Name: ______________________________________

Topic 1: Working as a Physicist Part 4

Date:

Time:

Total marks available:

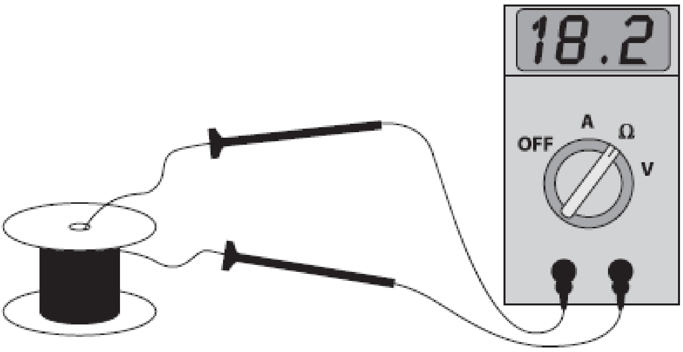
Total marks achieved: ______

Questions

Q1.

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)

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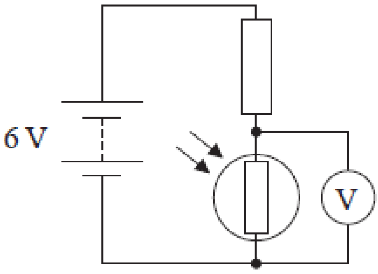
(Total for question = 2 marks)

Q2.

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

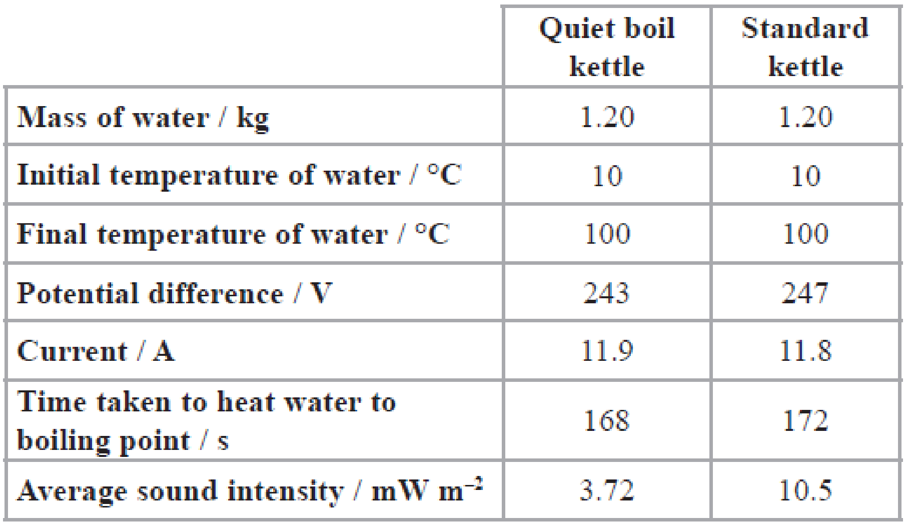
(Total for question = 1 mark)

Q3.

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)

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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)

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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)

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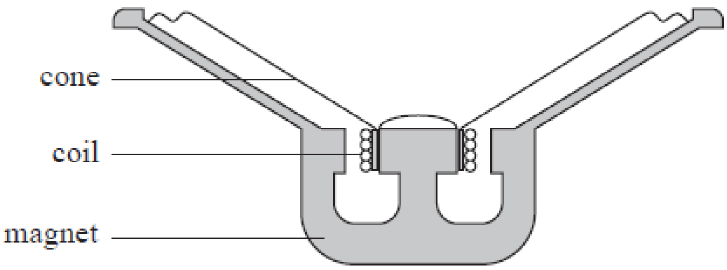
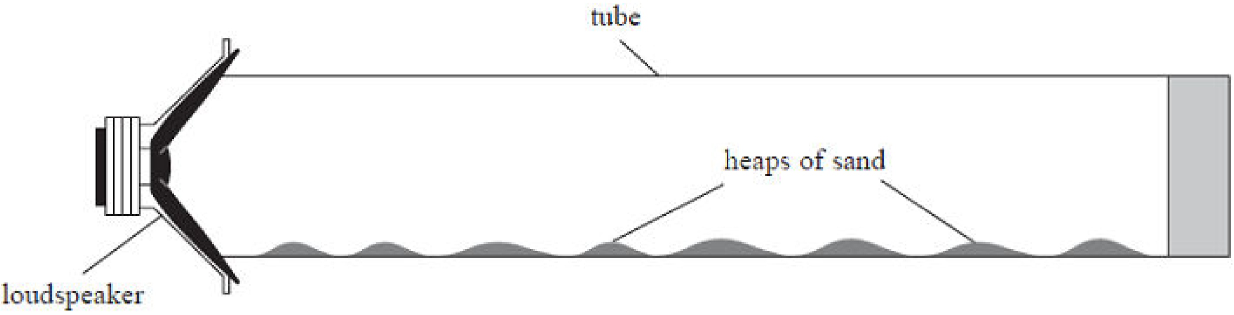
(Total for question = 10 marks)

Q4.

A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate. The loudspeaker is mounted in a wooden box. A cross-section through the loudspeaker is shown.



The student connected a signal generator to the loudspeaker, and placed the loudspeaker near to one end of a long tube containing sand. The student adjusted the signal generator until the sand collected in small heaps as shown.



(i) Explain why the sand collects in heaps.

(4)

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(ii) The student determined the distance *d* between the centres of adjacent heaps.

Describe the procedure she should follow to determine an accurate value for *d*.

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(iii) Assess whether the experimental data is consistent with a value for the speed of sound of 340 m s^{-1}.

signal generator frequency = 3.25 kHz.

d = 5.1 cm

(3)

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(Total for question = 10 marks)

Q5.

A student determined the specific heat capacity of aluminium.

She used an electrical heater to heat an aluminium block and measured the temperature of the block with a digital thermometer.

She connected the electrical heater into a circuit and took measurements to determine the power of the heater.

Draw a circuit diagram of a suitable circuit.

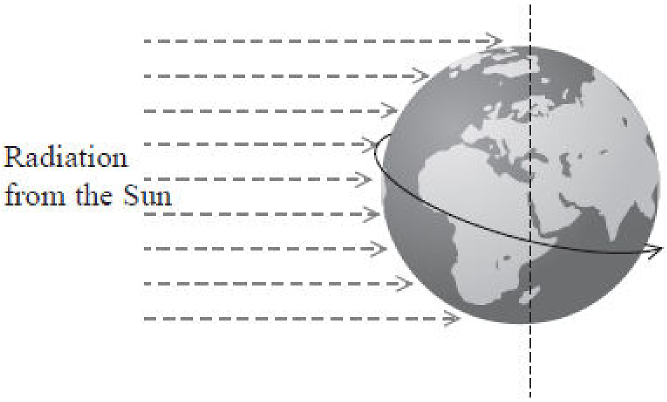
(2)

(Total for question = 2 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 $164\,\mathrm{W\,m^{-2}}$.



(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)

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(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)

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(Total for question = 8 marks)

Q7.

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)

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

(2)

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(Total for question = 6 marks)

Q8.

The Beaufort scale is used to describe wind intensity. On this scale the average wind speed v increases with the Beaufort scale value B.

The relationship between v and B is given by

$$v = kB^p$$

where k and p are constants.

Explain why a graph of log v against log B should give a straight line.

(2)

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(Total for question = 2 marks)

Q9.

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)

Q10.

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)

Q11.

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

(2)

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(Total for question = 2 marks)

Q12.

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)

Q13.

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)

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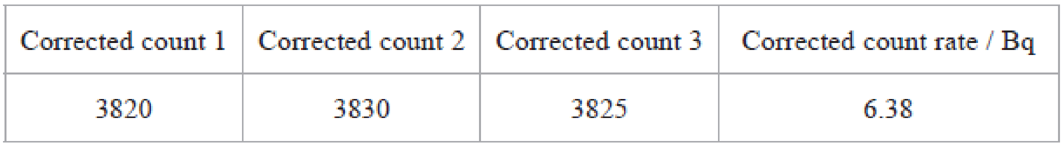
(b) A Geiger counter is used to measure the count from a sample of seaweed over a period of 10 minutes. The corrected readings obtained are shown in the table below.



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)

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(ii) Explain why the radioactive count is repeated.

(2)

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(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)

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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)

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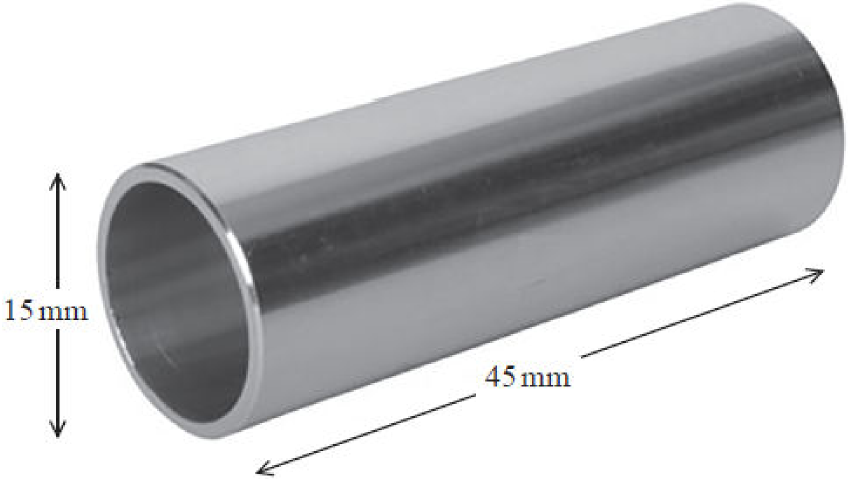
(Total for question = 9 marks)

Q14.

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)

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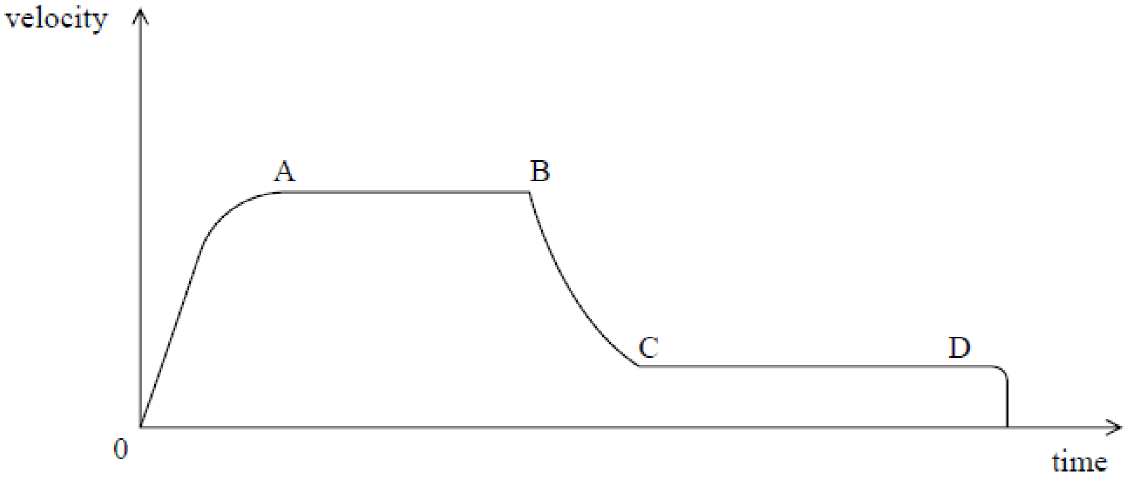
(Total for question = 1 mark)

Q15.

* 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)

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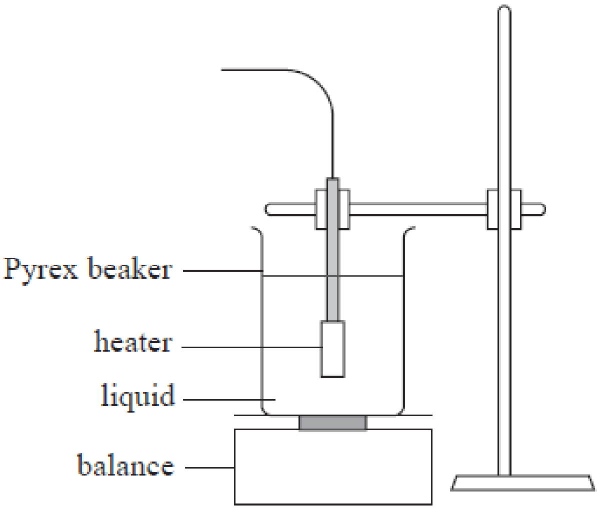
(Total for question = 6 marks)

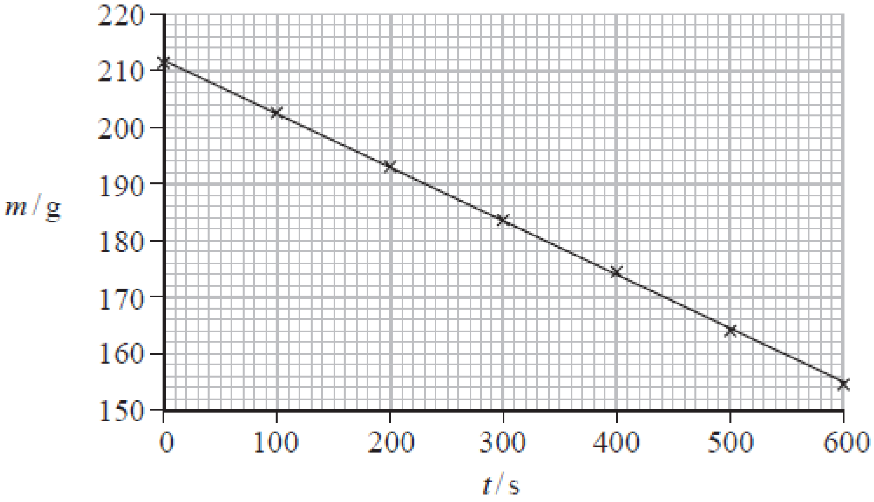
Q16.

A student determined the latent heat of vaporisation of a liquid using an electrical heater to boil the liquid in a Pyrex beaker.

The apparatus used is shown below.



The student monitored the mass of the beaker and the liquid *m* over the time *t* for which the liquid was boiling. Her results are plotted on the graph.



The student used her graph to determine a value for the latent heat of the liquid in the beaker. She concluded that the liquid was pure water.

Liquid	Latent heat of vaporisation / MJ kg^{-1}
Pure water	2.26
Weak salt water solution	2.10
Strong salt water solution	2.00

Comment on the validity of the student's conclusion.

$V = 20.5\,V$

$I = 10.5$ A

(7)

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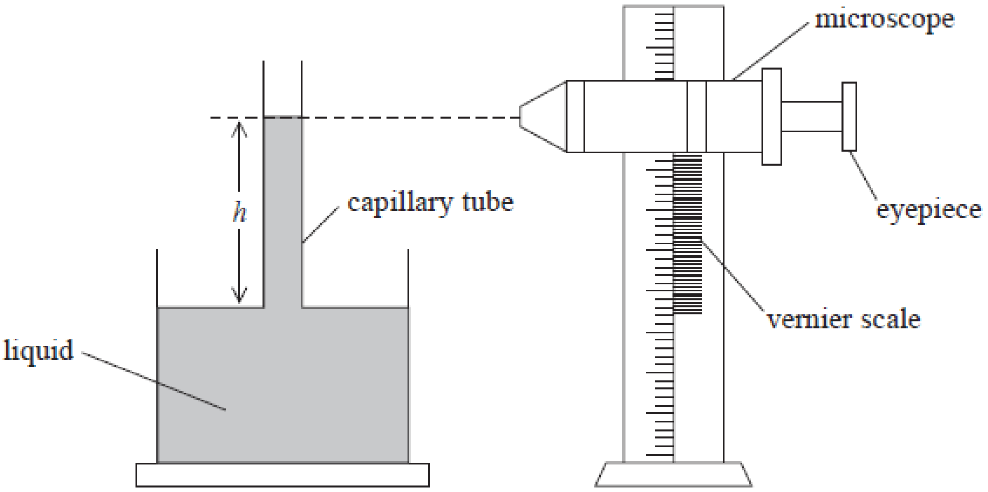
(Total for question = 7 marks)

Q17.

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.

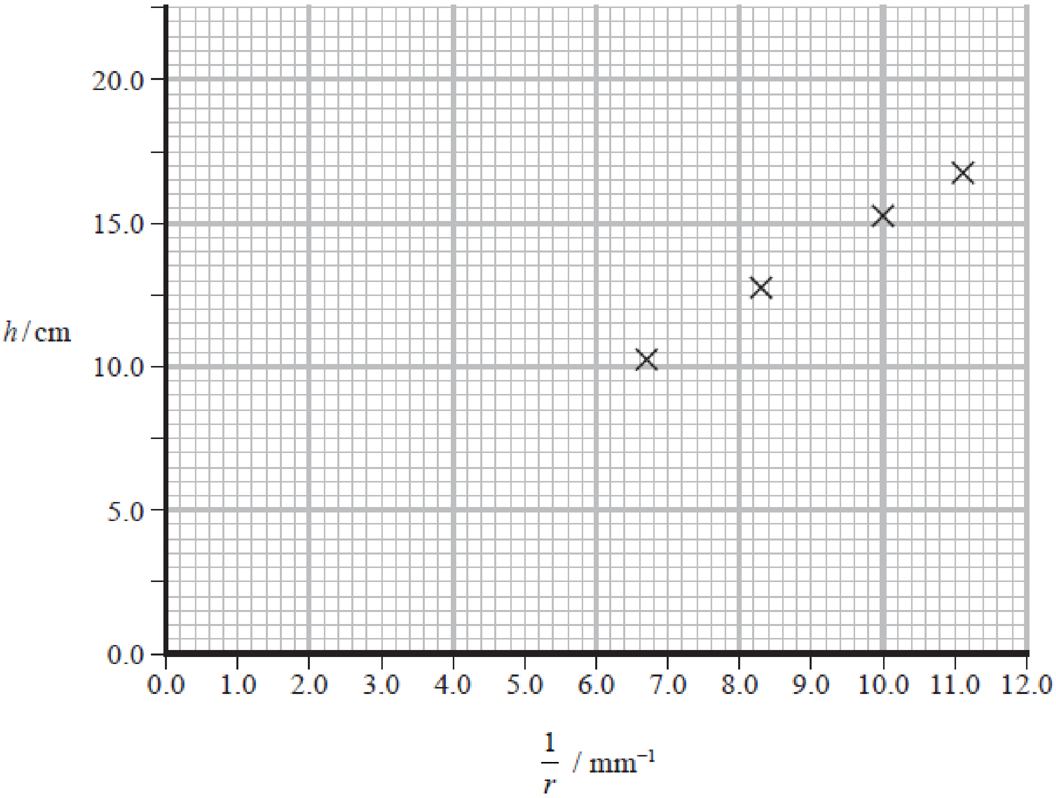
Bottom of liquid column / cm	**Top of liquid column / cm**
12.00	27.10

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)

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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)

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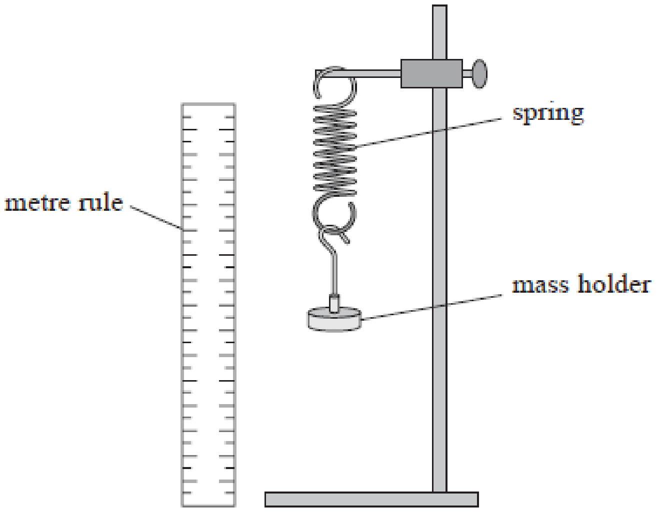
(Total for question = 7 marks)

Q18.

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



The student measured the length of the spring as he added masses to the holder. The rule was held as shown to measure the distance between the top and bottom coils of the spring. He determined the extension for each value of total mass on the holder. He did this by subtracting the original length of the spring from each extended length.

(i) Explain whether this method would produce accurate values for the extensions of the spring.

(4)

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(ii) Explain how the student could modify his method in order to obtain more accurate values for the extensions of the spring.

(5)

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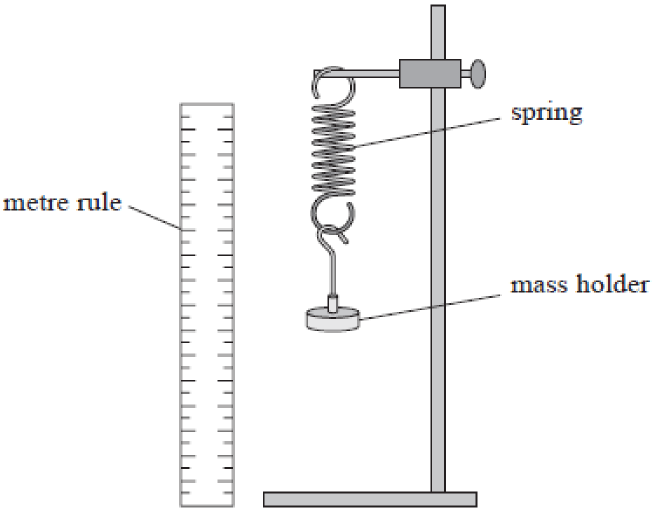
(Total for question = 9 marks)

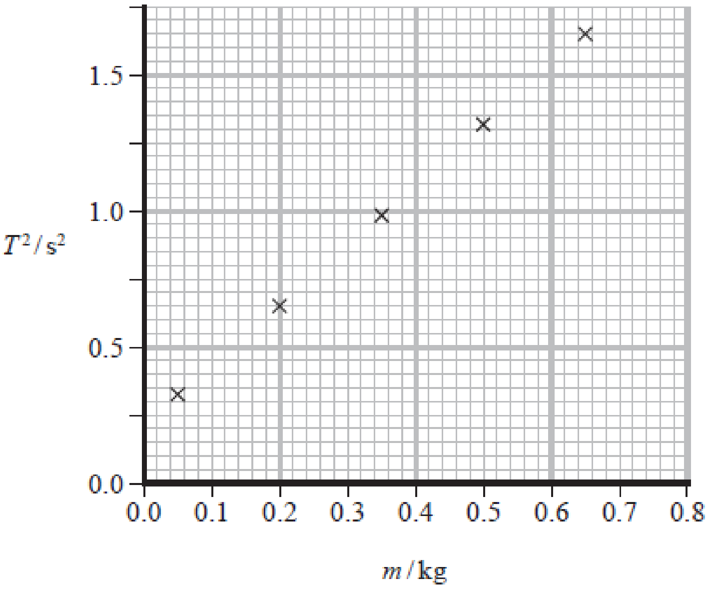
Q19.

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



In another experiment, the student displaced the mass vertically each time a mass was added to the spring. He used a stopwatch to determine the period of vertical oscillations of each mass.

The student used his data to plot a graph of T^2 against m as shown.



The student expected the graph to be a straight line through the origin. He thought that there may be systematic error due to reaction time.

(i) Give an example of another possible systematic error in this experiment.

(1)

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(ii) Another student suggests that to reduce the uncertainty in the value for the period, a data logger connected to a light gate could be used to measure time.

Comment on the student's suggestion.

(3)

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(iii) Determine a value for the stiffness of the spring.

(3)

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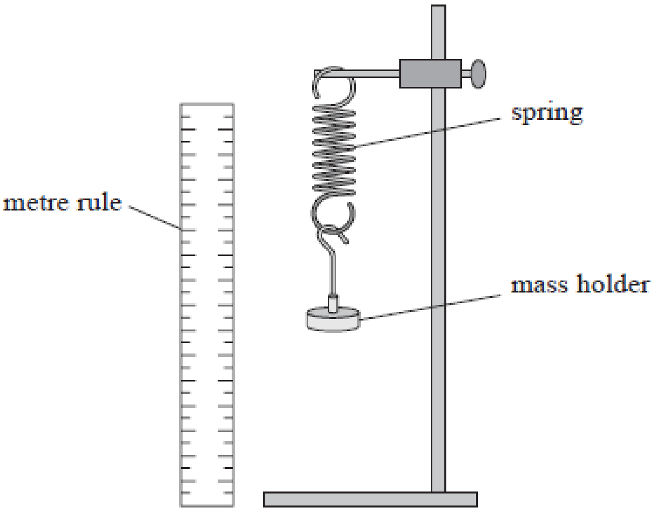
Stiffness of spring = ...

(Total for question = 7 marks)

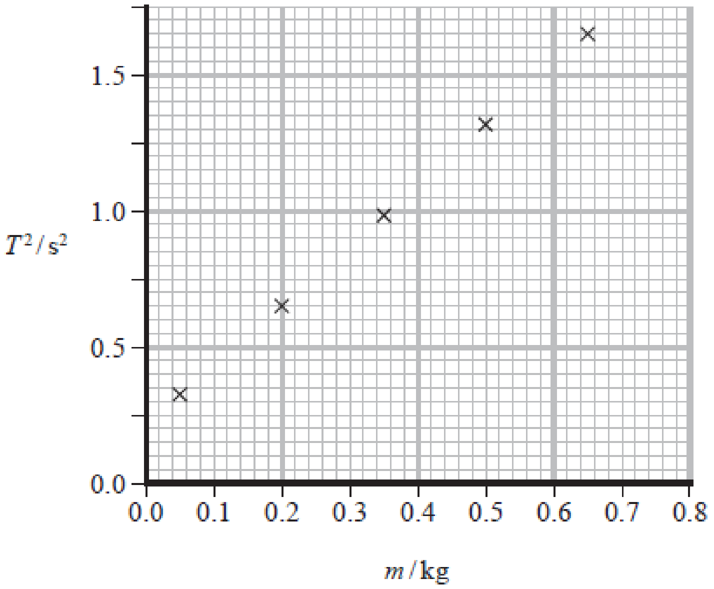
Q20.

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



In another experiment, the student displaced the mass vertically each time a mass was added to the spring. He used a stopwatch to determine the period of vertical oscillations of each mass.

The student used his data to plot a graph of T^2 against *m* as shown.



When determining the period of oscillation for each mass, the student measured the time for 20 oscillations. He repeated this measurement to obtain a mean time for 20 oscillations.

Explain how the student's procedure contributed to the accuracy of the measurement.

(3)

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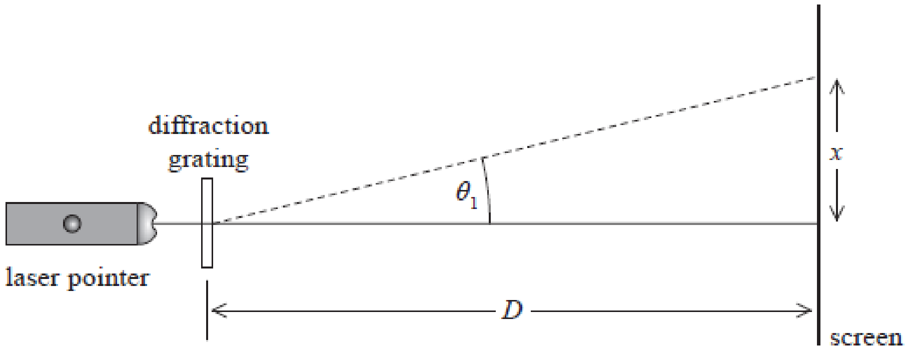
(Total for question = 3 marks)

Q21.

Light from a laser pointer was passed through a diffraction grating. The light was perpendicular to the diffraction grating as shown. A diffraction pattern was produced on a screen.



The distance between the first order maximum and the central maximum of the diffraction pattern was *x*. The distance between the diffraction grating and the screen was *D*.

Distance x was measured to be 0.500 m with a metre rule. The wavelength of light λ_1 from the laser pointer was 650 nm.

The laser pointer was replaced with one that produced light of a different wavelength. The new distance *x* was measured to be 0.400 m.

D = 1.45 m

Explain one modification to this method that would decrease the uncertainty in the calculated value of λ_2.

(2)

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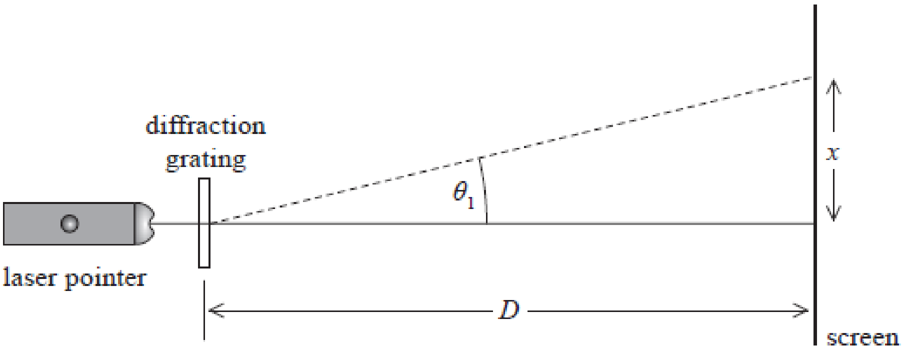
(Total for question = 2 marks)

Q22.

Light from a laser pointer was passed through a diffraction grating. The light was perpendicular to the diffraction grating as shown. A diffraction pattern was produced on a screen.



The distance between the first order maximum and the central maximum of the diffraction pattern was *x*. The distance between the diffraction grating and the screen was *D*.

In another experiment, the light from the laser pointer was not quite perpendicular to the screen.

Explain how this would change the diffraction pattern produced on the screen.

(3)

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(Total for question = 3 marks)

Q23.

The Beaufort scale is used to describe wind intensity. On this scale the average wind speed *v* increases with the Beaufort scale value *B*.

The relationship between *v* and *B* is given by

$$v = kB^p$$

where *k* and *p* are constants.

The table gives some values of *v* and corresponding values of *B*.

v / m s^{-1}	B		
2.00	1		
10.0	3		
21.5	5		
36.0	7		
50.5	9		
68.0	11		

(i) Plot a graph of log *v* against log *B* on the grid.
Use the columns provided to show any processed data.

(5)

(ii) Determine the values of *p* and *k*.

(3)

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p = ...

k = ...

(Total for question = 8 marks)

Q24.

A physicist investigates how light intensity varies with distance from a light bulb. She sets up the apparatus as shown.

The relationship between *R* and *d* is given by

$$R = k\,d^{\,p}$$

where k and p are constants.

Explain why a graph of ln *R* against ln *d* should give a straight line.

(2)

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(Total for question = 2 marks)

Q25.

A physicist investigates how light intensity varies with distance from a light bulb. She sets up the apparatus as shown.

She measures *R* for different values of *d* and records the following results.

d/m	R/kΩ		
1.00	1.79		
1.20	2.24		
1.60	3.32		
2.00	4.04		
2.60	5.50		

(i) Plot a graph of ln *R* against ln *d*. Use the columns provided to show any processed data.

(5)

(ii) Determine the mathematical relationship between *R* and *d*.

(4)

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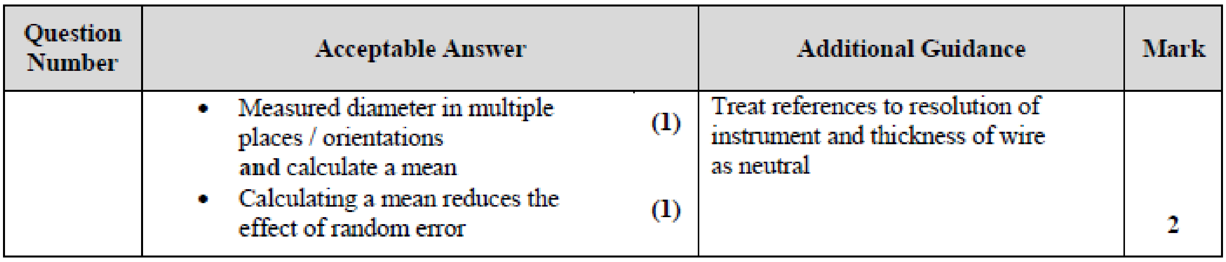
(Total for question = 9 marks)

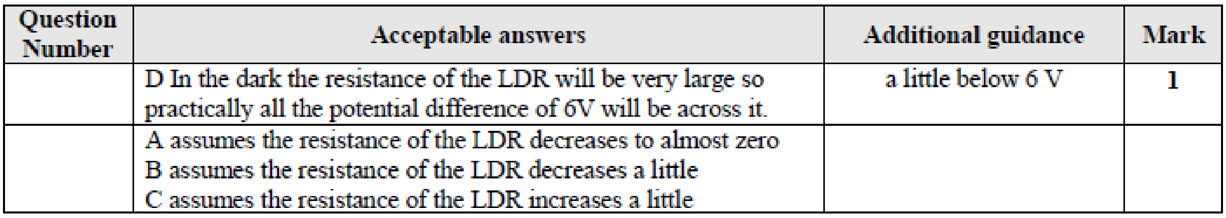
Mark Scheme

Q1.



Question Number	Acceptable Answer	Additional Guidance	Mark
	• Measured diameter in multiple places / orientations and calculate a mean **(1)** • Calculating a mean reduces the effect of random error **(1)**	Treat references to resolution of instrument and thickness of wire as neutral	**2**

Q2.



Question Number	Acceptable answers	Additional guidance	Mark
	D In the dark the resistance of the LDR will be very large so practically all the potential difference of 6V will be across it.	a little below 6 V	**1**
	A assumes the resistance of the LDR decreases to almost zero B assumes the resistance of the LDR decreases a little C assumes the resistance of the LDR increases a little		

Q3.

Question Number	Acceptable answers		Additional guidance	Mark
(a)	• use of $W = VIt$ • use of $\Delta E = mc\Delta\theta$ • use of efficiency = useful power • output / total power input • efficiency = 0.90 Or 90%	(1) (1) (1) (1)	Example of calculation: W = 247 V × 11.8 A × 172 s = 501 000 J ΔE = 1.20 kg × 4180 J kg^{-1} K^{-1} × (101 - 11) K = 451 000 J Efficiency = 451 000 / 501 000 = 0.90	**(4)**

Question Number	Acceptable answers		Additional guidance	Mark
(b)	• calculates area of sphere of radius 30 cm = 1.13 m^2 • use of $I = P/A$ • use of $W = Pt$ • W = 2.0 J	(1) (1) (1) (1)	Example of calculation: Area = 4π × $(0.3\ \text{m})^2$ = 1.13 m^2 P = 10.5 × 10^{-3} W m^{-2} × 1.13 m^2 = 1.19 × 10^{-2} W W = 1.19 × 10^{-2} W × 172 s = 2.0 J	**(4)**

Question Number	Acceptable answers		Additional guidance	Mark
(c)	An explanation that makes reference to the following: • the quiet boil electric kettle is more efficient, but only by 3% which isn't 'much' • the energy transferred by sound is very small, so it is not the reason for the difference	 (1) (1)	Allow 1 mark if the student gives a comment that the uncertainties are too high to draw a valid conclusion without reference to the data in the question, the candidate's calculations may be awarded one mark	**(2)**

Q4.

Question Number	**Acceptable Answer**	**Additional Guidance**	**Mark**

(i)	• A standing wave is set up in the tube **Or** interference (of sound waves) takes place in the tube (1) • Where constructive interference occurs the amplitude is a maximum **Or** at antinodes the amplitude is a maximum (1) • Where destructive interference occurs the amplitude is a minimum **Or** at nodes the amplitude is zero/minimum (1) • Sand is displaced from points of max amplitude to points of min amplitude **Or** sand is displaced from antinodes to nodes (1)		4
(ii)	• Measure over at least 3 heaps (1) • Divide by the number of gaps between the heaps (1) • Repeat measurement and calculate average (1)	i.e at least 2 gaps	3
(iii)	• Use of $d = \frac{\lambda}{2}$ (1) • Use of $v = f\lambda$ (1) • v = 330 (m s^{-1}) and a comment on consistency with 340 m s^{-1} (1)	Example of calculation: $\lambda = 2d = 2 \times 5.1 \times 10^{-2}$ m = 0.102 m $v = 3.25 \times 10^3$ Hz × 0.102 m = 332 m s^{-1}	3

Q5.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Series circuit including power supply, heater and ammeter. (1) • Voltmeter connected in parallel with heater (1)		2

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: - Radiation is absorbed/scattered passing through the atmosphere. (1) - Radiation is reflected from the top of the atmosphere (1) - Only half of the Earth's surface has radiation from the Sun incident on it at any one instant. (1) - The intensity of radiation (normal to the surface) is greater at the equator than at the poles. (1)		4
(ii)	- Use of $A=4\pi r^2$ (1) - Use of efficiency= $\frac{\text{useful power output}}{\text{total power input}}$ (1) - Use of $I = \frac{P}{A}$ (1) - % of surface needed is 0.0005%, so claim is not valid (1) [Accept reverse calculation to show power generated by cells over 0.5% of the Earth would generate 1.06×10^5 GW]	Example of calculation: $A = \frac{P}{I}$ $= \frac{100 \times 10^9 \text{ W}}{0.25 \times 164 \text{ W m}^{-2}} = 2.44 \times 10^9 \text{ m}^2$ $A = 4\pi \times (6.4 \times 10^6 \text{ m})^2$ $= 5.15 \times 10^{14} \text{ m}^2$ % needed = $\frac{2.44 \times 10^9 \text{ m}^2}{5.15 \times 10^{14} \text{ m}^2} \times 100\% = 0.00047\ \%$	4

Q7.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • Identify when the distance fallen between frames has become constant • Measure the distance fallen over a number of frames **Or** measure the distance fallen between frames a number of times and calculate an average distance • Calculate terminal velocity by dividing the distance fallen by the time taken • Use $\frac{1}{60}$ s as time between frames.	(1) (1) (1) (1)	MP3: Allow reference to $v = \frac{s}{t}$ to calculate terminal velocity	4
(ii)	An explanation that makes reference to the following points: • There may be parallax error in reading the ball position **Or** the metre rule may not be vertical • Recorded distance may be greater than actual distance, so calculated terminal velocity would be greater than true value.	(1) (1)	Recorded distance may be less than actual distance, so terminal velocity would be less than true value	
	OR • The frame rate may be not be 60 s^{-1} • Time between frames may be less than 1/60 s, so calculated terminal velocity may be greater than true value	(1) (1)	Time between frames may be more than 1/60 s, so calculated terminal velocity may be less than true value	2

Q8.

Question Number	Acceptable Answer		Additional Guidance	Mark
	An explanation that makes reference to the following points: • Shows expansion $\log v = p \log B + \log k$ • Compares with $y = mx + c$ and identifies p as the gradient	(1) (1)		2

Q9.

Question Number	Answer	Mark
	B	**1**

Q10.

Question Number	Answer	Mark
	D	**1**

Q11.

Question number	**Acceptable answers**	**Additional guidance**	**Mark**
	- Use of $F = BIl$ or use of $F=Bqv$ **(1)** - Converts N to kg m s^{-2} **(1)**	Example $B = \frac{F[\text{kg m } s^{-2}]}{I[\text{A}]\ l[\text{m}]}$ So units are kg A^{-1} s^{-2}	**2**

Q12.

Question Number	Answer	Mark
	C	**1**

Q13.

Question Number	Answer	Mark
(a)	Activity is the rate of decay of (unstable) nuclei **Or** activity is the number of (unstable) nuclei that decay in unit time **(1)**	1

(b)(i)	Background radiation/count will increase the recorded count **Or** background count must be subtracted from the recorded count **(1)** **Or** background radiation contributes systematic error to the count [Do not accept "to correct for background radiation"]	**1**
(b)(ii)	Radioactive decay is a random process (so count for a fixed period will vary) **(1)** [Ignore references to spontaneous, accurate, reliable] Idea that repeating enables a mean/average value to be calculated **(1)**	**2**
(b)(iii)	Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ **(1)** Use of $A = A_0 e^{-\lambda t}$ [allow 2.5 Bq for A_0 here; allow use of $N = N_0 e^{-\lambda t}$] **(1)** $A = 0.47$ Bq **(1)** [Allow calculation of number of half lives elapsed and use of $A = A_0 \left(\frac{1}{2}\right)^{t/t_{1/2}}$ for mp1 and mp2] <u>Example of calculation:</u> $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{8.0\,\mathrm{d}} = 0.0866\mathrm{d}^{-1}$ $A = A_0 e^{-\lambda t} = 6.38 \times \mathrm{e}^{-0.0866\mathrm{d}^{-1} \times 30\mathrm{d}} = 6.38\,\mathrm{Bq} \times 0.074 = 0.47\,\mathrm{Bq}$	**3**
(b)(iv)	Idea that people have to be close to or ingest seaweed for any degree of risk **Or** β particles are moderately ionising **(1)** **Or** β particles can enter body through the skin The half-life is short **Or** after a month the activity has decayed to negligible levels **(1)** **Or** the radioisotope doesn't remain in the seaweed for very long	**2**
	Total for Question	**9**

Q14.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Systematic (error) (1)		1

Q15.

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table></td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>*
(continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td></td><td></td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
* (continued)	**Indicative content** • As parachute opens (at B) the upwards force increases • Along BC the velocity is decreasing at a non-constant rate • The drag is greater than weight (negative gradient) • The drag is decreasing (curved line) • Eventually the drag force balances the weight • No acceleration so line is horizontal		

Q16.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of $P = VI$ (1) • Calculation of gradient (1) • Gradient = $\frac{\Delta m}{\Delta t}$ (1) • Use of $\Delta E = mL$ and $P = \frac{\Delta E}{\Delta t}$ (1) (1) • $L = 2.30 \times 10^6$ (J kg^{-1}) • Comparison of calculated value for L with values in table and appropriate conclusion. (1) (1)	For MP2 and MP3 credit Δm read from graph and used with corresponding Δt value For MP3 and MP4, credit $L = \frac{VI}{\text{gradient}}$ Answers in the range (2.26 – 2.34) × 10^6 J kg^{-1}	
	• But not all of the energy supplied to the liquid will be used to boil the liquid **Or** thermal energy will be transferred to surroundings	Example of calculation: $\text{grad}=\frac{(211\text{-}155)\times10^{-3}\ \text{kg}}{(0\text{-}600)\ \text{s}}=9.33\times10^{-5}\ \text{kg s}^{-1}$ $\therefore \frac{\Delta m}{\Delta t}=9.33\times10^{-5}\ \text{kg s}^{-1}$ $P=20.5\ \text{V}\times10.5\ \text{A}=215\ \text{W}$ $\therefore L=\frac{215\ \text{W}}{9.33\times10^{-5}\text{kg s}^{-1}}=2.30\times10^{6}\ \text{J kg}^{-1}$	7

Q17.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Line of best fit drawn • Value of 1/*r* calculated • $h = 13.8$ cm	Example of calulation $\frac{1}{r} = \frac{1}{0.11\text{ mm}} = 9.1\text{ mm}^{-1}$	**3**
(ii)	• There are only 4 points, which isn't enough to form a firm conclusion **(1)** • The range of the points is insufficient to form a firm **(1)** conclusion (no data between 0.0 and 6.0 on *x*-axis) **(1)** **Either** • $h = \frac{k}{r}$ suggests a straight line **(1)** through the origin • the points plotted do lie in a **(1)** straight line **(1)** **Or** • $h = \frac{k}{r}$ suggests hr is a constant • This is approximately true (k ≈ 1.5)	Credit there may be systematic error in *h* causing the points to be displaced	**4**

Q18.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	**MAX 4** • It's difficult to measure from the same position on the spring each time (1) • Ruler may move between readings (1) • There may be parallax error in reading positions (1) • The student has only taken one measurement for each added mass (1) • Hence this method would not produce accurate values (dependent upon at least one from MP1 – MP4) (1)	Mark (i) and (ii) holistically	**4**
(ii)	**MAX 5** • Attach a pointer to the bottom of the spring **Or** take measurements from bottom of mass holder (1) • Bring metre rule closer to the spring (1) • Take measurements from the metre rule as masses are added and as masses are removed (1) • Calculate a mean extension for each mass (1) • Method to ensure metre rule is vertical (1) • Method to reduce parallax error (1)	Mark (i) and (ii) holistically e.g. use of a set square, lining up against a vertical, use of spirit level e.g. take reading at eye level	**5**

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Ignoring mass of holder / spring when determining the oscillating mass (1)		1
(ii)	• Using a data logger (and light gate) would eliminate reaction time (1) • So the uncertainty in the measurement (of the time) would be reduced (1) • Not easy to measure timings for multiple swings/oscillations with a data logger (1)		3
(iii)	• Identify gradient as $\frac{4\pi^2}{k}$ (1) • Determine gradient of graph (1) • $k = 17.8\ \text{N m}^{-1}$ [17.5 → 18.5] (1)	<u>Example of calculation</u> Gradient = $2.21\ \text{s}^2\ \text{kg}^{-1}$ $k = \frac{4\pi^2}{2.21\ \text{s}^2\ \text{kg}^{-1}}$ $= 17.8\ \text{N m}^{-1}$	3

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Timing a large number of oscillations minimised the percentage uncertainty in the measurement (1) • Repeating each timing measurement and calculating a mean minimised the effect of random errors (1) • Taking a repeat measurement allowed a check for gross timing errors. (1)		3

Q21.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • Measure the distance between the two 1st/2nd order maxima (1) **Or** measure the distance from the 2nd order to the central maximum (1) **Or** increase the distance from the grating to the screen • This increases the distance measured on the screen (and reduce the % uncertainty) MP2 dependent upon MP1		**2**

Q22.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • Maxima on one side move closer to the central maximum (1) • Maxima on the other side move further away from the central maximum (1) • Intensity of maxima would be different on each side of central maximum (1)	Allow 1 mark for spacing of maxima on screen will change	**3**

Q23.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>(i)</td><td>• Log values correct and to 3 SF (1)
<table>
<tr><th>Log (v /m s^{-1})</th><th>Log B</th></tr>
<tr><td>0.301</td><td>0.00</td></tr>
<tr><td>1.00</td><td>0.477</td></tr>
<tr><td>1.33</td><td>0.699</td></tr>
<tr><td>1.56</td><td>0.845</td></tr>
<tr><td>1.70</td><td>0.954</td></tr>
<tr><td>1.83</td><td>1.04</td></tr>
</table>
• Labels and unit (1)
• Scales (1)
• Plots (1)
• Line of best fit (1)</td><td>Allow ln v against ln B
<table>
<tr><th>ln (v /m s^{-1})</th><th>ln B</th></tr>
<tr><td>0.693</td><td>0.00</td></tr>
<tr><td>2.30</td><td>1.10</td></tr>
<tr><td>3.07</td><td>1.61</td></tr>
<tr><td>3.58</td><td>1.95</td></tr>
<tr><td>3.92</td><td>2.20</td></tr>
<tr><td>4.22</td><td>2.40</td></tr>
</table>
Check labels on graph axes (not table)
Don't credit difficult scales (e.g. increments of 3, 4, 7)
Check 2 points furthest from the line (within half a square) Don't check points on difficult scales</td><td>5</td></tr>
<tr><td>(ii)</td><td>• Gradient determined using large triangle - at least half the plotted length (1)
• p = 1.47 to 2/3 SF and no units (1)
• Obtains $k = 2.00$ m s^{-1} (1)</td><td>MP3 answer should round to 2; don't penalise SF</td><td>3</td></tr>
</table>

Q24.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: • Shows expansion $\ln R = p \ln(d) + \ln(k)$ **(1)** • Compares with y = mx+ c **and** states that the gradient is p which is constant **(1)**		2

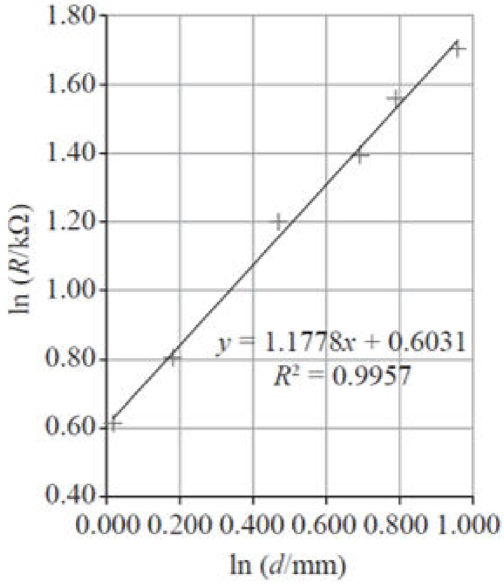
Q25.

Question number	Acceptable answers	Additional guidance	Mark
(i)	• Ln values correct and to 3 or 4 SF **(1)**	See marking guidance for graph plotting	

d/m	R/kΩ	ln (d/m)	ln (R/kΩ)
1.00	1.79	0.000	0.582
1.20	2.24	0.182	0.806
1.60	3.32	0.470	1.200
2.00	4.04	0.693	1.396
2.20	4.70	0.788	1.548
2.60	5.50	0.956	1.705

- Labels and unit **(1)**
- Scales **(1)**
- Plots **(1)**
- Line of best fit **(1)**

5

Question number	Acceptable answers	Additional guidance	Mark
(i) (continued)			
(ii)	• Finds gradient with large triangle – at least half the plotted length **(1)** • 1.13 < p < 1.23 to 2/3 SF and no units **(1)** • Obtains k = 1.8 **(1)** • States relationship between R and d **(1)**		**4**