through microscope

The table below shows the readings from which the diameter of the first dark circle was calculated.

Position of left-hand side of circle / mm	Position of right-hand side of circle / mm	Diameter / mm
54.79	49.66	5.13

(i) Use these readings to estimate the percentage uncertainty in the diameter due to the resolution of the instrument.

(2)

.....

.....

.....

.....

Percentage uncertainty = ...

(ii) State why the actual percentage uncertainty would have been greater than the value calculated in (i).

(1)

.....

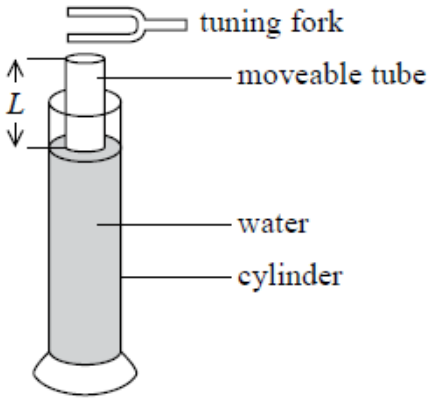
.....

.....

(Total for question = 3 marks)

Q3.

A set of tuning forks is used to find a value for the speed of sound in air.
A tuning fork is struck and then held near to the end of an air column formed by a moveable tube. The moveable tube is used to adjust the length, *L*, of the air column until a standing wave is set up in the tube and the loudest sound is heard. The experiment is repeated for a number of different tuning forks.



The following results are obtained by a student.

Fork frequency/Hz	Length, L/cm	Speed of sound/m s^{-1}
256	31.9	327
320	25.6	328
512	16.1	330

Student A says "These results show that the speed of sound increases as the frequency of the sound increases".

Student B says "The speed of sound should be the same for each frequency".

By estimating the uncertainties in these results, conclude which of these statements is valid.

.....

.....

.....

.....

.....

.....

.....

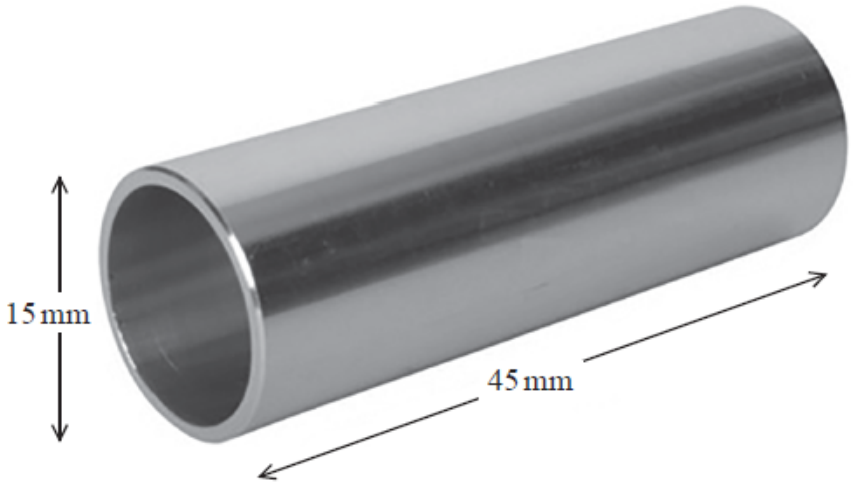
.....

(Total for question = 4 marks)

Q4.

An engineer was checking the dimensions of a steel tube. The tube had a length of about 45 mm

and an external diameter of about 15 mm as shown.



She used a digital micrometer to measure the diameter of the tube. Before taking the reading she closed the jaws of the micrometer to check for a zero error.

Describe the procedure she should follow to determine an accurate value for the external diameter of the tube.

(3)

.....

.....

.....

.....

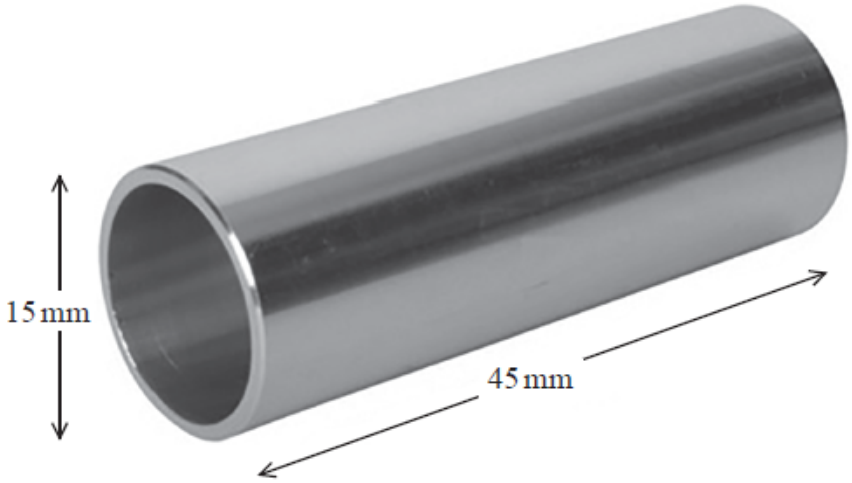
.....

.....

(Total for question = 3 marks)

Q5.

An engineer was checking the dimensions of a steel tube. The tube had a length of about 45 mm and an external diameter of about 15 mm as shown.



She used a digital micrometer to measure the diameter of the tube. Before taking the reading she closed the jaws of the micrometer to check for a zero error.

The engineer determined the length of the tube using the micrometer. The reading on the micrometer scale was 45.043 mm. She recorded the reading as 45.0 mm. State why recording a reading of 45.043 mm could not be justified.

(1)

.....

.....

.....

(Total for question = 1 mark)

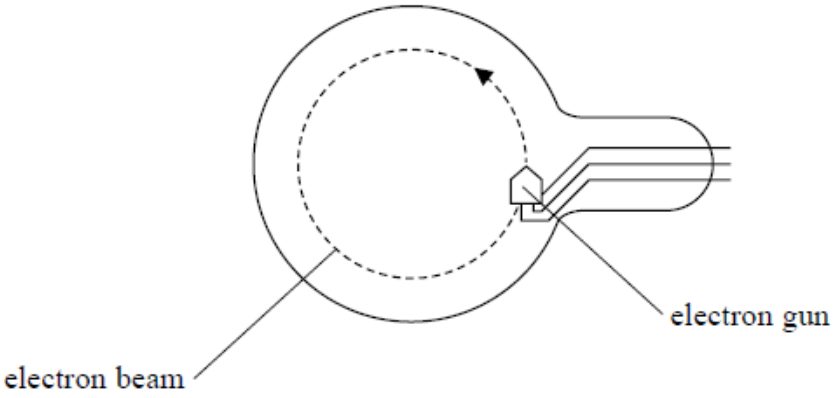
Q6.

An electron beam tube can be used to demonstrate the deflection of electrons in a uniform magnetic field. The tube contains a very low pressure gas so that electron paths can be seen.



(Source: http://www.klingereducational.com/images/products/thumbs/555571.jpg)

Electrons are emitted from the electron gun travelling vertically upwards into a region of uniform horizontal magnetic flux density.



The magnetic flux density is varied while the speed of the electrons remains constant.
The following data is obtained.

Radius/cm	Magnetic flux density/mT	
8.0	0.63	
9.5	0.52	
11.0	0.46	

Theory suggests that the radius of the electron path is inversely proportional to the magnetic flux density.

Analyse the data and comment on this suggestion, you may use the table to show any calculated values.

(4)

.....

.....

.....

.....

.....

.....

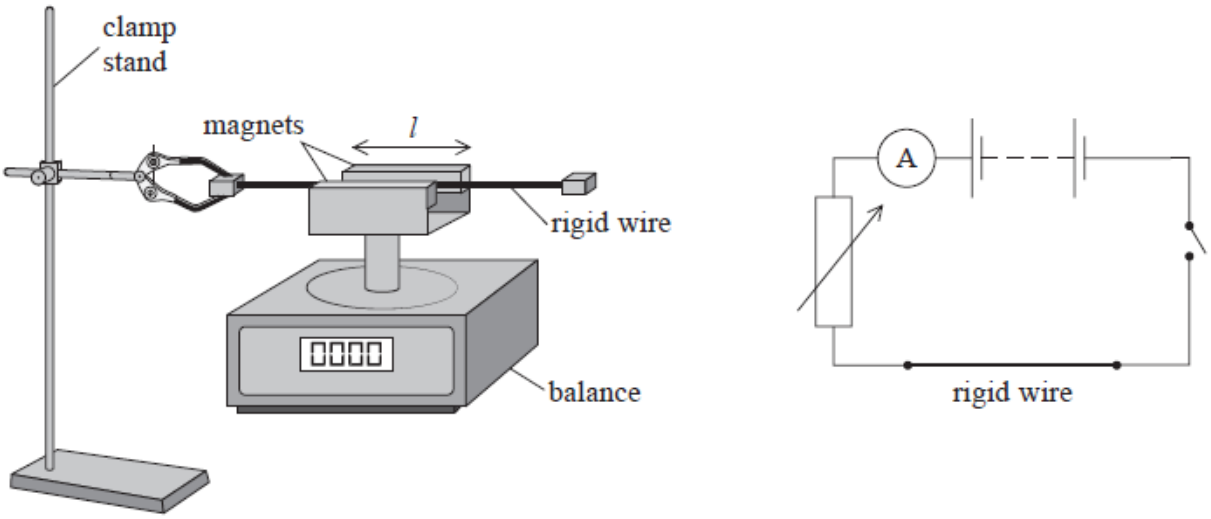
.....

.....

(Total for question = 4 marks)

Q7.

A student set up the apparatus shown. A length of rigid wire was held horizontally by a clamp in a uniform magnetic field of flux density *B*.
The circuit connected to the rigid wire is also shown.



With the switch open, the balance was set to zero. When the switch was closed a current *I* in the circuit was recorded by the ammeter and the reading on the balance increased.

The student wrote the following statement

"The balance could read to the nearest 0.01 g, which makes my values for the magnetic force both accurate and precise."

Comment on this statement.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q8.

A spring is made from loops of thick steel wire as shown.



There are two extra loops, one on each end of the spring.

A student determined the length of steel used to make the spring by using vernier calipers to measure the width *w* of the spring.

The length of wire *l* on each loop is given by $l = \pi w$

The student obtained the following values for *w*.

w / mm	15.3	15.2	15.4	15.3

(i) Calculate *l*.

(3)

.....

.....

.....

.....

.....

.....

.....

l = ...

(ii) Estimate the percentage uncertainty in your value for *l*.

(2)

.....

.....

.....

.....

% uncertainty in *l* = ...

(iii) Calculate the total length *L* of wire used to make the spring.

(2)

.....

.....

.....

L = ...

(Total for question = 7 marks)

Q9.

(a) A magnetic field can be measured with a device called a Hall probe. The probe is connected to a voltmeter. When the probe is placed at right angles to a magnetic field, a potential difference is recorded on the voltmeter. The potential difference increases with increasing magnetic flux density.

A wire carries a constant current. A Hall probe is used to investigate how the magnetic flux density produced by the wire varies with distance from the wire.

The potential difference *V* was recorded for a range of distances *r*.

r/cm	V/V
1.0	0.725
1.5	0.483
2.0	0.363
2.5	0.29
3.0	0.242
3.5	0.21

(i) Criticise these results.

(2)

.....

.....

.....

.....

.....

(ii) It is suggested that V and r are related by the equation

$$V = \frac{k}{r}$$

where k is a constant.

(1) Determine by calculation whether this suggestion is valid.

(2)

.....

.....

.....

.....

.....

(2) A graph of $\frac{1}{V}$ is plotted against r.

State how the graph would indicate that the equation is correct.

(1)

.....

.....

.....

(b) The Hall probe can be replaced with a small coil of wire which is connected to a sensitive voltmeter. The plane of the coil is at right angles to the magnetic field produced by the current-carrying wire.

(i) Explain, with reference to Faraday's law, why the voltmeter reading would be zero.

(2)

.....

.....

.....

.....

(ii) State **three** different ways in which an e.m.f. could be induced in this coil.

(3)

.....

.....

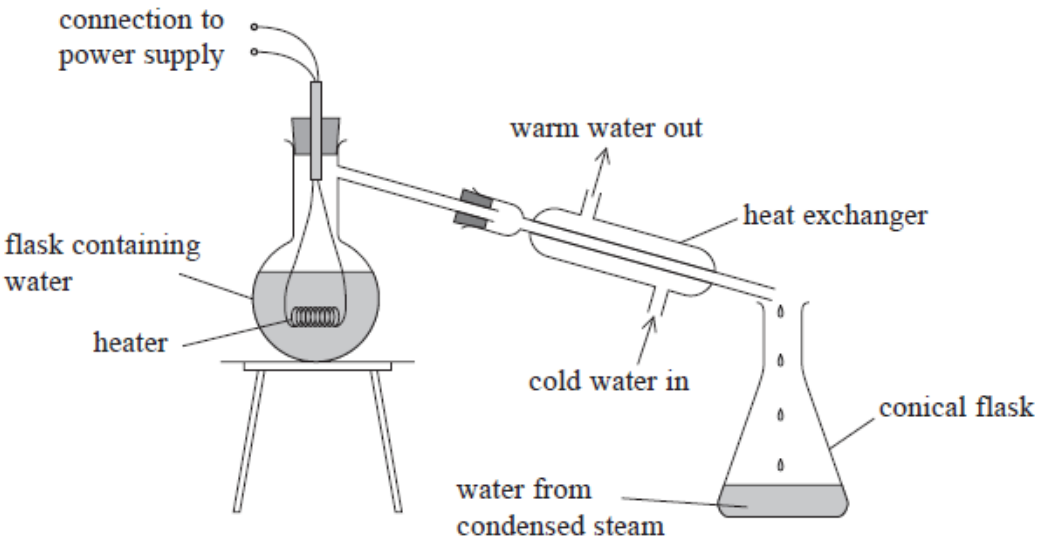
.....

.....

(Total for question = 10 marks)

Q10.

The apparatus shown can be used to determine a value for the specific latent heat of vaporisation of water.



(a) In one experiment the current in the heater was 8.20 A, and the potential difference across the heater was 230 V.

(i) Show that the power of the heater was about 2 kW.

(2)

.....

.....

.....

(ii) There was 0.655 kg of water in the flask at an initial temperature of 22.5 °C.
The heater was switched on, and the water in the flask was heated to boiling point.

Calculate the minimum time taken for the water to be heated to 100.0 °C.

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

(3)

.....

.....

.....

.....

.....

Minimum time taken for water to be heated = ...

(b) The heater was left on and water continued to boil in the flask. The water was allowed to boil for a few minutes. The conical flask was then placed under the heat exchanger and water was collected in it.

(i) Give a reason why the water was left boiling for a few minutes before the conical flask was put in place.

(1)

.....

.....

.....

.....

(ii) Water with a mass of 95.0 g was collected in a time of 125 s.

Calculate the rate of energy transfer in the heat exchanger.

specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}

(3)

.....

.....

.....

.....

.....

Rate of energy transfer in the heat exchanger = ...

(iii) Discuss your answers to (a)(i) and (b)(ii).

(3)

.....

.....

.....

.....

.....

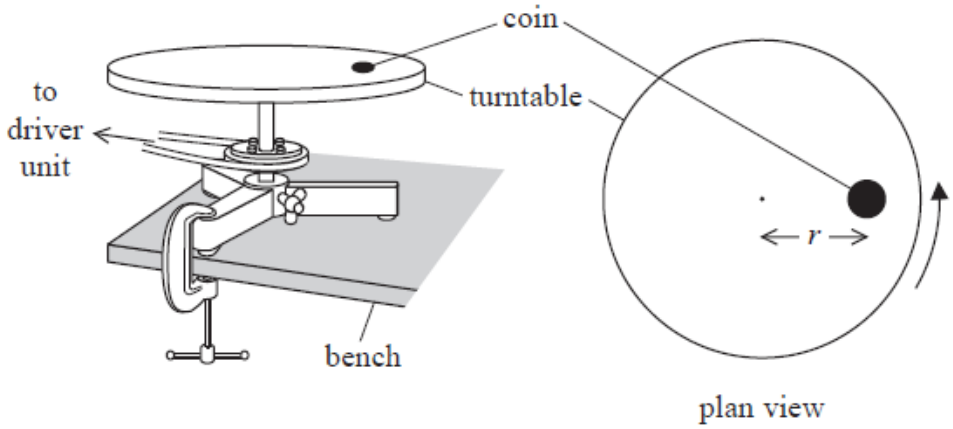
.....

(Total for question = 12 marks)

Q11.

A student was investigating the forces involved in circular motion.

He placed a small coin on a horizontal turntable as shown. The turntable was connected to a driver unit so that it could be rotated at a constant rate.



The student switched on the driver unit and increased the rate of rotation until the coin slid off the turntable. He read the angular velocity ω of the turntable from a digital display on the driver unit. He then replaced the coin in the original position on the turntable and repeated the procedure.

His results are shown.

ω / rad s^{-1}				
0.125	0.112	0.118	0.123	0.116

(i) The student used the results to calculate a mean value of ω.

State the purpose of calculating a mean.

(1)

.....

(ii) Calculate the percentage uncertainty in the mean value of ω.

(3)

.....

.....

.....

.....

.....

Percentage uncertainty = ...

(iii) The student used ω and r to calculate the centripetal acceleration of the coin at the instant it started to slide.

Calculate the percentage uncertainty in this centripetal acceleration.

(3)

.....

.....

.....

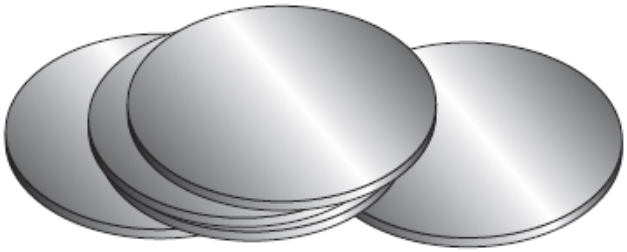
.....

Percentage uncertainty = ...

(Total for question = 7 marks)

Q12.

A student is investigating the properties of steel. He has fifty steel discs available.



Each disc has a diameter $d \approx 1.3$ cm and a thickness $t \approx 2$ mm.

The measured uncertainty in d is ± 0.1 mm and the measured uncertainty for t is ± 0.05 mm.

Determine the percentage uncertainty in the calculated volume of the disc.

(3)

.....

.....

.....

.....

.....

.....

.....

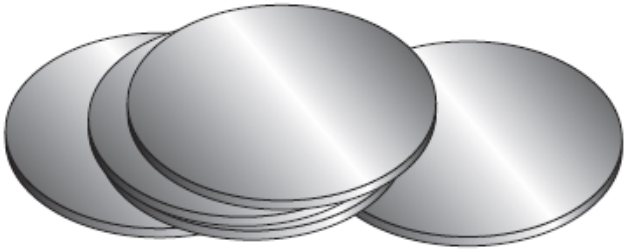
.....

Percentage uncertainty in volume = ...

(Total for question = 3 marks)

Q13.

A student is investigating the properties of steel. He has fifty steel discs available.



Each disc has a diameter $d \approx 1.3$ cm and a thickness $t \approx 2$ mm.

A balance which can measure mass with a resolution of 0.2 g is available.

Determine the minimum number of discs that should be placed on the balance together if the percentage uncertainty in the measurement of the mass is to be less than 0.5%.

(4)

density of steel = 7900 kg m^{-3}

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Minimum number of discs = ...

(Total for question = 4 marks)

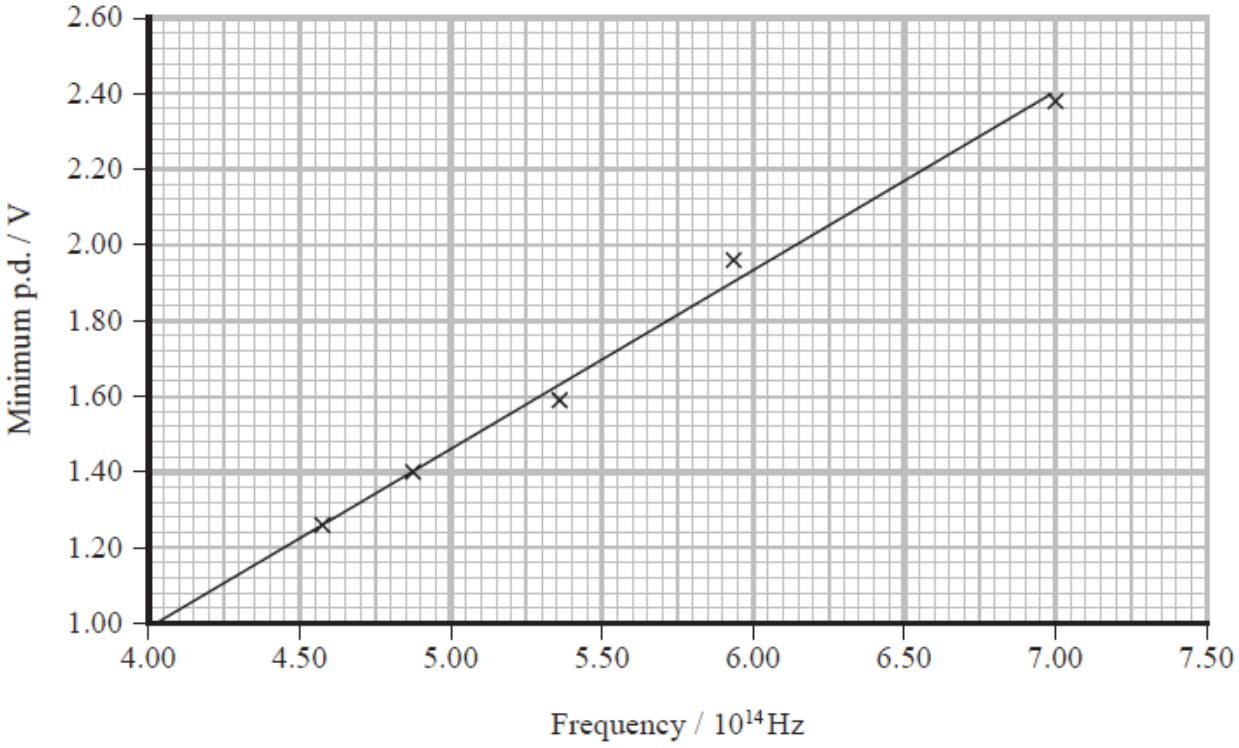
Q14.

The Planck constant can be determined in a school laboratory using light emitting diodes (LEDs).

An LED emits light when the potential difference (p.d.) across it is large enough to transfer sufficient energy to an electron to result in the emission of a photon.
The electron must have energy greater than or equal to the photon energy.

The minimum p.d. required to produce light from LEDs emitting different frequencies was measured by increasing the p.d. from zero until light was first seen.

The graph shows the results.



There are two problems with using LEDs to determine the Planck constant:

- when the p.d. is increased and the LED first emits light it is difficult to see
- the LEDs do not emit a single frequency but also light of frequencies slightly above and below the recorded frequency.

Discuss the extent to which these problems are consistent with obtaining a result from this graph for the Planck constant which is higher than the accepted value.

(3)

.....

.....

.....

.....

.....

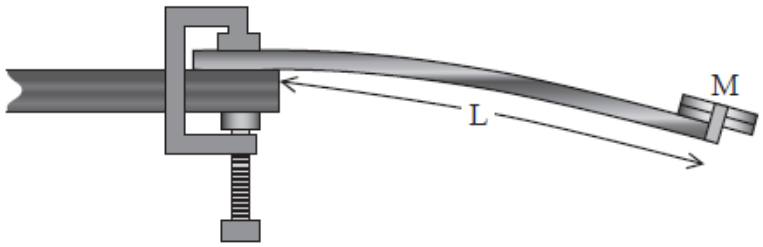
.....

.....

(Total for question = 3 marks)

Q15.

A metre rule clamped at one end is an example of a cantilever. The diagram shows an arrangement of a cantilever where a mass *M* is attached to the end of a metre rule and the rule clamped with a free length *L*.



When *M* is displaced, the period of oscillation *T* of the cantilever is related to *L* and the Young modulus *E* of the material of the metre rule by the following equation:

$$T^2 = \frac{KML^3}{E}$$

where *K* is a constant.

A student uses this arrangement to compare the Young modulus values for two metre rules. The metre rules have identical dimensions, but are made from different types of wood.

(a) One of the metre rules is set into oscillation, and the time for 20 oscillations is measured with an electronic stopwatch. This is repeated twice with the same metre rule. The same procedure is carried out for the second metre rule, using an identical mass and free length.

(i) Explain why a pointer placed at the equilibrium position of the end of the metre rule would

help the student to obtain repeatable data.

(2)

.....

.....

.....

.....

(ii) The student collects the following data.

	Time for 20 oscillations t_1 / s	Time for 20 oscillations t_2 / s	Time for 20 oscillations t_3 / s
Metre rule 1	19.3	19.1	19.3
Metre rule 2	21.3	21.5	21.5

Use this data to calculate a value for the ratio E_2/E_1 of the Young modulus values of the two metre rules.

(3)

.....

.....

.....

.....

.....

.....

E_2/E_1 = ...

(b) The student intends to use a graphical method to determine a value for the Young modulus of one of the metre rules. She decides that she will vary the free length L and measure the time period for each length.

(i) State what variables she should plot.

(1)

y-axis

.....

x-axis

.....

(ii) Explain how the student can use her graph to determine the Young modulus of the rule.

You may assume that she has been provided with the value of *K*.

(2)

.....

.....

.....

.....

(c) Explain what the student could do to reduce the uncertainty in her measurement of the time period.

(2)

.....

.....

.....

.....

(Total for question = 10 marks)

Q16.

A student is carrying out an experiment to determine a value for the acceleration due to gravity *g*. He drops a ball from various heights, which he measured with a metre rule.
The ball has a built in timer which starts when the ball is released and stops when the ball hits the ground.



The student starts by releasing the ball from a height of 1.00 m and measures the time taken for the ball to fall. He repeats this twice.

t_1 /s	t_2 /s	t_3 /s
0.45	0.51	0.43

(a) Use the student's data to calculate a value for *g*.

(3)

.....

.....

.....

.....

.....

g = ...

(b) Estimate the percentage uncertainty in your value for *g*.

(3)

.....

.....

.....

.....

.....

Percentage uncertainty = ...

(c) The student then measured the time interval for the ball to fall from a 3.00 m height. Explain how this would improve the value obtained for *g*.

(2)

.....

.....

.....

.....

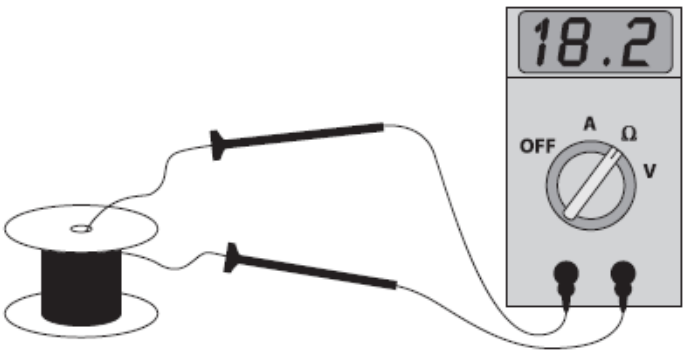
.....

(Total for question = 8 marks)

Q17.

A student carried out an experiment to determine the resistivity of nichrome wire.

He used an ohmmeter to measure the resistance of a length of nichrome wire as shown.



The diameter of the wire was measured as 0.27 mm ± 0.01 mm.
The length of the wire was measured as 1.25 m ± 0.05 m.

Explain how the student could reduce the uncertainty in the measurement of the diameter.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q18.

A student released a ping pong ball in front of a metre rule and used a phone camera to record the motion of the ball as it fell. The phone camera captures 60 images per second, which may be played back one image at a time.

The ball was dropped from a height such that it reached its terminal velocity as it passed the metre rule.

(i) Explain how the terminal velocity of the ball could be determined using the phone camera recording.

(4)

.....

.....

.....

.....

.....

.....

(ii) Explain how a systematic error could affect the value obtained for the terminal velocity.

(2)

.....

.....

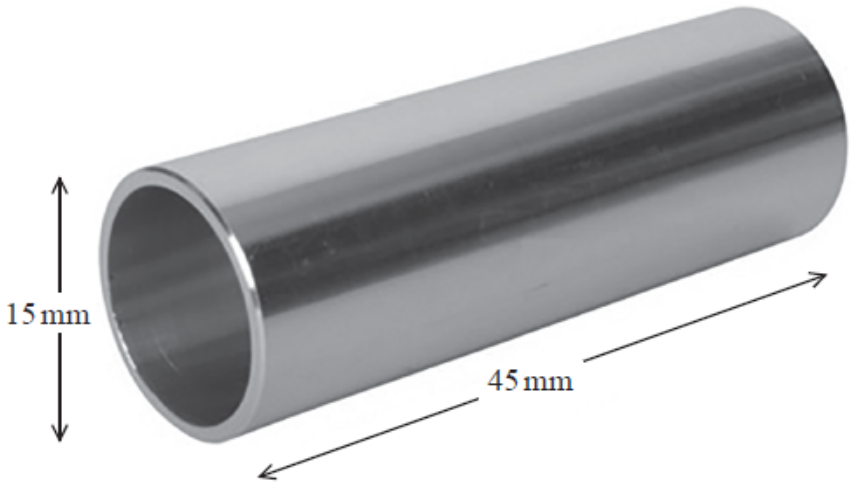
.....

.....

(Total for question = 6 marks)

Q19.

An engineer was checking the dimensions of a steel tube. The tube had a length of about 45 mm and an external diameter of about 15 mm as shown.



She used a digital micrometer to measure the diameter of the tube. Before taking the reading she closed the jaws of the micrometer to check for a zero error.

State the type of error she avoided by doing this.

(1)

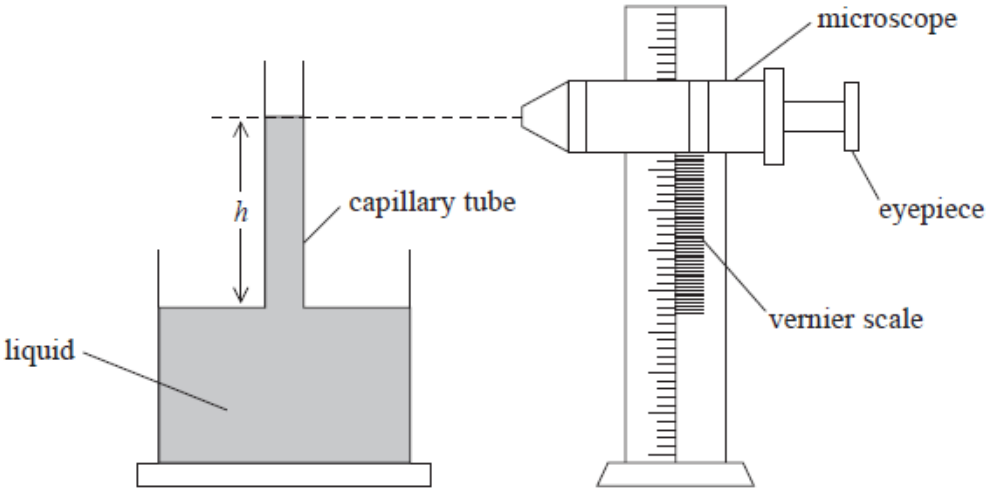
.....

(Total for question = 1 mark)

Q20.

A student measured the height *h* of a liquid column in a capillary tube. She used a travelling microscope to make measurements of the positions of the top and bottom of the liquid column.

The travelling microscope consists of a simple microscope that can be moved vertically along a vernier scale.



The student used a capillary tube with an internal radius r equal to 0.10 mm and recorded the following readings from the vernier scale.

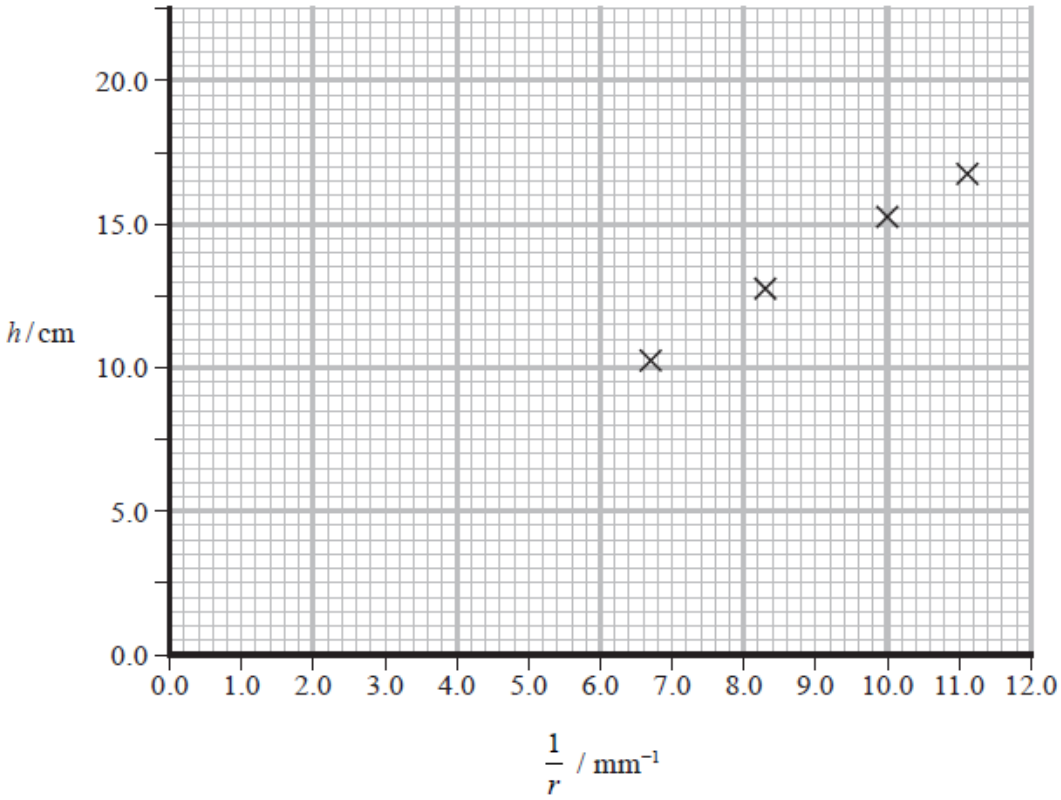
Bottom of liquid column / cm	Top of liquid column / cm
12.00	27.10

The student repeated the measurement of h for capillary tubes of different radii.

The table shows the student's final data.

r / mm	$1/r$	h / cm
0.09	11.1	16.56
0.10	10.0	15.1
0.12	8.3	12.6
0.15	6.7	10.33

The student plotted the following graph.



(i) Determine the height of the liquid column that the student could expect for a tube with an internal radius of 0.11 mm.

(3)

.....

.....

.....

.....

.....

.....

Height of liquid column = ...

(ii) In her notes it stated that

$$h = \frac{k}{r} \qquad \text{where } k \text{ is constant}$$

Assess the extent to which the student's data supports this relationship.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 7 marks)

Q1.

A student carries out an experiment to investigate the stretching of a liquorice lace.

(a) The student fixes one end of the lace to a support and adds different masses to the end of it, measuring the extension each time with a metre rule. His results are shown in the table.

Mass/kg	Force/N	Extension/m
0.03	0.294	0.005
0.04	0.392	0.0075
0.06	0.589	0.011
0.07	0.687	0.012

Criticise the recording of these results.

(3)

.....

.....

.....

.....

.....

.....

(b) Describe how the student should measure the extension of the lace to make his results as accurate as possible.

(2)

.....

.....

.....

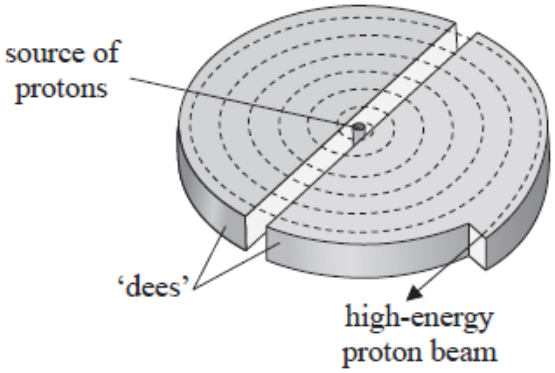
.....

(Total for question = 5 marks)

Q2.

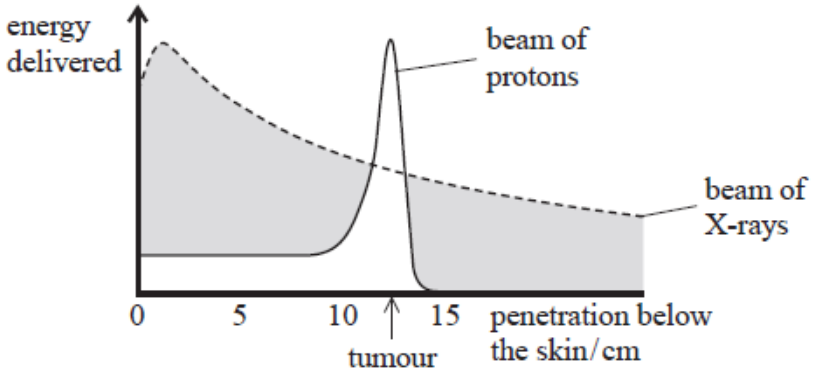
Proton beam therapy is being introduced in the UK as a new cancer treatment.

A beam of protons is accelerated by a cyclotron to an energy of 23 MeV and is then focused onto a tumour.



Conventional treatment may use X-rays to deliver energy to a tumour.

The graph shows the variation of energy delivered with penetration below the skin for a beam of protons and a beam of X-rays.



Deduce why the beam of protons could be a more effective treatment for tumours than a beam of X-rays.

(2)

.....

.....

.....

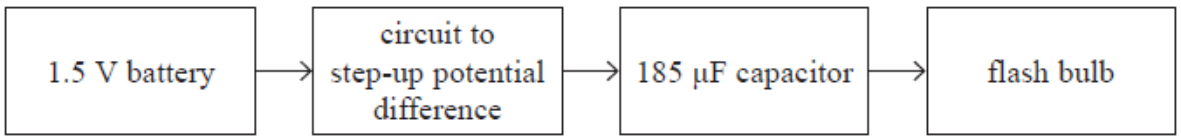
.....

(Total for question = 2 marks)

Q3.

* Cameras usually have an inbuilt flash bulb that can be used to take photographs in poor light conditions. As a photograph is taken, the bulb should be able to produce a bright flash of light for up to 4 ms.

A capacitor can be used along with a battery as a power supply for the flash bulb. The flow diagram shows a possible arrangement.



Comment on the suitability of using this capacitor arrangement as a power supply rather than connecting the bulb directly to the battery.

A typical flash bulb has a resistance of 6 Ω.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q4.

(a) A magnetic field can be measured with a device called a Hall probe. The probe is connected to a voltmeter. When the probe is placed at right angles to a magnetic field, a potential

difference is recorded on the voltmeter. The potential difference increases with increasing magnetic flux density.

A wire carries a constant current. A Hall probe is used to investigate how the magnetic flux density produced by the wire varies with distance from the wire.

The potential difference V was recorded for a range of distances r.

r/cm	V/V
1.0	0.725
1.5	0.483
2.0	0.363
2.5	0.29
3.0	0.242
3.5	0.21

(i) Criticise these results.

(2)

.....

.....

.....

.....

.....

(ii) It is suggested that V and r are related by the equation

$$V = \frac{k}{r}$$

where k is a constant.

(1) Determine by calculation whether this suggestion is valid.

(2)

.....

.....

.....

.....

.....

(2) A graph of

$\frac{1}{V}$ is plotted against r.

State how the graph would indicate that the equation is correct.

(1)

.....

.....

.....

(b) The Hall probe can be replaced with a small coil of wire which is connected to a sensitive voltmeter. The plane of the coil is at right angles to the magnetic field produced by the current-carrying wire.

(i) Explain, with reference to Faraday's law, why the voltmeter reading would be zero.

(2)

.....

.....

.....

.....

(ii) State **three** different ways in which an e.m.f. could be induced in this coil.

(3)

.....

.....

.....

.....

(Total for question = 10 marks)

Q5.

The photograph shows a 'quiet boil' electric kettle. The makers of the kettle claim that it boils water with much less noise than a standard kettle.



A laboratory technician takes some measurements to compare a 'quiet boil' electric kettle with a standard electric kettle.

The table shows the results recorded by the technician.

	Quiet boil kettle	Standard kettle
Mass of water / kg	1.20	1.20
Initial temperature of water / °C	10	10
Final temperature of water / °C	100	100
Potential difference / V	243	247
Current / A	11.9	11.8
Time taken to heat water to boiling point / s	168	172
Average sound intensity / mW m^{-2}	3.72	10.5

A student uses the values in the table to calculate the efficiency of each kettle at heating the water to boiling point. He calculates the efficiency of the 'quiet boil' kettle to be 0.93

Calculate the efficiency of the standard kettle.

specific heat capacity of water = 4180 J kg^{-1} K^{-1}

(4)

.....

.....

.....

.....

.....

.....

.....

Efficiency = ...

(b) The intensity of the sound produced by each kettle was measured with a sound meter which was 30.0 cm from the centre of the kettle.

Calculate the energy transferred by sound while the water in the standard kettle is brought to the boil. You may treat the kettle as a point source.

(4)

.....

.....

.....

.....

.....

.....

.....

Energy transferred = ...

(c) The label on the original packaging of the quiet boil electric kettle states, 'This kettle is much more efficient than a standard kettle because it produces less sound.'

Explain the extent to which this statement is supported by your calculations.

(2)

.....

.....

.....

.....

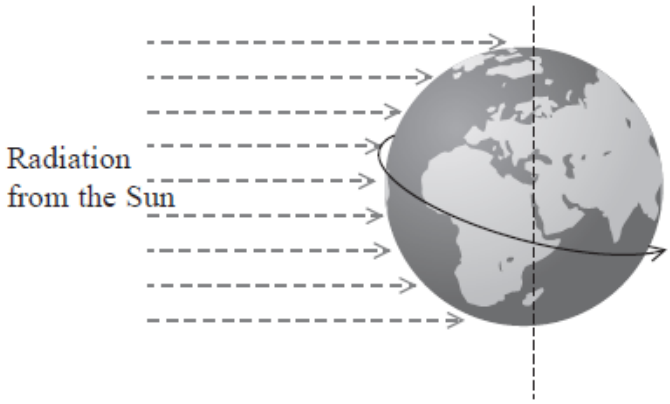
.....

(Total for question = 10 marks)

Q6.

Solar panels consisting of combinations of photovoltaic cells use energy in the radiation received from the Sun to generate electricity.

The average intensity of radiation from the Sun incident at the Earth's surface over a 24-hour period has been determined to be 164 W m^{-2}.



(i) The average intensity of radiation from the Sun at the Earth's surface is much less than the intensity incident at the top of the Earth's atmosphere.

Explain why.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) It is claimed that the area of solar panels needed to generate 100 GW of power is about 0.5% of the surface area of the Earth.

Assess the validity of this claim.

radius of Earth = 6.4 × 10^6 m

typical efficiency of solar panels = 25%

(4)

.....

.....

.....

.....

.....

.....

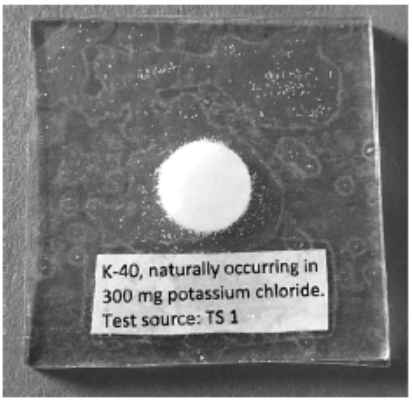
.....

.....

(Total for question = 8 marks)

Q1.

A school science department keeps a sample of potassium chloride to use as a test source for Geiger-Müller tubes.



Potassium contains 0.012% of the unstable isotope potassium-40.

The science department also has a sample of strontium-90. This undergoes beta decay with a half-life of 29 years.

State why the half-life of potassium-40 makes the potassium chloride a more suitable material than strontium-90 for the test.

(1)

.....

.....

.....

.....

(Total for question = 1 mark)

Q2.

A magician did a trick which he claimed was the most dangerous ever. He positioned himself midway between two charged spheres which were separated by a distance of about two metres. Each sphere was charged to a potential that would cause ionisation at a distance of one metre. He wore a protective suit of chain mail and a helmet consisting of a metal cage. The protective suit and helmet were earthed to a potential of 0 V.



A scientist said "there is no danger in this and I would happily do it tomorrow".

Explain whether this statement is justified.

(3)

.....

.....

.....

.....

.....

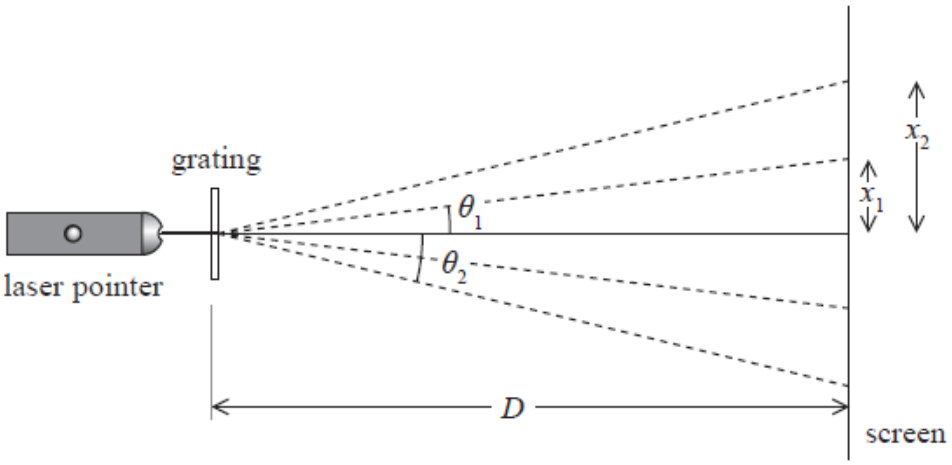
.....

.....

(Total for question = 3 marks)

Q3.

A student is using a diffraction grating to determine the wavelength of the light emitted by a laser pointer. The light from the laser pointer is directed so that it is normal to the plane of the grating. The diffracted light is viewed on a screen a distance *D* from the grating.



The diagram shows the first two diffracted orders where x_1 and x_2 are the distances of the maxima for these orders from the central maximum of the diffraction pattern.

(a) Before carrying out the experiment, the student carries out a risk assessment to ensure that the experimental procedure is safe.

Explain one precaution that should be taken.

(2)

.....

.....

.....

.....

(b) The student measures the distances from the central maximum of the diffraction pattern for various diffracted orders n, using a metre rule.

n	x_n / cm	θ / °	sin θ
0	0	0.00	0.000
1	35.5	11.4	0.20
2	74		
3	126.5	35.9	0.586
4	211	50.4	0.771

(i) Criticise the results that are recorded.

(1)

.....

.....

.....

(ii) Complete the data for the 2nd order maximum.

D = 1.750 m

(2)

.....

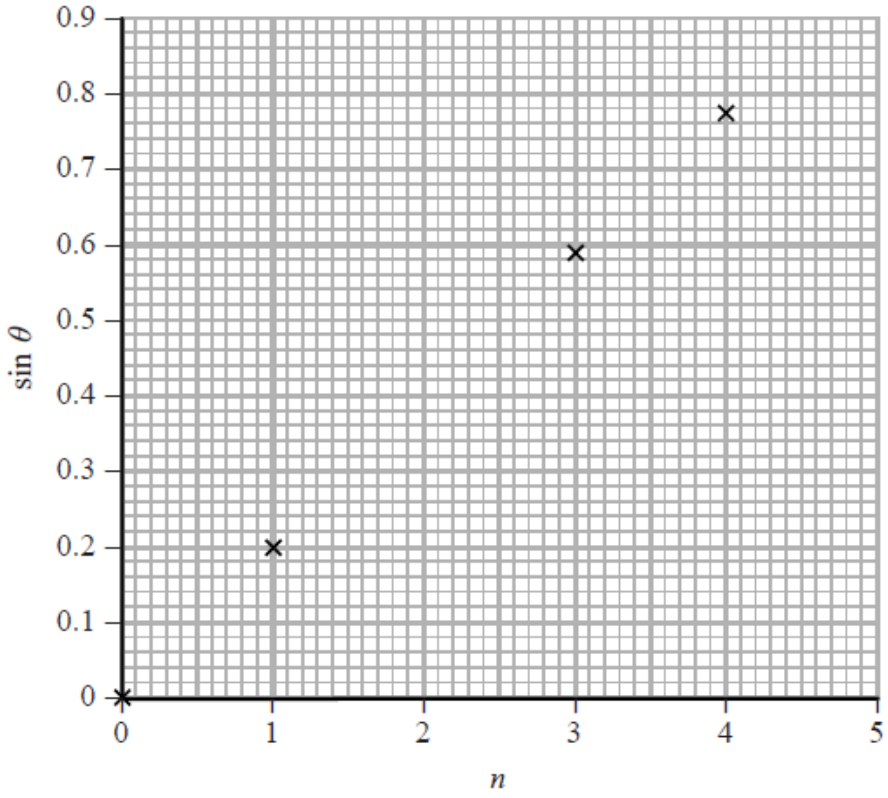
.....

.....

.....

(iii) Add your data to the axes and draw a line of best fit.

(1)



(iv) Use your graph to determine a value for the wavelength of the laser light.
The grating has 300 lines per mm

(5)

.....

.....

.....

.....

.....

.....

.....

.....

Wavelength = ...

(c) State and justify two modifications to the experimental method which would have improved the accuracy of the value obtained for the wavelength.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 15 marks)

Q4.

In 2015 the Messenger spacecraft crashed into the surface of the planet Mercury after four years in orbit observing the surface of Mercury.

Messenger's orbit was highly elliptical, varying between 200 km and 15 000 km above the surface of Mercury. Messenger completed one full orbit every 12 hours.

mass of Messenger spacecraft = 565 kg
mass of planet Mercury = 3.30×10^{23} kg
radius of planet Mercury = 2430 km

It has been suggested that the same orbital period of about 12 hours could have been achieved if Messenger was in a circular orbit 7690 km above the surface of Mercury.

(i) Determine whether this suggestion is correct.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) The elliptical orbit chosen had advantages over this circular orbit.

Explain **one** advantage.

(2)

.....

.....

.....

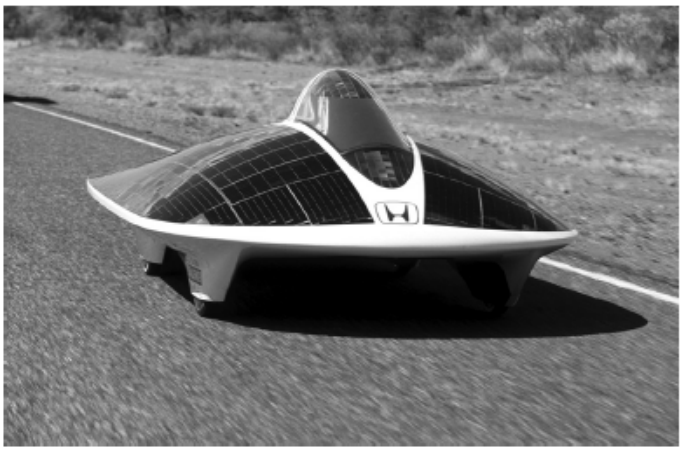
.....

(Total for question = 6 marks)

Q5.

The world solar challenge is set every two years, in Australia. The challenge is to complete a three thousand kilometre route with a vehicle powered only by the Sun.

Vehicles have their surfaces fitted with solar panels, as shown in the photograph.



(Source: © LAURENT DOUEK/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY)

Solar power alone would not be suitable for a family car because it is not sunny all the time.

Give two further reasons why solar power alone would not be suitable.

(2)

.....

.....

.....

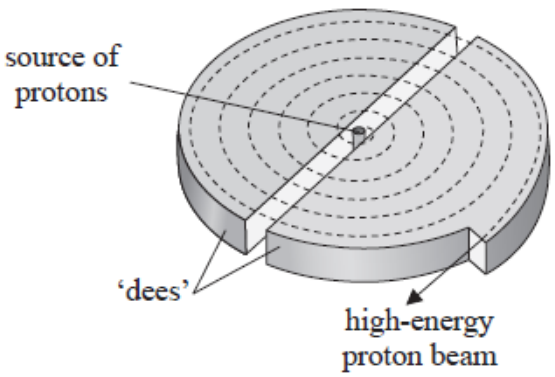
.....

(Total for question = 2 marks)

Q6.

Proton beam therapy is being introduced in the UK as a new cancer treatment.

A beam of protons is accelerated by a cyclotron to an energy of 23 MeV and is then focused onto a tumour.



Developing new cancer treatments is expensive.

Give two possible reasons why money should be provided for the development of this new cancer treatment.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q7. On 1st November 2006, the former Russian spy Alexander Litvinenko fell ill. Twenty one days later he died from the radiation effects of polonium-210. Experts suggest that as little as 0.89 μg of polonium-210 would be enough to kill, although Mr Litvinenko's death was linked to a much larger dose of the radioactive isotope. Traces of the isotope were later found in washrooms at five locations around London visited by the Russian.

Polonium-210 has a half life of 138 days.

(a) (i) In a 0.89 μg sample of polonium-210 there are 2.54×10^{15} atoms of polonium. Show that the decay constant for polonium-210 is about 6×10^{-8} s^{-1}, and hence calculate the activity of a sample of this size.

(4)

.....

.....

.....

.....

.....

Activity = ...

(ii) Calculate the fraction of polonium-210 nuclei that have decayed after a time of 21 days.

(3)

.....

.....

.....

.....

Fraction decayed = ...

(b) Polonium-210 emits alpha particles. Explain why polonium-210 is virtually harmless unless it is taken into the body.

(2)

.....

.....

.....

.....

(c) (i) Complete the equation below for the decay of polonium.

(2)

$$^{210}_{84}\text{Po} \rightarrow \text{____}\text{Pb} + \text{____}\alpha$$

(ii) State why the Pb nuclei would recoil from the alpha particles emitted during the decay.

(1)

.....

.....

.....

(d) Radioactive decay is said to occur spontaneously and randomly. Explain what is meant by spontaneous and random in this context.

(2)

Spontaneous

.....

.....

.....

Random

.....

.....

.....

(e) Suggest why traces of the isotope were found in locations visited by the Russian.

(2)

.....

.....

.....

.....

(Total for Question = 16 marks)

Q8.

Positron emission tomography (PET) is a nuclear medicine imaging technique. Pairs of gamma rays, produced when positrons from a radioisotope annihilate with electrons, are detected to form the image.

Radioisotopes used in PET scanning are typically isotopes with short half-lives such as carbon-11. Carbon-11 has a half-life of 1220 s and decays by positron emission to stable boron-11. Positrons are the antiparticles to electrons.

(a) Explain what is meant by a radioactive atom.

(2)

.....

.....

.....

.....

(b) Complete the equation for the decay of carbon-11.

$$^{11}_{6}\mathrm{C} \rightarrow \text{.....}\mathrm{B} + \text{.....}\mathrm{e}^{+} + {}^{0}_{0}\nu_{e}$$

(2)

(c) Calculate the energy in joules released in a positron decay of carbon-11.

	Mass / MeV/c^2
positron	0.511
carbon	10 253.6
boron	10 252.2

(3)

.....

.....

.....

.....

.....

Energy = ... J

(d) Explain why carbon-11 is a relatively safe radioisotope to use within the body.

(2)

.....

.....

.....

.....

(e) A patient was injected intravenously with a radioactive compound containing carbon-11 with an activity of 1.58×10^6 Bq.

The sample was prepared 3600 s before it was administered to the patient.

Calculate the activity of the sample when it was prepared.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

Activity of the sample = ...

(Total for Question = 13 marks)

Q9.

The photograph shows the containers of two radioactive sources kept in a school.



The school is required to make a safety inspection of the sources every year.

(i) Explain how the sources can be tested to ensure that each source is in the correct container.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Explain a safety precaution that must be applied during this procedure.

(2)

.....

.....

.....

.....

Q10.

In March 2011, a nuclear meltdown occurred at the Fukushima Nuclear Power Plant and radioactive materials were released into the environment.

A month later, seaweed off the coast near Long Beach, California was found to be contaminated with iodine-131, a radioisotope that decays by emitting β particles. In one sample the activity was found to be 2.5 Bq per gram of dry seaweed.

(a) State what is meant by the activity of a radioactive source.

(1)

.....

.....

(b) A Geiger counter is used to measure the count from a sample of seaweed over a period of 10 minutes. The corrected readings obtained are shown in the table below.

Corrected count 1	Corrected count 2	Corrected count 3	Corrected count rate / Bq
3820	3830	3825	6.38

(i) State why the readings obtained from the Geiger counter have to be corrected.

(1)

.....

.....

(ii) Explain why the radioactive count is repeated.

(2)

.....

.....

.....

.....

.....

(iii) The measurements were repeated with the same sample of seaweed 30 days later. Calculate the new corrected count rate of the sample.

half-life of iodine-131 = 8.0 days

(3)

.....

.....

.....

.....

.....

New corrected count rate = ...

(iv) There is a moderate risk to the public from the accumulation of iodine-131 in the seaweed. Explain why.

(2)

.....

.....

.....

.....

(Total for question = 9 marks)

Q1.

The power of the lens in the human eye changes as the lens changes shape. This enables a person to see objects at different distances clearly. To change the shape, muscles in the eye put the lens under stress.

A teacher was modelling the human eye. He placed an object 60 cm from a converging lens system. A real image of the object was observed with a magnification of 0.5

The converging lenses that were available to the teacher had powers of 2D, 3D and 4D.

Deduce which lens, or combination of lenses, the teacher used.

(4)

.....

.....

.....

.....

.....

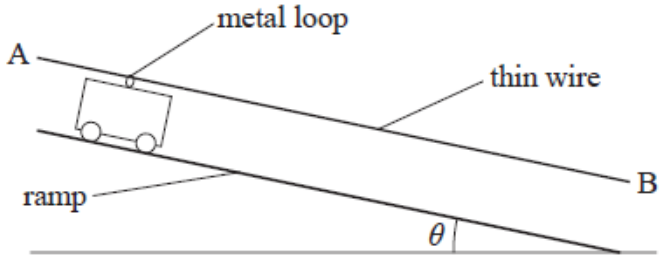
.....

(Total for question = 4 marks)

Q2.

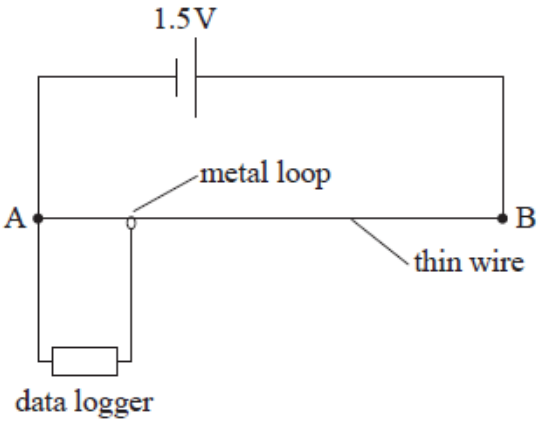
A student investigates the motion of a friction-free trolley down a ramp. On the top of the trolley there is a metal loop which makes contact with a length of thin resistance wire, AB, fixed above the ramp. The resistance wire has a uniform diameter.

The trolley accelerates down the ramp and the metal loop stays in contact with the wire along the full length of the ramp.



The student uses a protractor to measure the angle θ between the ramp and the horizontal and records a value of 4° with an uncertainty of ±1°.

(a) The two ends of the wire are connected to a 1.5 V cell. A data logger, set to measure potential difference, is connected to the metal loop and to the negative terminal of the cell.



Explain how the potential difference recorded by the data logger will vary as the loop moves along the length of the
wire AB.

(3)

.....

.....

.....

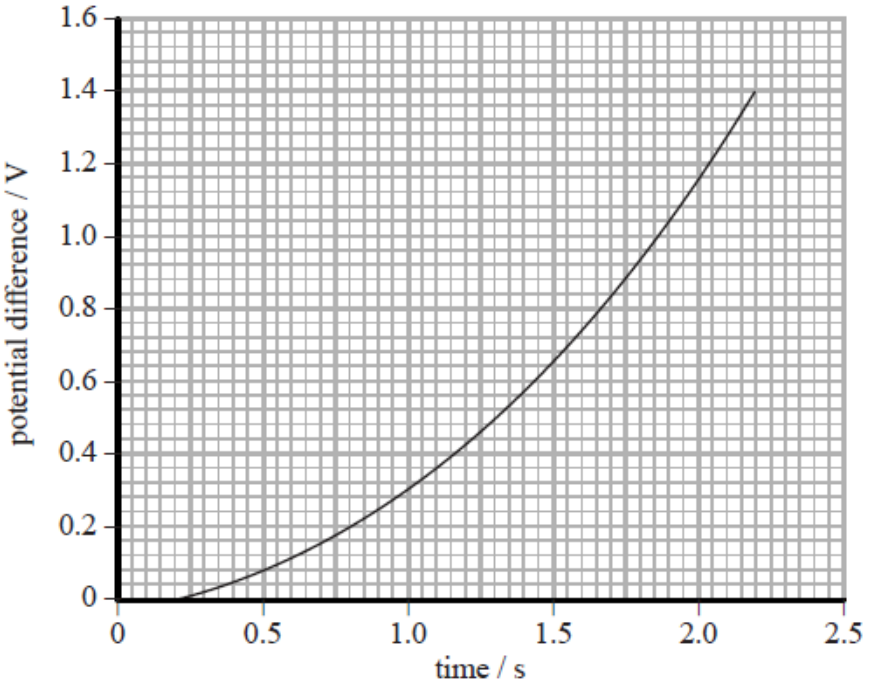
.....

.....

.....

.....

(b) The graph shows the data obtained from the data logger.



Determine the velocity of the trolley at 1.5 s.

1.5 V represents a distance of 2.00 m.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

Velocity = ...

(c) The student calculated the velocity of the trolley at 2.0 s to be 1.5 m s^{-1}.

By considering the acceleration of the trolley, determine whether the student's measurement of θ was within the uncertainty quoted.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q3.

A mobile phone is powered by a lithium-ion battery. The information shown is taken from the battery.

3.82 V
6.91 W h

The mobile phone, when purchased, was supplied with a charging plug marked 1 A, 5V. The mobile phone owner lost the original charging plug and replaced it with a charging plug marked 0.5 A, 5 V.



original charging plug
1A, 5 V



replacement charging plug
0.5A, 5 V

By evaluating the information given, discuss the suitability of using the replacement charging plug for this mobile phone. Include references to possible benefits, disadvantages and risks associated with using the replacement charging plug.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q4.

When tidying a prep room, a teacher discovers a tray of resistance wires that have lost their labels. She decides to ask her students to carry out experiments to determine the material that each wire is made of by measuring the resistivity of the wires.

(a) Explain why the teacher asks the students to measure the resistivity and not the resistance of the wires.

(2)

.....

.....

.....

.....

*(b) You are to describe a method to determine accurately the resistivity of one of the metal wires.

Your description should include:

- the circuit diagram you would use
- the quantities you would measure
- the graph you would plot
- how you would determine the resistivity

(9)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q5.

One region of Australia decided to trial the removal of the speed limit on some roads.

The following statements were made in an online forum discussing this issue.

> Comment
>
> *"If a car was going faster, it would have better fuel economy. A lot of modern cars have engines that are more efficent at 200 km h^{-1} than at 100 km h^{-1}."*
>
> Reply
>
> *"You confuse efficiency with fuel consumption. You cannot get better fuel economy at higher speeds."*

Justify the statement in the reply.

(3)

.....

.....

.....

.....

.....

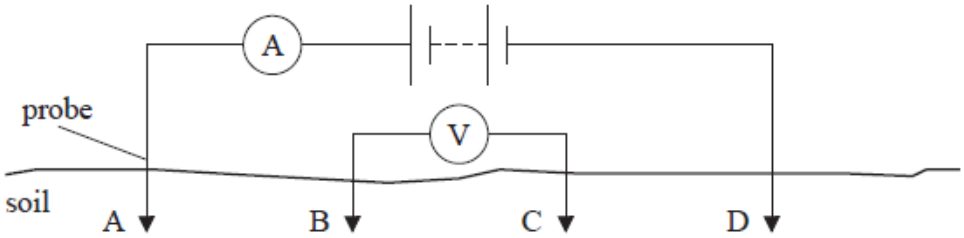
.....

(Total for question = 3 marks)

Q6.

Archaeologists use resistivity surveying of soil to search for the remains of buildings and settlements under the ground.

A basic arrangement that can be used to determine the resistivity of a region of soil is shown.



Probes are placed at positions A and D so that the length AD of soil forms part of the circuit. The ammeter measures the current through the soil.

A second pair of probes connected to a voltmeter is placed at positions B and C.
This measures the potential difference between positions B and C in the soil.

The table gives the resistivity of some different materials.

Material	Resistivity / Ωm
Undisturbed clay	4–20
Compacted clay	100–200
Limestone	500–1000
Sandstone	1500–10 000

The probes connected to the voltmeter are kept at a constant separation of 0.75 m and are moved along the soil between positions A and D.

The current is constant at 9.5 mA. The voltmeter reading varies between 1.8 V and 8.0 V.

It can be assumed that the sample of soil under investigation has a cross-sectional area of 0.65 m^2.

Deduce two possible materials that could be present in the soil between positions A and D.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q7. On 1st November 2006, the former Russian spy Alexander Litvinenko fell ill. Twenty one days later he died from the radiation effects of polonium-210. Experts suggest that as little as 0.89 μg of polonium-210 would be enough to kill, although Mr Litvinenko's death was linked to a much larger dose of the radioactive isotope. Traces of the isotope were later found in washrooms at five locations around London visited by the Russian.

Polonium-210 has a half life of 138 days.

(a) (i) In a 0.89 μg sample of polonium-210 there are 2.54×10^{15} atoms of polonium. Show that the decay constant for polonium-210 is about 6×10^{-8} s^{-1}, and hence calculate the activity of a sample of this size.

(4)

.....

.....

.....

.....

.....

Activity = ...

(ii) Calculate the fraction of polonium-210 nuclei that have decayed after a time of 21 days.

(3)

.....

.....

.....

.....

Fraction decayed = ...

(b) Polonium-210 emits alpha particles. Explain why polonium-210 is virtually harmless unless it is taken into the body.

(2)

.....

.....

.....

.....

(c) (i) Complete the equation below for the decay of polonium.

(2)

$$^{210}_{84}\text{Po} \rightarrow \text{.....Pb} + \text{.....}\alpha$$

(ii) State why the Pb nuclei would recoil from the alpha particles emitted during the decay.

(1)

.....

.....

.....

(d) Radioactive decay is said to occur spontaneously and randomly. Explain what is meant by spontaneous and random in this context.

(2)

Spontaneous

.....

.....

.....

Random

.....

.....

.....

(e) Suggest why traces of the isotope were found in locations visited by the Russian.

(2)

.....

.....

.....

.....

(Total for Question = 16 marks)

Q8.

Positron emission tomography (PET) is a nuclear medicine imaging technique. Pairs of gamma rays, produced when positrons from a radioisotope annihilate with electrons, are detected to form the image.

Radioisotopes used in PET scanning are typically isotopes with short half-lives such as carbon-11. Carbon-11 has a half-life of 1220 s and decays by positron emission to stable boron-11. Positrons are the antiparticles to electrons.

(a) Explain what is meant by a radioactive atom.

(2)

.....

.....

.....

.....

(b) Complete the equation for the decay of carbon-11.

$$^{11}_{6}C \rightarrow \text{.....}B + \text{.....}e^{+} + {}^{0}_{0}\nu_{e}$$

(2)

(c) Calculate the energy in joules released in a positron decay of carbon-11.

	Mass / MeV/c^2
positron	0.511
carbon	10 253.6
boron	10 252.2

(3)

.....

.....

.....

.....

.....

Energy = ... J

(d) Explain why carbon-11 is a relatively safe radioisotope to use within the body.

(2)

.....

.....

.....

.....

(e) A patient was injected intravenously with a radioactive compound containing carbon-11 with an activity of 1.58×10^6 Bq.

The sample was prepared 3600 s before it was administered to the patient.

Calculate the activity of the sample when it was prepared.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

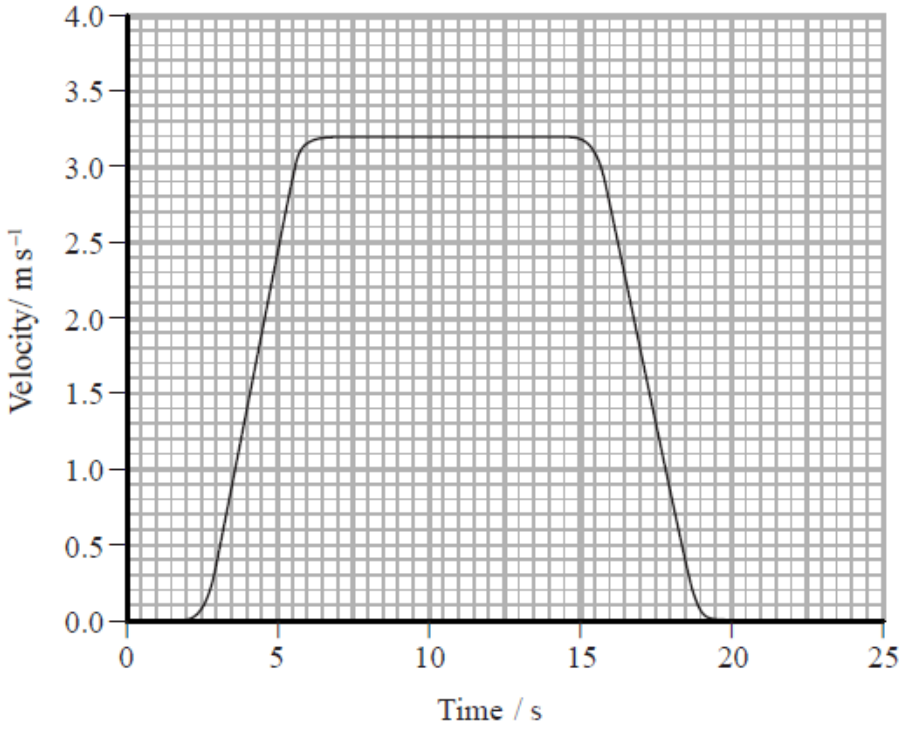
.....

Activity of the sample = ...

(Total for Question = 13 marks)

Q9.

A lift moves upwards from the ground to the tenth floor of a building. The velocity-time graph for the lift is shown.



The power developed by the lift when travelling upwards with different loads is shown in the table.

Number of passengers	Load / kg	Power developed when accelerating / kW	Power developed when at constant velocity / kW
0	0	34	25
1	75	39	28
2	150	44	31
3	225	49	34

(i) By considering the forces acting on the lift as it rises, discuss the difference in values for the power developed by the lift.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Lifts use a significant proportion of all total energy consumption of a building.

When designing the lift systems, engineers compare the predicted daily energy consumption of different lift motors by

- estimating the time for typical lift journey based on the number of floors in the building and the speed of the lift
- estimating the number of lift journeys per day
- using daily energy consumption = maximum power output of motor × number of journeys × time per journey

Discuss the advantages and disadvantages of using this method to compare the predicted energy consumption of different lift motors.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

Q10.

The maximum speed limit on motorways has not been raised since the 1960s.
However, developments in engineering mean that modern cars have much higher top speeds than cars in the past and can stop safely in shorter distances.

Discuss the risks and benefits of raising the maximum speed limits on motorways.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)