Name: ____

Topic 7: Electric and Magnetic Fields Part 1

Date:

Time:

Total marks available:

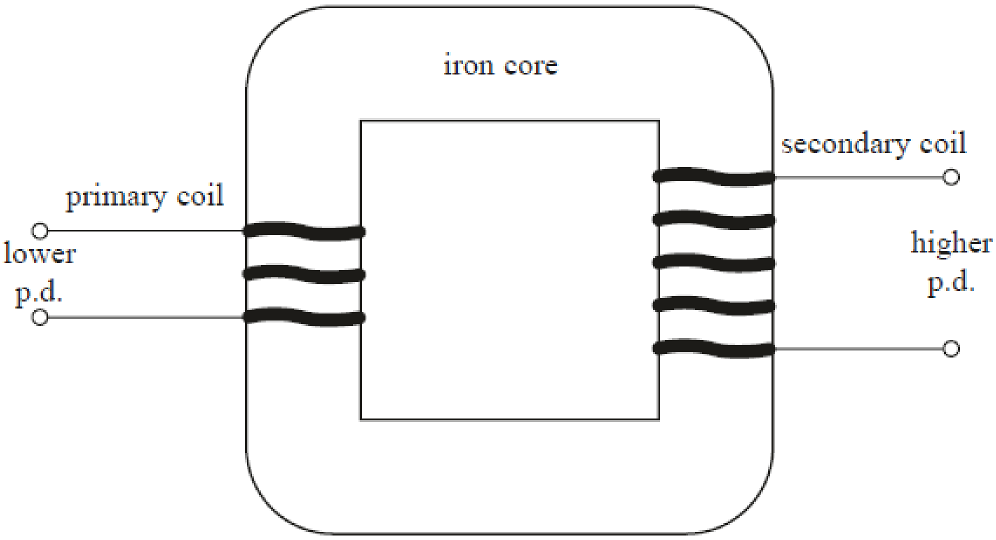
Total marks achieved: ______

Questions

Q1.

Electrical transmission systems are used to transmit electrical power from place to place. Transformers are used to change potential differences (p.d.) and power transmission cables are used to transmit power.

The diagram shows a step-up transformer.



A step-up transformer is used to convert a lower p.d. to a higher p.d. An alternating p.d. is applied to the primary coil.

Explain how a higher p.d. is produced across the secondary coil.

(4)

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(Total for question = 4 marks)

Q2.

Our understanding of the atom has developed over time, from early models in which atoms were considered to be hard incompressible spheres, through to the nuclear model of the atom and the ladder model in which electrons exist in a discrete number of allowed energy states.

The nuclear model of the atom was established following a series of experiments in which alpha particles were directed at thin gold foil.

(i) An alpha particle approaching a gold nucleus, $^{197}_{79}Au$, head-on will be brought to rest and returned along its original path.

Calculate the minimum distance between the alpha particle and the nucleus for alpha particles of energy of 5.5 MeV.

(4)

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Minimum distance = ...

(ii) It is observed that electrons, with energy of 5.5 keV, are diffracted as they pass through the thin gold foil.

Explain a conclusion about the electrons that can be made from this observation.

(3)

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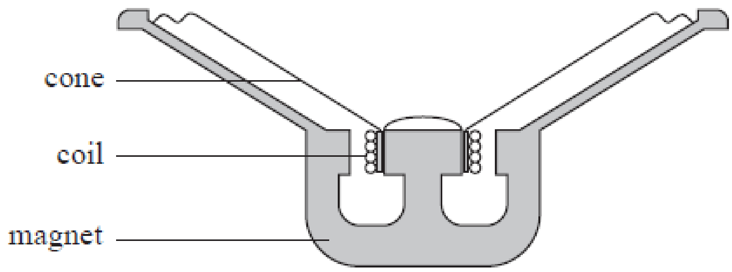
(Total for question = 7 marks)

Q3.

*****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.



A student made the following observations:

- when an alternating potential difference (p.d.) is applied to the coil, the cone oscillates
- the frequency of oscillation is the same as the frequency of the p.d.
- at particular frequencies, the box vibrates with a large amplitude.

Explain these observations.

(6)

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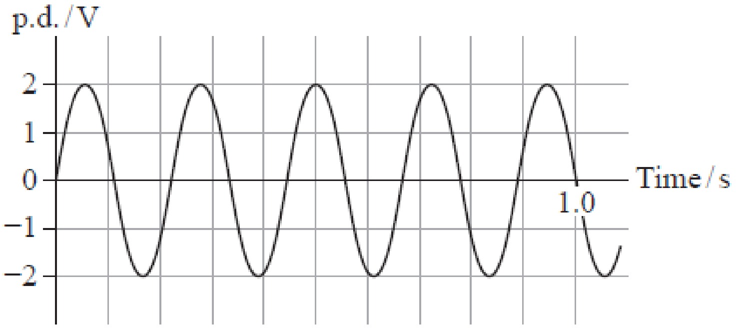
(Total for question = 6 marks)

Q4.

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 ☒.

The graph shows how a potential difference (p.d.) varies with time.



Which of the following is correct?

☐ **A** The frequency is 4.5 Hz.

☐ **B** The peak value is 4.0 V.

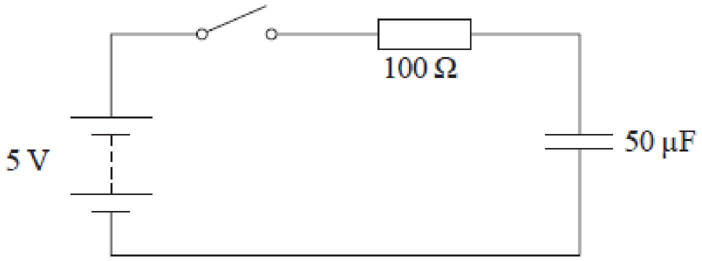
☐ **C** The period is 0.20 s.

☐ **D** The root mean square value of p.d. is 1.0 V.

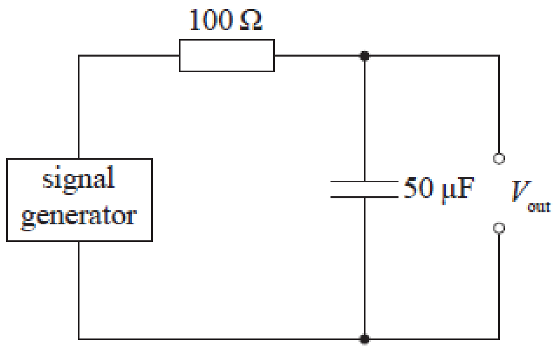
(Total for question = 1 mark)

Q5.

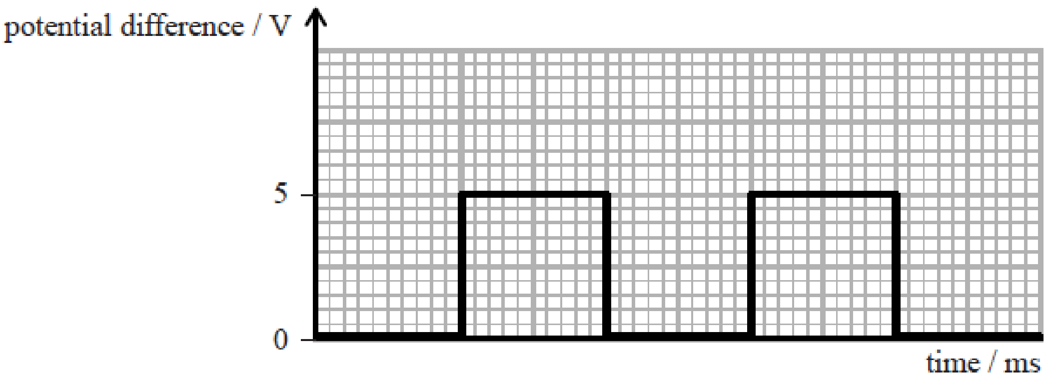
A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



The battery and switch are replaced by a signal generator providing a square wave output of peak potential difference 5 V. The signal generator has negligible internal resistance.



The graph shows the square wave output of the signal generator. The frequency of the square wave is 20 Hz.



On the graph add values to the time axis and sketch a graph of the potential difference, V_{out}, across the capacitor for two cycles of the square wave. Assume the capacitor is initially uncharged.

(5)

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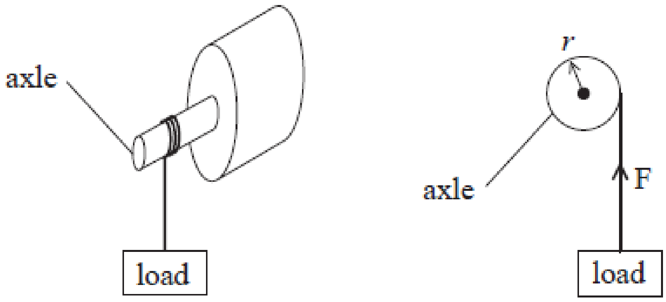
(Total for question = 5 marks)

Q6.

Motors usually have a rotating component which can do work *W*.

(a) A motor lifts a load in a time *t*. The axle of the motor has a radius *r* and exerts a force *F*.



The power produced by a motor can be calculated by using the following word equation.

Power = moment of the force exerted by the rotating axle × angular velocity

Derive this equation, starting with power $P = \frac{W}{t}$.

(4)

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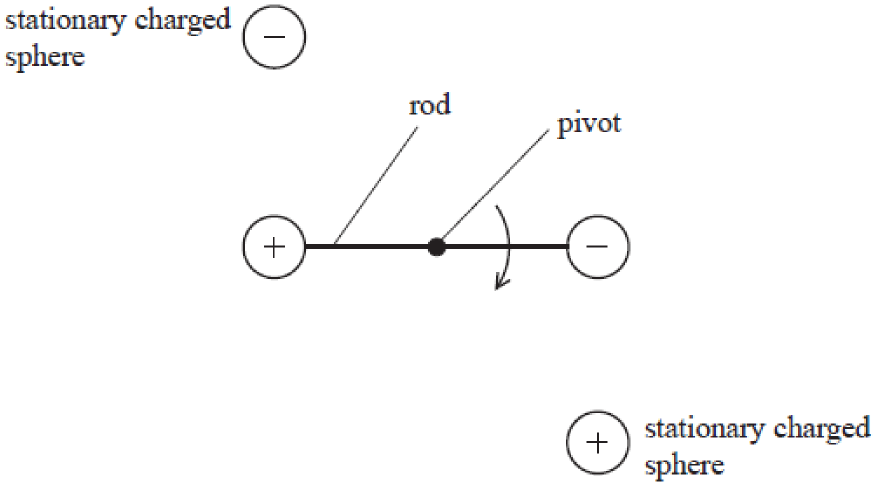
(b) An electrostatic motor was first demonstrated by Benjamin Franklin in 1750.

The diagram shows a simplified version of part of this motor.

This consists of a rod, with an oppositely charged sphere at either end, which rotates around a fixed pivot. Two stationary charged spheres apply a force on the spheres at either end of the rod.

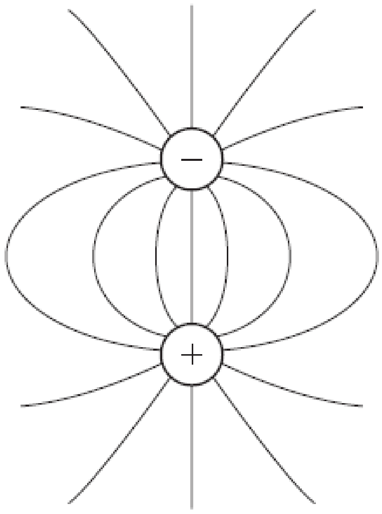


(i) In the diagram below, electric field lines have been drawn around one pair of these spheres.

Add to the diagram to show

- the directions of the field lines
- the lines of equipotential.

(3)



(ii) The distance between the centres of each charged sphere in this pair is 5.0 cm.

Show that the force between this pair of charged spheres is about 0.04 N.

charge on each sphere = 0.10 μC

(2)

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(c) The table shows the typical power and the corresponding angular velocity required for three different appliances.

	Power / W	**Angular velocity / rad s^{-1}**
Electric car	2.0×10^4	300
Vacuum cleaner	1.4×10^3	1000
Small pond pump	0.5	200

Deduce which of these appliances, in principle, could use the electrostatic motor in (b).

You should use the word equation in (a) and assume that the length of the rod in the electrostatic motor is 8.0 cm.

Assume that the electrostatic motor would deliver a constant force throughout one complete rotation.

(4)

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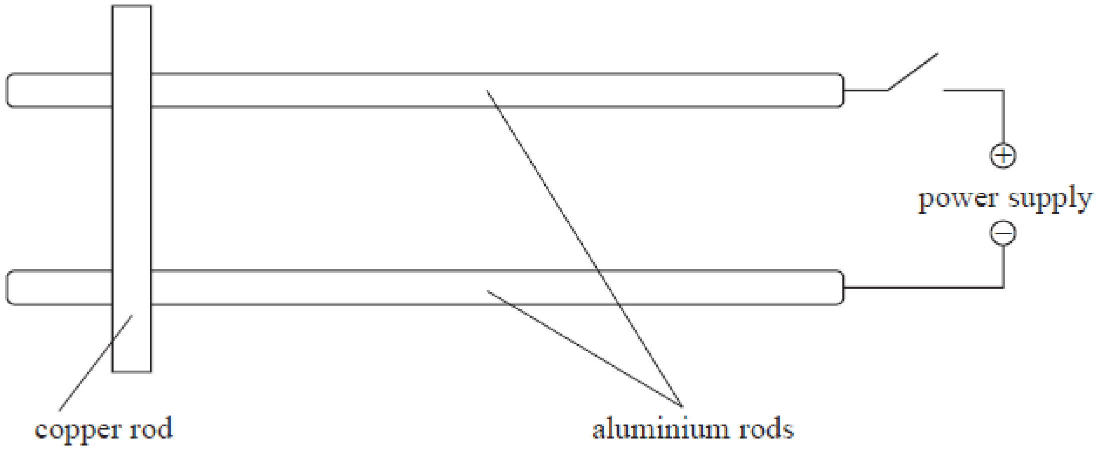
(Total for question = 13 marks)

Q7.

The apparatus shown in the diagram can be used to demonstrate that a force acts on a current-carrying conductor when the conductor is in a magnetic field.



The apparatus is placed in a magnetic field. When the switch is closed, the copper rod rolls along the aluminium rods.

(a) Add to the diagram to indicate the direction of the current in the copper rod.

(1)

(b) State the direction of the magnetic field that will make the copper rod move to the right.

(2)

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(Total for question = 3 marks)

Q8.

At the beginning of the 20th century, Rutherford carried out large-angle alpha particle scattering experiments using gold ($^{197}_{79}Au$) foil.

The vast majority of the alpha particles went straight through the foil whilst a few were deflected straight back.

In one experiment the alpha particles had an initial energy of 7.7 MeV.

Calculate the distance of closest approach of the alpha particles to the nucleus of a gold atom. Assume that the gold nucleus remains at rest.

(4)

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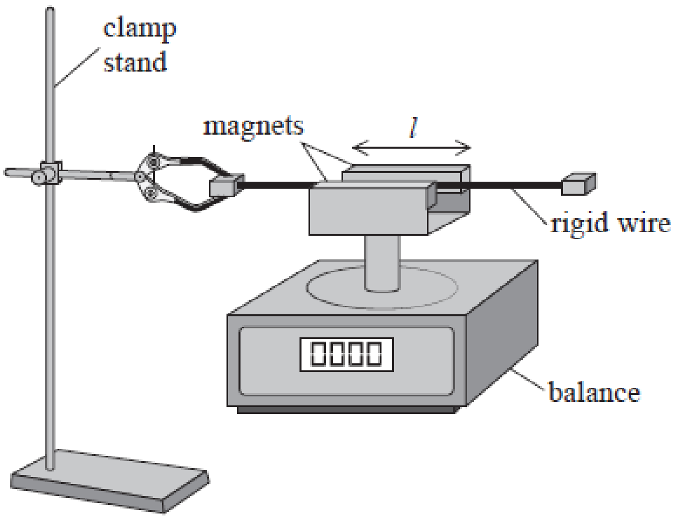
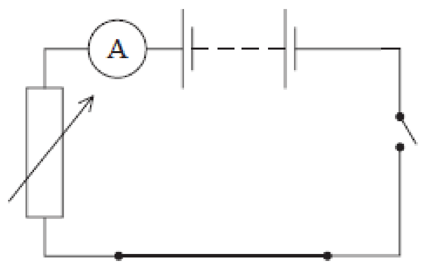
Distance of closest approach = ...

(Total for question = 4 marks)

Q9.

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 length *l* of wire in the magnetic field was 15.5 cm. When the current in the circuit was 4.55 A, the reading on the balance increased by 5.65 g.

Calculate the magnetic flux density *B* in the region of the rigid wire.

(3)

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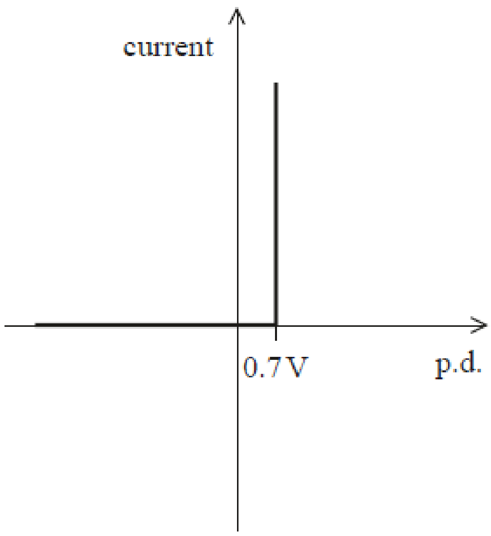
B = ...

(Total for question = 3 marks)

Q10.

The graph shows how current varies with potential difference (p.d.) for an ideal diode.



An alternating p.d. V_{IN} has a peak value of 3.4 V.

(i) Calculate the r.m.s. value.

(2)

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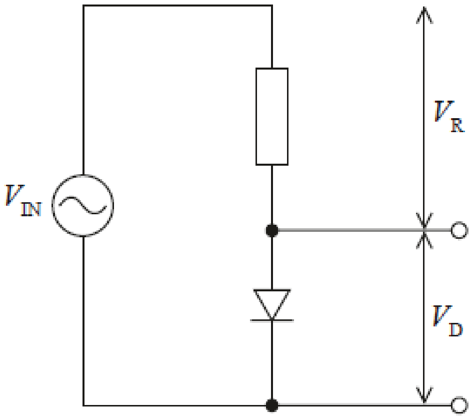
r.m.s. value = ...

(ii) V_{IN} is applied to a diode and resistor as shown.



The p.d. across the resistor is V_R and the p.d. across the diode is V_D. V_D is the output.

Explain why $V_{IN} = V_R + V_D$ at any given time.

(2)

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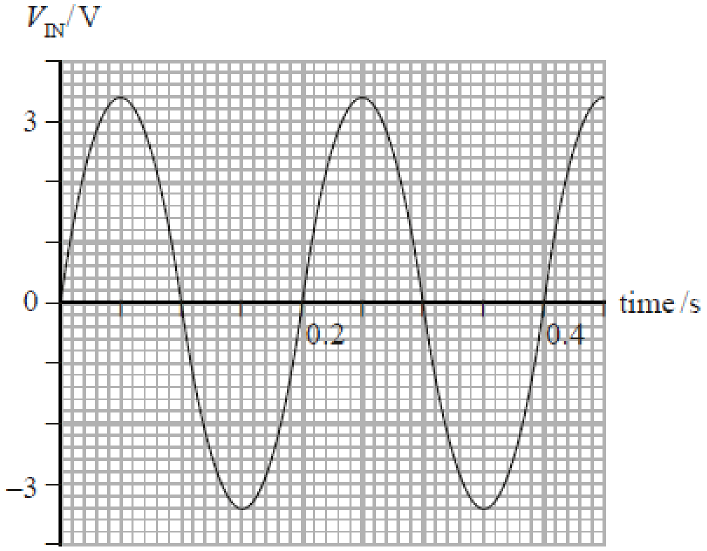
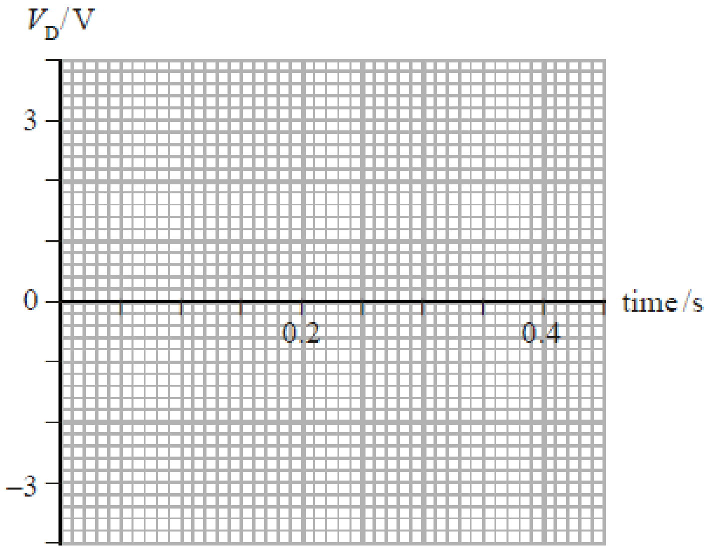
(iii) The graph shows how V_{IN} varies with time.

Sketch a graph of V_D against time using the axes provided below.

(3)





(Total for question = 7 marks)

Q11.

What is the acceleration of an electron at a point in an electric field where the electric field strength is 2.0×10^4 N C^{-1}?

☐ **A** 2.8×10^{-16} m s^{-2}

☐ **B** 3.2×10^{-15} m s^{-2}

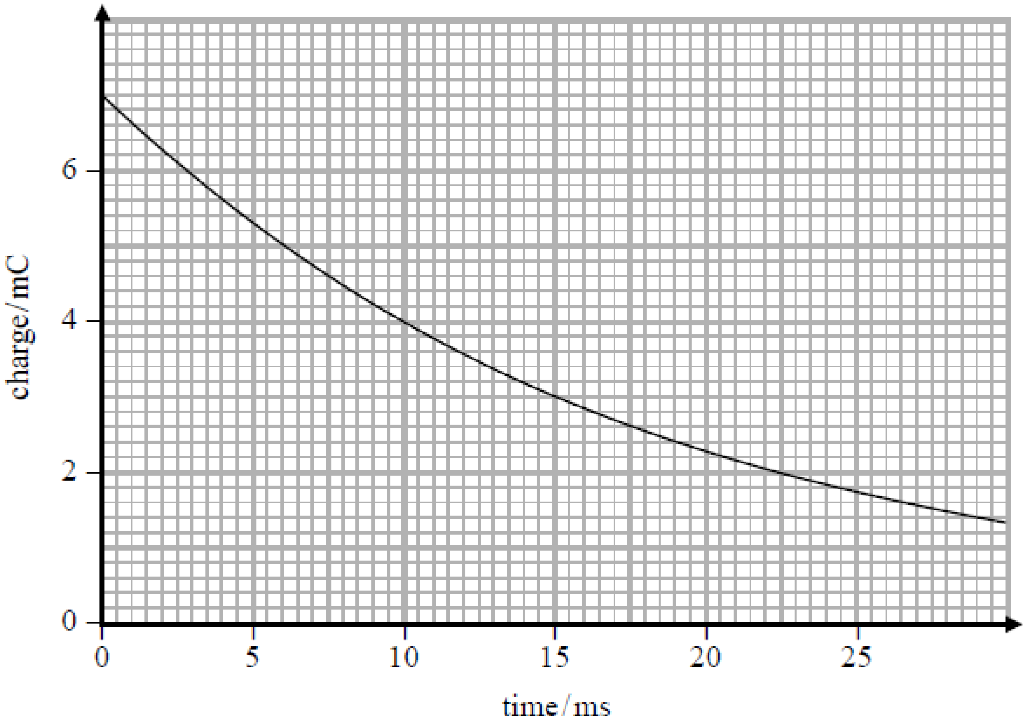
☐ **C** 1.8×10^{11} m s^{-2}

☐ **D** 3.5×10^{15} m s^{-2}

(Total for question = 1 mark)

Q12.

A capacitor is discharged through a resistor of resistance 900 Ω. The graph shows how the charge on the capacitor decreases with time.



Calculate the capacitance of the capacitor.

(4)

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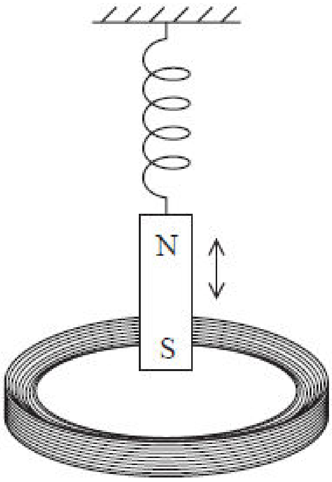
Capacitance = ...

(Total for question = 4 marks)

Q13.

* A magnet is attached to the end of a spring as shown in the diagram.



The magnet is displaced vertically and released so that it oscillates.

The average vertical component of the magnetic flux density through the coil varies at a maximum rate of 0.035 T s^{-1}.
Calculate the maximum current in the copper ring.

radius of copper ring = 5.0 cm
resistance of copper ring = 6.7×10^{-5} Ω

(4)

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Maximum current = ...

Q14.

A defibrillator is an electrical device designed to deliver a brief electrical signal to restore a normal rhythm to the heart. Electrodes are attached to the chest of a patient and a charged capacitor is discharged through the chest cavity.

In one defibrillator a 56 μF capacitor is charged by a potential difference of 2500 V.
During the discharge of the capacitor the resistance between the electrodes is 45 Ω.

Show that the time taken for 99% of the discharge to take place is about 12 ms and hence calculate the average current delivered by the defibrillator during this period.

(6)

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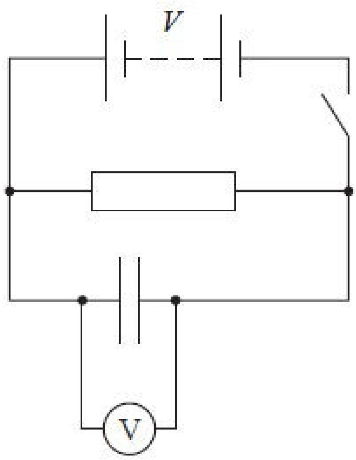
Average current = ...

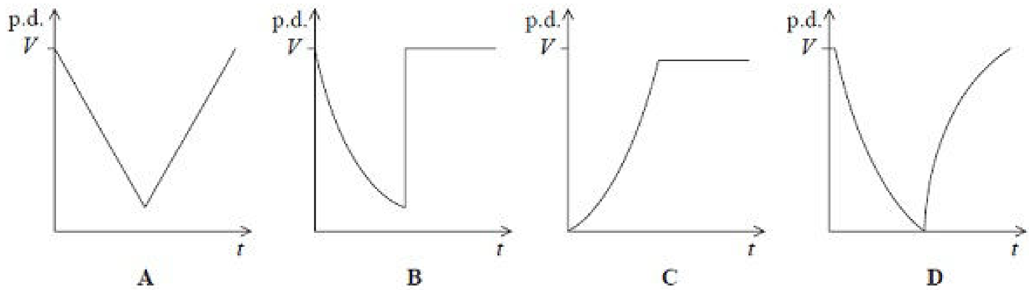
(Total for question = 6 marks)

Q15. The capacitor shown in the circuit below is initially charged to a potential difference (p.d.) *V* by closing the switch.

The power supply has negligible internal resistance.



The switch is opened and the p.d. across the capacitor allowed to fall. A short time later the switch is closed again. Select the graph that shows how the p.d. across the capacitor varies with time, after the switch is opened.



☒ **A**

☒ **B**

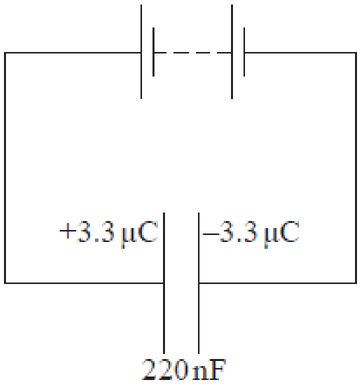
☒ **C**

☒ **D**

(Total for Question = 1 mark)

Q16.

A capacitor is charged by a battery as shown in the circuit diagram.



(a) Calculate the e.m.f. of the battery and the energy stored in the charged capacitor.

(4)

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E.m.f. = ...

Energy = ...

(b) The capacitor is disconnected from the battery and discharged through a 20 MΩ resistor.

Calculate the time taken for 80% of the charge on the capacitor to discharge through the resistor.

(3)

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Time taken = ...

(c) Use an equation to explain whether the time taken for the capacitor to lose half its energy is greater or less than the time taken to lose half its charge.

(3)

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(d) A student carries out an experiment to record data so that she can plot a graph of potential difference against time as the capacitor discharges.

State **two** advantages of using a datalogger rather than a voltmeter and stopwatch to record this data.

(2)

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(Total for question = 12 marks)

Q17. A student is investigating how the potential difference across a capacitor varies with time as the capacitor is charging.

He uses a 100 μF capacitor, a 5.0 V d.c. supply, a resistor, a voltmeter and a switch.

(a) (i) Draw a diagram of the circuit he should use.

(2)

(ii) Suggest why a voltage sensor connected to a data logger might be a suitable instrument for measuring the potential difference across the capacitor in this investigation.

(1)

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(b) Calculate the maximum charge stored on the capacitor.

(2)

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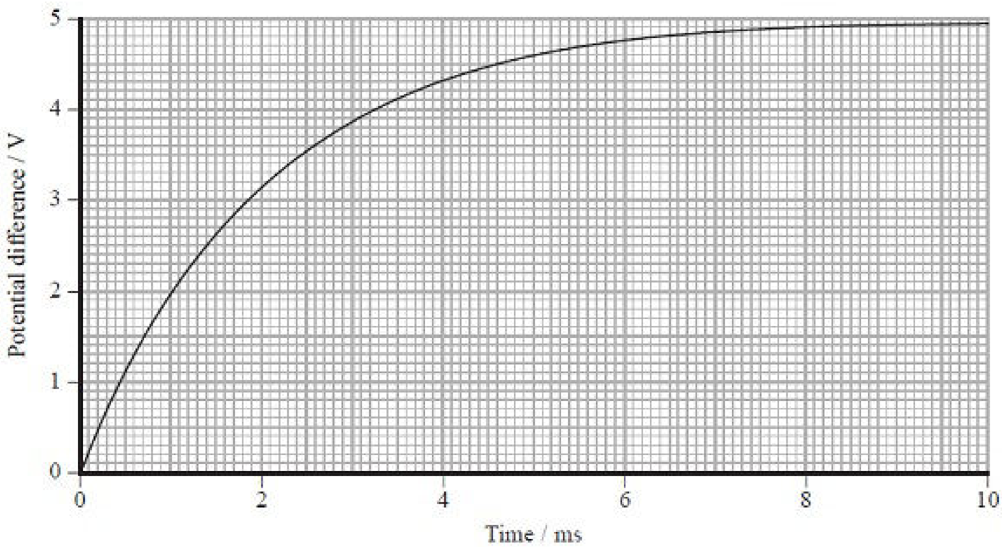
Charge = ...

(c) The graph shows how the potential difference across the capacitor varies with time as the capacitor is charging.



(i) Estimate the average charging current over the first 10 ms.

(2)

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Average charging current = ...

(ii) Use the graph to estimate the initial rate of increase of potential difference across the capacitor and hence find the initial charging current.

(3)

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Initial charging current = ...

(iii) Use the value of the initial charging current to find the resistance of the resistor.

(2)

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Resistance = ...

(Total for Question = 12 marks)

Q18. A particular experiment requires a very large current to be provided for a short time.

(a) An average current of 2.0×10^3 A is to be supplied to a coil of wire for a time of 1.4×10^{-3} s. The resistance of the coil is 0.50 Ω.

(i) Show that the charge that flows through the coil during this time is about 3 C.

(2)

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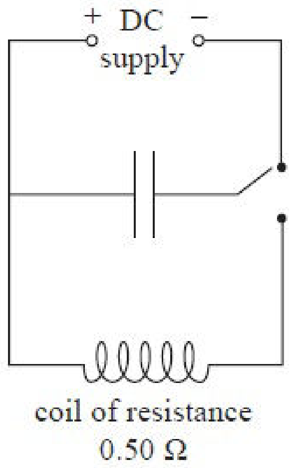
(ii) The circuit shows how a capacitor could be charged and then discharged through the coil to provide the current.



The circuit contains a capacitor of capacitance 600 μF. This capacitor is suitable to provide the current for 1.4×10^{-3} s.

Explain why the capacitor is suitable.

(3)

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(b) It can be assumed that the 600 μF capacitor completely discharges in 1.4×10^{-3} s.

(i) Calculate the potential difference of the power supply.

(2)

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Potential difference = ...

(ii) Calculate the average power delivered to the coil in this time.

(3)

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Average power = ...

(Total for Question = 10 marks)

Q19.

In recent years there has been a development of ultracapacitors which have much higher capacitance than traditional capacitors. Capacitors store energy due to charge in an electric field whereas batteries store energy due to a chemical reaction. There are several applications where ultracapacitors have an advantage over batteries; for example storing energy from rapidly fluctuating supplies or delivering charge very quickly.

(a) A typical ultracapacitor has a capacitance of 1500 F and a maximum operating potential difference of 2.6 V.

(i) Show that the charge on this capacitor when fully charged is about 4000 C.

(2)

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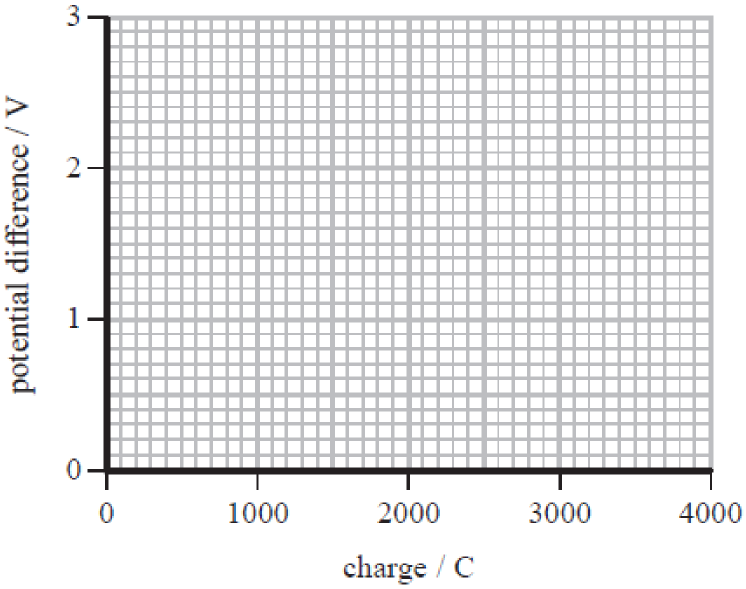
(ii) Complete the graph on the axes below to show how the potential difference varies with charge for this capacitor.

(2)



(iii) Calculate the energy stored in this capacitor when fully charged.

(2)

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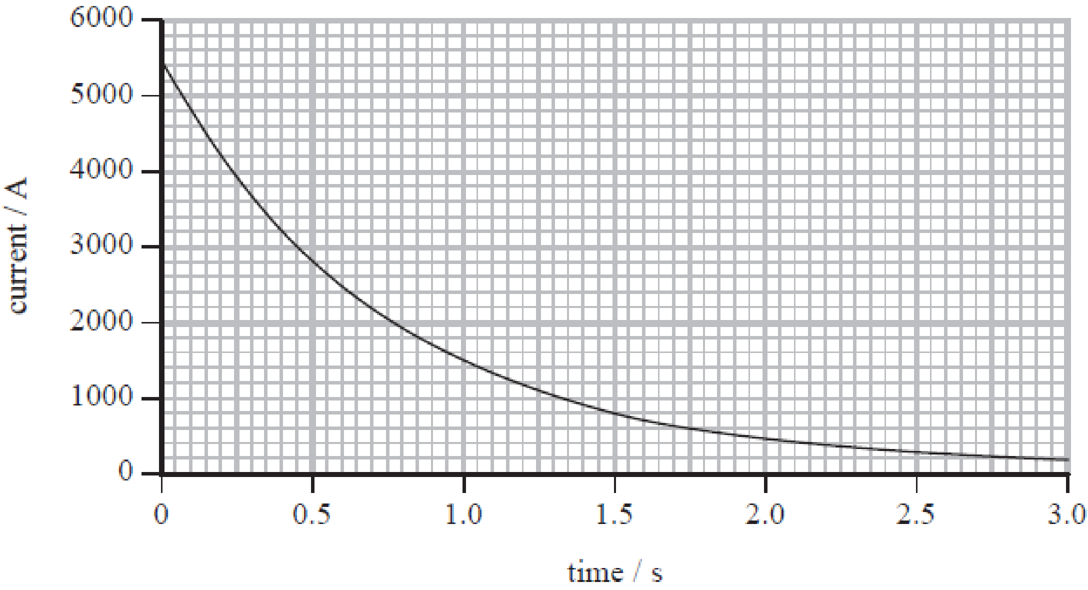
Energy = ...

(b) The graph below shows how the current varies with time as the capacitor is discharged through a circuit.



(i) Describe and explain the shape of the graph.

(2)

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(ii) Calculate the resistance of the circuit.

(4)

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Resistance = ...

(c) There is a limit to the amount of charge an ultracapacitor can hold but it can deliver the charge very quickly. A battery can deliver much more charge but only at a slower rate. For electric powered vehicles it is suggested that using a combination of batteries and ultracapacitors would give the best performance.

Suggest, with reasons, which stages of a journey would be more suited to ultracapacitors and which would be more suited to batteries.

(3)

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(Total for question = 15 marks)

Q20.

At the beginning of the 20th century, Rutherford carried out large-angle alpha particle scattering experiments using gold ($^{197}_{79}$Au) foil.

The vast majority of the alpha particles went straight through the foil whilst a few were deflected straight back.

Rutherford also carried out the experiment with aluminium ($^{27}_{13}$Al) foil.
The aluminium foil had the same thickness as the gold foil and the alpha particles had the same initial kinetic energy.

The following observations were made.

Observation 1:
The fraction of alpha particles scattered at any particular angle for aluminium foil was always much less than for gold foil.

Observation 2:
The alpha particles scattered from aluminium foil had less kinetic energy than the alpha particles scattered from gold foil.

Explain how these observations can be used to deduce how an aluminium nucleus compares to a gold nucleus.

(4)

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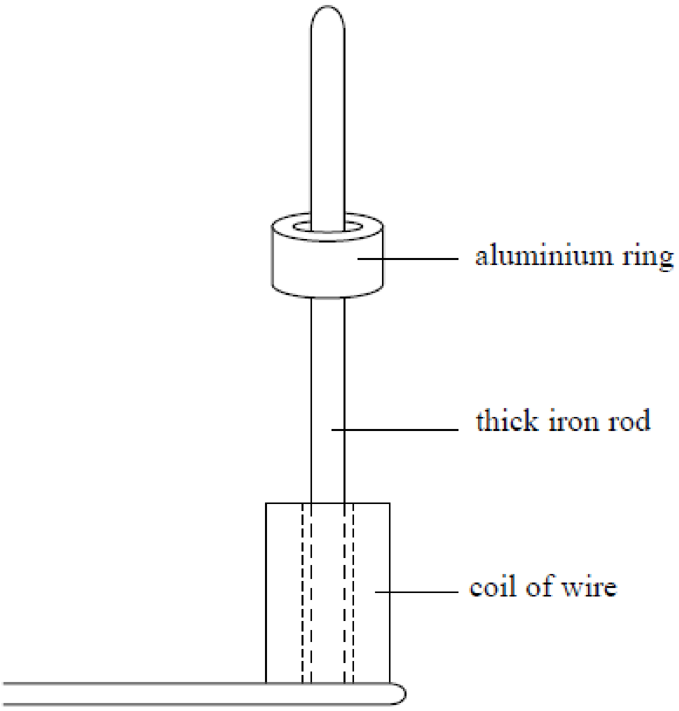
(Total for question = 4 marks)

Q21.

A coil of wire is placed around the lower end of an iron rod. The coil is supplied with an alternating current.

A thick aluminium ring is placed around the iron rod above the coil. The coil remains in the position shown.



The current is switched off and the aluminium ring comes to rest on top of the coil.
The supply to the coil is changed and a direct current (dc) is switched on. An upwards force *F* acts on the ring for 0.05 s accelerating it to a final speed, *v*. The ring then moves freely through a height of 30 cm.

Mean diameter of ring = 4.8 cm
Mass of ring = 0.019 kg
Magnetic field strength = 0.032 T

(i) Use conservation of energy to calculate the speed *v* of the ring after 0.05 s.

(2)

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v = ...

(ii) Use the idea of impulse to calculate the magnitude of the mean force *F* acting on the ring and hence the mean current *I* in the ring.

(6)

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F = ...

I = ...

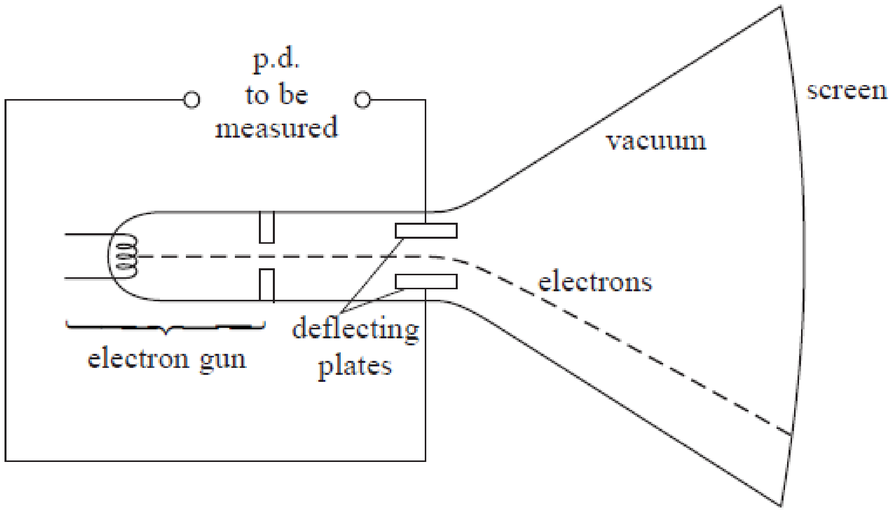
(Total for question = 8 marks)

Q22.

Cathode ray tubes are used in oscilloscopes.

The diagram shows a simplified cathode ray tube that can be used to determine the magnitude and polarity of a potential difference (p.d.).

The cathode ray tube consists of an electron gun, a pair of deflecting plates and a fluorescent screen.



(a) The electron gun includes a filament. When this filament is heated, electrons are released and are accelerated by a p.d. of 1.5 kV to form an electron beam.

(i) Name the process by which electrons are released from the heated filament.

(1)

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(ii) Show that the maximum velocity of the electrons is about 2×10^7 m s^{-1}.

(2)

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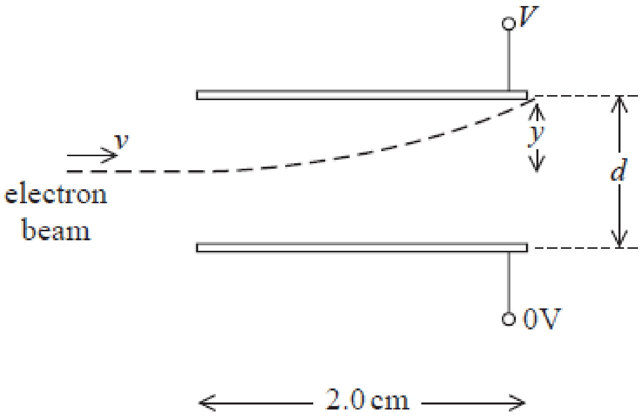
(b) The electron beam then enters a uniform electric field between the two parallel horizontal deflecting plates. The magnitude and direction of the deflection is determined by the p.d. *V* that is applied across the plates.

The diagram shows one possible path of the electron beam as it passes between the plates.



(i) Show that the acceleration of an electron, of mass *m* and charge *Q*, is given by

$$\frac{VQ}{dm}$$

(2)

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(ii) Calculate the magnitude of the vertical deflection y of the beam as it leaves the plates.

V = 50 V
d = 0.01 m

(5)

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y = ...

(c) A laboratory oscilloscope with the time base turned off operates in the same way as this simplified cathode ray tube. A student uses an oscilloscope in this way to monitor an alternating p.d. of 53 V_{rms}

On the grid, draw the trace that would be seen on the screen.

(4)

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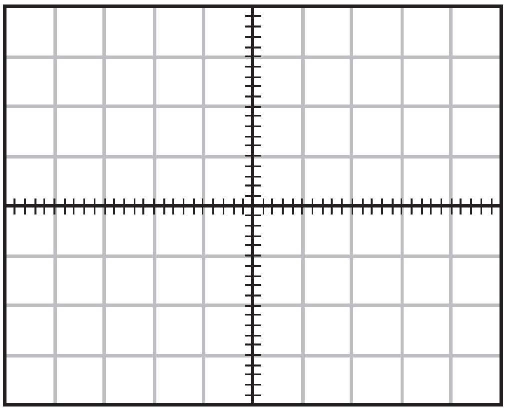


1 square = 25 V

(Total for question = 14 marks)

Q23. Two protons, separated by a distance *x*, experience a repulsive force *F*.

If the separation is reduced to *x*/3 the force between the protons will be

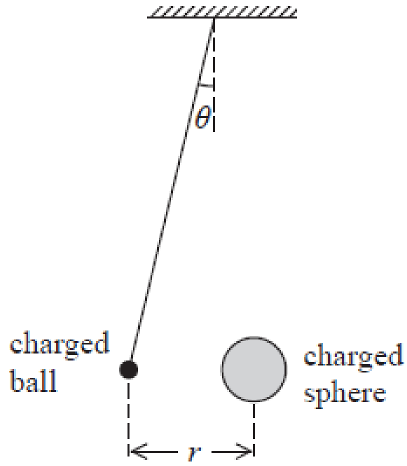
- ☐ **A** *F*/9
- ☐ **B** *F*/3
- ☐ **C** 3*F*
- ☐ **D** 9*F*

(Total for Question = 1 mark)

Q24.

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)

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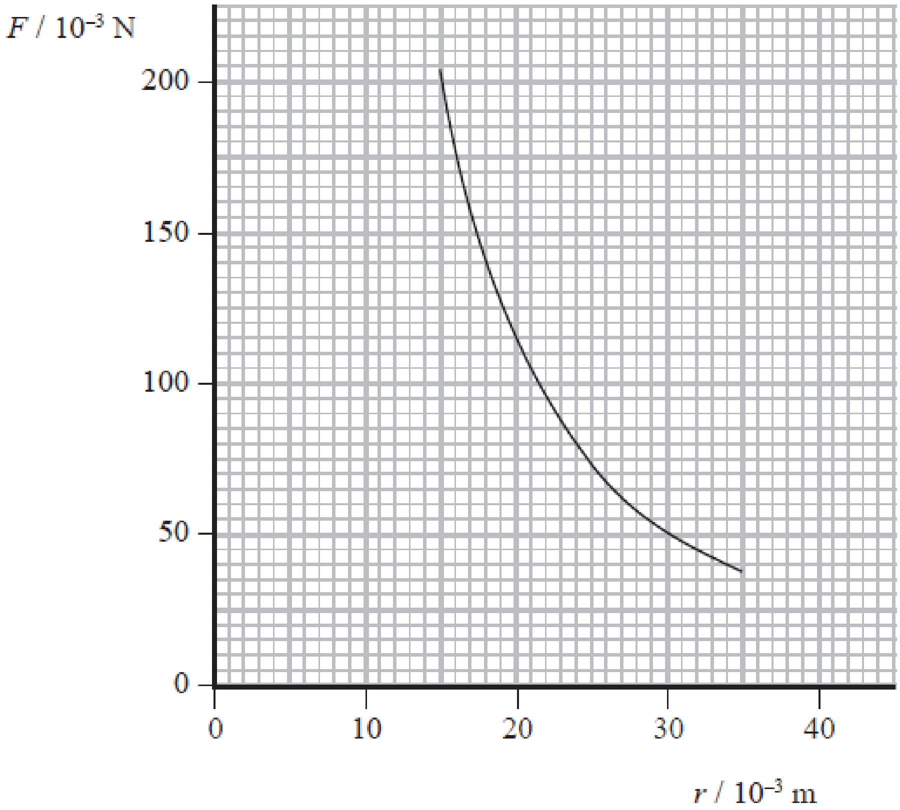
(b) (i) The student can increase the magnitude of the force by moving the sphere towards the suspended ball.
She takes pairs of measurements of r and θ and calculates the magnitude of the force F. She then plots a graph of F against r.



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

(4)

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

Calculate the charge on the ball.

(3)

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Charge = ...

(Total for question = 11 marks)

Q25.

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)

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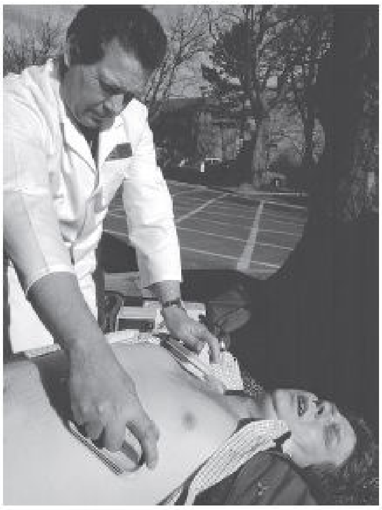
(Total for question = 3 marks)

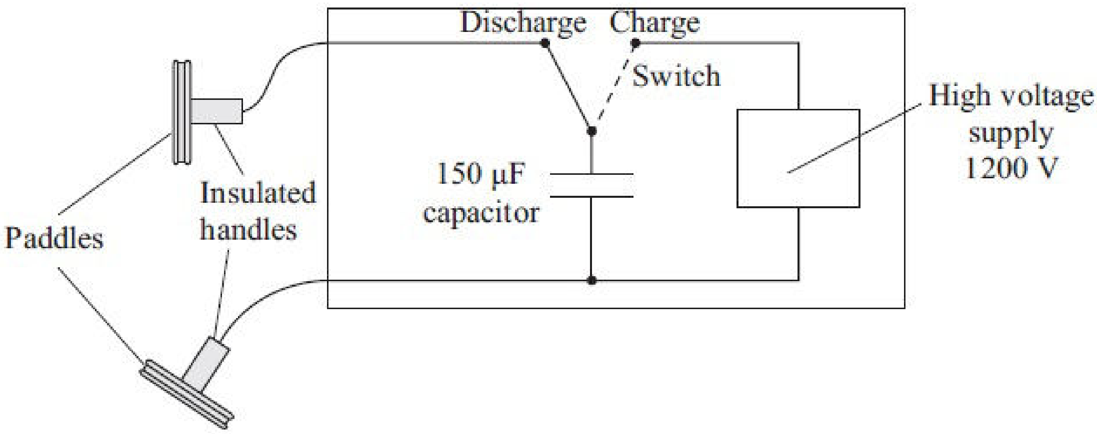
Q26.

A defibrillator is a machine that is used to correct an irregular heartbeat or to start the heart of someone who is in cardiac arrest.



The defibrillator passes a large current through the heart for a short time.

The machine includes a high voltage supply which is used to charge a capacitor. Two defibrillation 'paddles' are placed on the chest of the patient and the capacitor is discharged through the patient.



(a) The 150 μF capacitor is first connected across the 1200 V supply

Calculate the charge on the capacitor.

(2)

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Charge = ...

(b) Calculate the energy stored in the capacitor.

(2)

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Energy stored = ...

(c) When the capacitor discharges there is an initial current of 14 A in the chest of the patient.

(i) Show that the electrical resistance of the body tissue between the paddles is about 90 Ω

(1)

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(ii) Calculate the time it will take for three quarters of the charge on the capacitor to discharge through the patient.

(3)

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Time = ...

(iii) Body resistance varies from person to person. If the body resistance was lower, the initial current would be greater.

State how this lower body resistance affects the charge passed through the body from the defibrillator.

(1)

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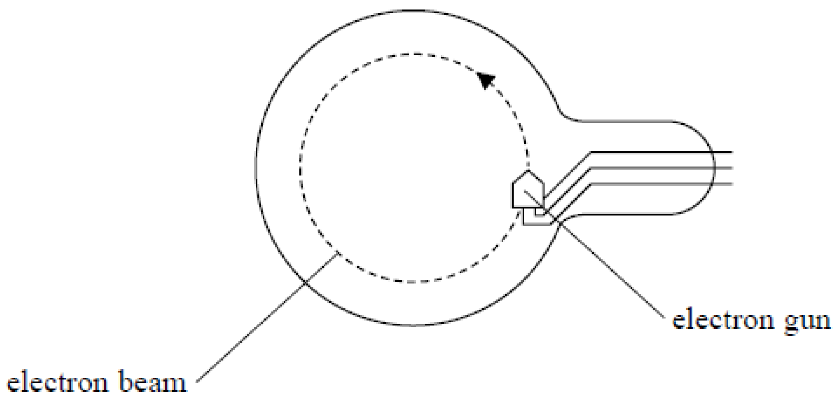
(Total for question = 9 marks)

Q27.

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.



Explain why the electrons follow a circular path.

(3)

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(Total for question = 3 marks)

Q28.

Electric fields are caused by both point charges and by parallel plates with a potential difference across them.

Describe the difference between the electric field caused by a point charge and the electric field between parallel plates. Your answer should include a diagram of each type of field and reference to electric field strength.

(5)

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Q29.

Mains electricity in the UK is 230 V rms.

The peak voltage of the mains supply is given by

☐ **A** $\frac{230}{\sqrt{2}}$ V

☐ **B** $230\sqrt{2}$ V

☐ **C** $\frac{\sqrt{2}}{230}$ V

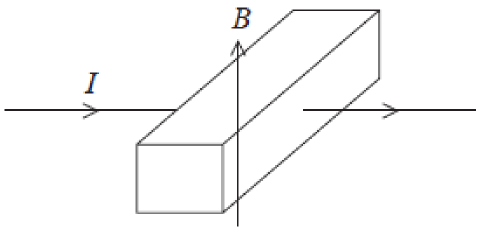
☐ **D** $\frac{230}{2}$ V

(Total for question = 1 mark)

Q30.

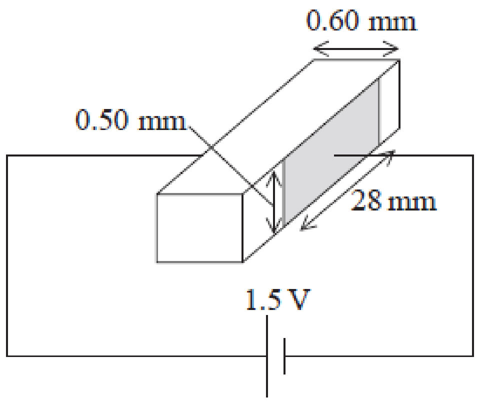
Some liquids conduct electricity. This property can be used to pump these liquids through pipes.

A short section of a rectangular pipe containing a liquid is shown in the diagram. The pipe is placed in a magnetic field of flux density *B* and a current *I* is passed through the liquid as shown.



A practical demonstration of this principle used two rectangular electrodes, opposite each other on either side of the pipe, a distance of 0.60 mm apart. The dimensions of the electrodes are shown in the diagram.

The electrodes were connected to a 1.5 V cell.
Salt water was pumped using a magnetic field of magnetic flux density 0.40 T.



(i) Show that the current through the salt water is about 20 mA.

resistivity of salt water = 1.6 Ω m

(4)

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(ii) Hence calculate the force on the salt water.

(2)

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Force = ...

(Total for question = 6 marks)

Mark Scheme

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	• Alternating current/a.c. (in primary) produces changing/alternating magnetic flux/field **(1)** • The magnetic flux/field is linked to the secondary coil by the iron core **(1)** • The changing magnetic flux/field induces an emf in the secondary coil **(1)** • More turns on the secondary (will increase the rate of change of flux linkage according to Faraday's law). **(1)**	alt. to changing magnetic flux is $\Delta N\phi$ alt. quote of $V_1/V_2 = N_1/N_2$	**(4)**

Q2.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• Conversion of MeV to J • See $Q_1 = 79 \times 1.6 \times 10^{-19}$ **and** $Q_2 = 2 \times 1.6 \times 10^{-19}$ • Use of $V = \frac{Q}{4\pi\varepsilon_0 r}$ **and** $W = QV$ • $r = 4.1\times10^{-14}$ m	(1) (1) (1) (1)	<u>Example of calculation</u> $E_\alpha = 5.5\times10^6 \text{eV} \times 1.6\times10^{-19} \text{J eV}^{-1} = 8.8\times10^{-13} \text{J}$ $8.8\times10^{-13} \text{J} = \frac{79\times1.6\times10^{-19}\text{C}\times2\times1.6\times10^{-19}\text{C}}{4\pi\times8.85\times10^{-12} \text{F m}^{-1}\, r}$ $r = \frac{3.64\times10^{-26} \text{N m}^2}{8.8\times10^{-13} \text{J}} = 4.1\times10^{-14}$ m	4
(ii)	• Electrons are behaving like waves • wavelength$=\frac{h}{\text{momentum}}$ • Electron wavelength must be similar to the atomic spacing in the foil	(1) (1) (1)	MP3: Accept electron wavelength must be similar to the distance between (adjacent) nuclei	3

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	(see IC table and indicative content below)	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 table shows how the marks should be awarded for indicative content and structure and lines of reasoning.	

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

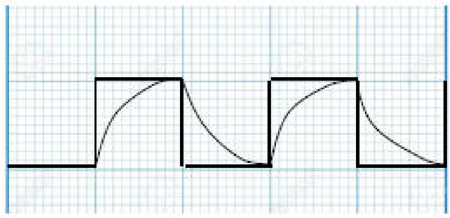
	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Acceptable Answer	Additional Guidance	Mark
Indicative content:	**Alternative to first 3 indicative content points:**	
IC1 Alternating p.d. causes an alternating current in the coil	IC1 Current in coil causes a magnetic field	
IC2 Current carrying conductor in a magnetic field experiences a force	IC2 Current is alternating so field changes direction with current (same frequency)	
IC3 Current is alternating, so force changes direction with current (same frequency) **Or** the alternating current drives the cone at the frequency of the p.d.	IC3 Field interacts with permanent magnet's field so coil experiences oscillating force	
IC4 The loudspeaker forces the box into oscillation		
IC5 (At certain frequencies) the frequency of oscillation equals the natural frequency of oscillation of the air in the box		
IC6 Maximum energy is transferred and the amplitude of vibration of the box increases	IC6 Resonance occurs and the amplitude of vibration of the box increases	6

Q4.

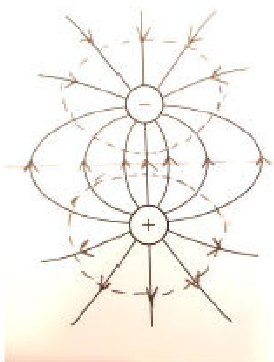
Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is A B is not correct as the peak value is 2 V C is not correct as the period is 0.22 s D is not correct as r.m.s. value of p.d. is 1.4 V		1

Q5.

Question Number	Acceptable answers		Additional guidance	Mark
	• Time axis: one cycle = 50 OR two cycles =100 • Use of time constant = RC • Charging curve, from 25 ms to 50 ms, just about reaching 5V as shown (ecf from their T) • One corresponding discharge curve • Curve should look exponential	(1) (1) (1) (1) (1)	Example of calculation $T = 1/f = 1/20\text{ Hz} = 0.050\text{ s}$ $\text{Two cycles} = 2 \times 0.050\text{ s} = 0.10\text{ s} = 100\text{ ms}$ $\text{Time Constant} = 100 \times 50 \times 10^{-6} = 0.005\text{ s}$ In half a cycle (0.025 s) there are 0.025 s / 0.005 s = 5 Time constants Ignore anything drawn in the first half cycle  Time period should be marked 50 ms or equivalent	5

Q6.

Question Number	Acceptable answers		Additional guidance	Mark
(a)	• Replace Work W by force × distance • Replace distance ÷ time by velocity v • Use $v = r \times$ Angular velocity • Recognise $F \times r$ is the moment of F	(1) (1) (1) (1)	Alternative method: Consider one revolution of axle , Load rises $2\pi r$ Work done = $2\pi rF$ Time taken = $2\pi \div \omega$ Power = Work ÷ time= $2\pi rF \div 2\pi/\omega$ to give reqd eq	4

Question Number	Acceptable answers		Additional guidance	Mark
(b)(i)	• Arrow away from + charge **Or** arrow towards − charge • At least 3 Equipotential lines, perpendicular to field lines • Symmetrical about vertical/horizontal axis and not touching/crossing	(1) (1) (1)	MP3 dependent on lines being perpendicular in MP2 	3

Question Number	Acceptable answers		Additional guidance	Mark
(b)(ii)	• Use of $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ • $F = 0.036$ (N)	(1) (1)	Example of calculation: $F = 8.99 \times 10^9\,\text{Nm}^2\text{C}^{-2}\,\frac{(0.1\times10^{-6}\,\text{C})^2}{(0.05\text{m})^2}$ $F = 0.036\text{N}$	2

Question Number	Acceptable answers		Additional guidance	Mark
(c)	• Use of moment = $F x$ • Expression for correct moment • Use of power = moment of force x angular velocity • Only realistic possibility is pond pump and $P = 0.6\text{W}$ (calculated answer could also be force and then comparison with b(i))	(1) (1) (1) (1)	Show that value gives 3.2×10^{-3} Nm and 0.64 W Example of calculation: Moment $= 0.036\text{N} \times 0.04\text{m} \times 2 = 2.89 \times 10^{-3}\,\text{Nm}$ $\text{Power} = 2.89\times10^{-3}\,\text{N m} \times 200\text{s}^{-1} = 0.58\text{W}$	4

Q7.

Question Number	Answer	Mark
	Arrow added to diagram downwards on or near the copper rod (1) An indication that the field is at right angles to the page or copper rod (1) Magnetic field into page (1) (Upward arrow for current →magnetic field out of page. If no arrow on rod MP2 &3 can still be scored)	3
	Total for question	3

Q8.

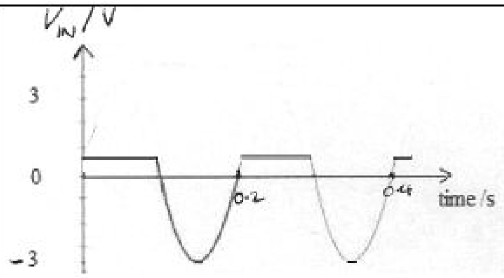
Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $V = Q/4\pi\varepsilon_0 r$ (1) • Conversion MeV to J (1) • Use of $V = W/Q$ (1) • $r = 3.0 \times 10^{-14}$ m (1)	allow for $Q = 2$ or 79, accept $V = kQ/r$ Must use $e = 1.6 \times 10^{-19}$ C to convert atomic number to C <u>Example of calculation</u>: $7.7 \times 10^6 \text{eV} \times 1.6 \times 10^{-19} \text{J eV}^{-1}$ $= 8.99 \times 10^9 \text{N m}^2\text{C}^{-2} \times 2 \times 79 \times (1.6 \times 10^{-19} \text{ C})^2 \div r$ $r = 2.27 \times 10^{-7} \div 7.7 \times 10^6$ $r = 2.95 \times 10^{-14}$ m	4

Q9.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of $F = BIl \sin\theta$ (1) • Use of $F = mg$ (1) • $B = 0.0786$ T (1)	Example of calculation: $BIl = mg$ $\therefore B = \dfrac{5.65 \times 10^{-3} \text{ kg} \times 9.81 \text{ N kg}^{-1}}{4.55 \text{ A} \times 15.5 \times 10^{-2} \text{ m}}$ $= 0.07859\ T$	3

Q10.

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Use of $V_{rms} = \frac{V_0}{\sqrt{2}}$ • V_{rms}= 2.4 V	(1) (1)	Example of calculation: $V_{rms}=\frac{3.4}{\sqrt{2}}$= 2.4 V	(2)

Question Number	Acceptable answers		Additional guidance	Mark
(ii)	• Energy is conserved **Or** Kirchoff's law **Or** potential difference is energy per unit charge • So the sum of p.d.s in a series circuit must equal the e.m.f. applied (MP2 is dependent on MP1)	(1) (1)	accept work done for energy accept V_{in} for emf Alternative: Current is the same in both components (1) $IV_{IN}= IV_R+ IV_D$ and I cancels (1)	(2)
(iii)	• Alternate half cycles of sine curve (with peak about 3 V) • Horizontal line in 1st half cycle and negative half cycle of a sine curve in 2nd half cycle • horizontal lines/spaces at a value of potential difference of 0.6 V to 0.8 V	(1) (1) (1)		(3)

Q11.

Question Number	Answer	Mark
	D	1

Q12.

Question number	Acceptable answers	Additional guidance	Mark
	Either • Use Q = 2.6 to read time constant from graph **(1)** **OR** draw tangent to curve at t = 0 and obtain time constant from intercept on x axis **(1)** • t = 17 – 18 (ms) **(1)** • Use of $T = RC$ with their T **(1)** • C = 0.019 - 0.021 mF **(1)** **OR** • Q_0 = 7 (mC) read from graph **(1)** • Any corresponding values of Q and t read from graph **(1)** • Use of $Q = Q_0 e^{-t/RC}$ with their values for Q_0, Q and t **(1)** • C = 0.0195 – 0.0196 mF **(1)** **OR** • Q_0 = 7 (mC) read from graph **(1)** • Q=3.5 (mC) when $T_{1/2}$ = 12.3 (ms) **(1)** • Use of $T_{1/2} = RC \ln 2$ **(1)** • C = 0.0195 – 0.0196 mF **(1)**	Example of calculation: T = 19 (ms) $C = 19 \times 10^{-3}/900$ = 0.021 mF	**4**

Q13.

Question Number	Answer		Mark
(c)	Use of area $A = \pi r^2$	(1)	
	Use of $\varepsilon = BA/t$	(1)	
	Use of $I = V/R$	(1)	
	I = 4.1 A	(1)	**4**
	(accept 4.1 – 4.2 A depending on where rounding is done) (candidates who use a circumference instead of an area can only score MP3) <u>Example of calculation</u> Area of coil = $\pi \times (0.05\text{ m})^2 = 7.9 \times 10^{-3}\text{ m}^2$ $\varepsilon = BA/t = 0.035\text{ T s}^{-1} \times 7.9 \times 10^{-3}\text{ m}^2 = 2.8 \times 10^{-4}\text{ V}$ $I = \varepsilon/R = 2.8 \times 10^{-4}\text{ V} / 6.7 \times 10^{-5}\ \Omega$ I = 4.1 A		

Q14.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of Q = CV (1) • Use of $Q = Q_0 e^{-t/RC}$ (1) • $Q/Q_0 = 0.01$ (1) • t = 11.6 ms (1) • Use of $I = \frac{Q}{t}$ (1) • I = 12 A (1)	Example of calculation: Q=CV = 56 × 10^{-6} F × 2500 V = 0.14 C $\ln\left(\frac{Q}{Q_0}\right) = e^{-t/RC}$ $\ln(0.01) = -\frac{t}{45\,\Omega \times 56 \times 10^{-6}\,F}$ $\therefore t = 0.0116\,s$ $I = \frac{Q}{t} = \frac{0.14\,s}{0.0116\,s} = 12.1\,A$	**(6)**

Q15.

Question Number	Answer	Mark
	B	**1**

Q16.

Question Number	Answer	Mark
(a)	Use of $C=Q/V$ (1) V= 15 V (1) Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** $W = Q^2/2C$ (1) $W = 2.5 \times 10^{-5}$ J (1) (candidates who use 6.6×10^{-6} C can only score MP1 and MP3) <u>Example of calculation</u> $V = Q/C = 3.3 \times 10^{-6}\,C / 220 \times 10^{-9}$ F V= 15 V $W = QV/2 = (3.3 \times 10^{-6}\,C \times 15\,V)/2$ $W = 2.5 \times 10^{-5}$ J	**4**
(b)	$Q = 0.2\,Q_0$ **Or** $Q = 6.6\times 10^{-7}$ C (1) Use of $Q = Q_0\, e^{-t/RC}$ (1) t = 7.1 s (1) (candidates who use $Q = 0.8\,Q_0$ can only score MP2) <u>Example of calculation</u> $Q = 0.2\,Q_0$ $Q = Q_0\, e^{-t/RC}$ $0.2\,Q_0 = Q_0\, e^{-t/RC}$ ln (0.2) = - t/ ($20\times 10^6\,\Omega \times 220 \times 10^{-9}$ F) t = 7.1 s	**3**

(c)	**Either** refers to $W = Q^2/2C$ **Or** $W \alpha Q^2$ If Q halves, $W \rightarrow Q^2/8C$ Or halving Q quarters W (Since W becomes a quarter in the time for Q to half) it takes less time for the energy to halve than the charge to halve. (dependent mark on either MP1 or MP2) **Or** Refers to $W = QV/2$ Q and V both decrease over time W will decrease faster so takes less time to half in value. (dependent mark on either MP1 or MP2)	 (1) (1) (1) (1) (1) (1)	3
(d)	Synchronous readings **Or** data logger records readings at exact time **Or** voltmeter and stop watch need 2 people and data logger only one More readings can be taken in a shorter time **Or** higher sampling rate (treat as neutral any reference to graph plotting automatically, human reaction time or accuracy)	 (1) (1)	2
	Total for question		**12**

Q17.

Question Number	Answer		Mark
(a)(i)	Capacitor, resistor, supply and switch all in series (ignore voltmeter) Voltmeter directly across capacitor	**(1)** **(1)**	**2**
(a)(ii)	Datalogger allows large number of readings to be taken **Or** graph can be plotted directly/automatically **Or** simultaneous reading of t and V can be taken **Or** idea that people can't record quickly enough, (treat as neutral accuracy, precision misreading or human reaction time)	**(1)**	**1**
(b)	Use of $C = Q/V$ $Q = 5.0 \times 10^{-4}$ C <u>Example of calculation</u> $Q = 100 \times 10^{-6}$ F $\times$ 5.0 V $Q = 5.0 \times 10^{-4}$ C	**(1)** **(1)**	**2**
(c)(i)	Use of $I = \Delta Q/\Delta t$ e.c.f their value of C from (b) $I = 0.05$ A (accept recalculation of Q using $V = 4.90$ or 4.95 V) <u>Example of calculation</u> $I = 5.0 \times 10^{-4}$ C / 10×10^{-3} s $I = 0.05$ A	**(1)** **(1)**	**2**
(c)(ii)	tangent drawn at t = 0 $\Delta V/\Delta t = 2000 - 3300$ V s^{-1} Initial current = 0.22 - 0.28 A (MP2 & 3 can be scored even if no tangent drawn) (No credit for exponential calculation) <u>Example of calculation</u> $\Delta V/\Delta t = 1.1$ V/ 0.5 ms = 2200 V s^{-1} $I = (\Delta V/\Delta t) \times C$ $I = 2200$ V s^{-1} $\times 100 \times 10^{-6}$ F $I = 0.22$ A	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Use of $V = IR$ using answer from (ii) correct evaluation of R (5V used with current range in (ii) gives 18 - 23 Ω) <u>Example of calculation</u> 5 V = 0.22 A $\times R$ $R = 23$ Ω	**(1)** **(1)**	**2**
	Total for question		**12**

Q18.

Question Number	Answer		Mark
(a)	Use of $Q = It$ $Q = 2.8$ C <u>Example of calculation</u> $Q = 2.0 \times 10^3$ A $\times 1.4 \times 10^{-3}$ s $Q = 2.8$ C	**(1)** **(1)**	**2**
(a)(ii)	See $\tau = RC$ $\tau = 3.0 \times 10^{-4}$ (s) Relates time constant to the time for which current is required <u>Example of calculation</u> $\tau = 0.50\Omega \times (600 \times 10^{-6}$ F) $\tau = 3.0 \times 10^{-4}$ s 1.4×10^{-3}s / 3.0×10^{-4} s = 4.7RC	**(1)** **(1)** **(1)**	**3**
(b)(i)	Use of $Q = CV$ $V = 4700$ V (e.c.f from (a)(i)) <u>Example of calculation</u> $V = 2.8$V / (600×10^{-6} F) $V = 4670$ V	**(1)** **(1)**	**2**
(b)(ii)	Use of $W = ½\, QV$ **Or** $W = ½\, Q^2/C$ **Or** $W = ½\, CV^2$ Use of $P = W/t$ $P = 4.7$ MW (e.c.f. from (a)(i) and/or (b)(i)) <u>Example of calculation</u> $P = (2.8 \text{ C} \times 2.8 \text{ C}) / (2 \times 600 \times 10^{-6} \text{ F} \times 1.4 \times 10^{-3} \text{ s})$ $P = 4.7$ MW	**(1)** **(1)** **(1)**	**3**
	Total for question		**10**

Q19.

Question Number	Answer		Mark
(a)(i)	Use of $Q = CV$ Q = 3900 (C) <u>Example of answer</u> Q = 1500 F × 2.6 V Q = 3900 C	(1) (1)	**2**
(a)(ii)	Straight line through the origin Passing through 2.6 V and answer to (a)(i) or 4000 C	(1) (1)	**2**
(a)(iii)	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** use of area under graph W = 5.1 kJ (use of 4000 C gives W = 5.2 kJ (allow ecf from (a)(i)) <u>Example of answer</u> W = 3900 C × 2.6 V / 2 W = 5070 J	(1) (1)	**2**
(b)(i)	Exponential decay Current decreases by equal fractions in equal time intervals	(1) (1)	**2**
(b)(ii)	See attempt of I_0/e Finds time (accept 0.75-0.80s) Use of $\tau = RC$ R = 0.0005 Ω **Or** Finds the time for I_o to half Uses $t_{1/2} = \tau \ln 2$ Use of $\tau = RC$ R = 0.00050 – 0.00053 Ω **Or**	(1) (1) (1) (1) (1) (1) (1) (1)	
	See attempt of 37% of 5400 A Finds time (accept 0.75 to 0.80 s) Use of $\tau = RC$ R = 0.0005 – 0.00053Ω **Or** Draws tangent at t = 0 to meet time axis. Records intercept of tangent with axis (accept 0.6 s - 0.9 s) Use of $\tau = RC$ R = 0.0004 Ω – 0.0006 Ω **Or** reads a value off the y-axis and corresponding time Subs into formula using 5400 (A) to find RC Substitutes for C to find R R = 0.00050 Ω – 0.00058 Ω <u>Example of calculation</u> 37% of 5400 A is 1998 A Time to fall to this value is 0.75 s RC = 0.75 s R =0.75 s / 1500 F = 0.0005 Ω	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	**4**

(c)	**Max 3** Ultracapacitor used for: overtaking **Or** going up a hill **Or** starting (from rest) **Or** accelerating. (1) Because this requires a large current/power. (1) Batteries used for travelling at constant speed (1) Because this requires a small current/power for a longer time (1)	3
	Total for question	**15**

Q20.

Question Number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: Observation 1 • (the fraction of alpha scattering is less for aluminium) so the force of repulsion is less (at a given distance) (1) • therefore the charge on an aluminium nucleus is less than on gold nucleus (1) Observation 2 • (the E_k is less for scattered alpha for aluminium) so recoiling nucleus must have some/more kinetic energy (1) • The mass of an aluminium nucleus is less than mass of a gold nucleus (1)		4

Q21.

Question number	Acceptable answers	Additional guidance	Mark
(i)	• Use of $\frac{1}{2}mv^2 = mgh$ **(1)** • $v = 2.43\ \text{m s}^{-1}$ **(1)**	Example of calculation: $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.30} = 2.43\ \text{m s}^{-1}$	**2**
(ii)	• Use of impulse = change in momentum **(1)** • Recognises initial velocity is zero **(1)** • Hence $F = 0.923$ N **(1)** • Use of $l = \pi d$ **(1)** • Equates calculated value of F with BIl **(1)** • Hence I = 191 A **(1)**	Example of calculation: $Ft = mv - mu$ where $u = 0$ So $F = (0.019\ \text{kg} \times 2.43\ \text{m s}^{-1})/0.05\ \text{s} = 0.923$ N $l = \pi \times 0.048\ \text{m} = 0.151$ m $I = 0.923\ \text{N}/(0.032\ \text{T} \times 0.151\ \text{m}) = 191$ A	**6**

Q22.

Question Number	Answer	Additional guidance	Mark
(a)(i)	thermionic emission		**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	• equate $\frac{1}{2}mv^2$ and VQ (1) • $v = 2.3 \times 10^7\ \text{m s}^{-1}$ (1)	Example of calculation: $E = 1500\ \text{V} \times 1.6 \times 10^{-19}\ \text{C} = 2.4 \times 10^{-16}\ \text{J}$ $v = \sqrt{\frac{2 \times 2.4 \times 10^{-16}\ \text{J}}{9.11 \times 10^{-31}\ \text{kg}}} = 2.3 \times 10^7\ \text{m s}^{-1}$	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	• use of $F = EQ$ and $E = \frac{V}{d}$ (1) OR see $F = \frac{VQ}{d}$ • equate $F = ma$ and $F = EQ$ (1)		**(2)**

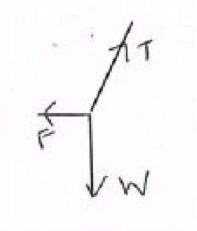
Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	• use of speed = distance/time (1) • $t = 8.7 \times 10^{-10}$ (s) (1) • use of $a = \frac{VQ}{dm}$ (1) • use of $s = ut + \frac{1}{2}at^2$ with $u = 0$ and vertical acceleration to find s (1) • $s = 3.3 \times 10^{-4}$ m (1)	Example of calculation: $t = \frac{0.02\text{ m}}{2.3\times10^{7}\text{m s}^{-1}} = 8.7 \times 10^{-10}$ s $s = \frac{1}{2} \times \left(\frac{50\text{ V} \times 1.6 \times 10^{-19}\text{ C}}{0.01\text{ m} \times 9.11 \times 10^{-31}\text{ kg}}\right) \times (8.7 \times 10^{-10}\text{ s})^2$ $s = 3.3 \times 10^{-4}$ m	**(6)**

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	• use of $V = V_0/\sqrt{2}$ (1) • vertical line (1) • positive and negative deflection shown (1) • maximum deflection 75 V (1)	Example of calculation: $V_0 = 53\text{ V} \times \sqrt{2} = 75\text{ V}$	**(4)**

Q23.

Question Number	Answer	Mark
	D	**1**

Q24.

Question Number	Answer	Mark
(a)(i)	*W*/*mg* and *T* correct (1) *F*/*E*/ electric force correct (1) Example of diagram  	2
(a)(ii)	See $T\cos\theta = W$ (1) See $T\sin\theta = F$ (1) **Or** Draws a correct triangle of forces (1) Correctly labels θ (1) (if a triangle is drawn it must be a closed polygon with correctly orientated direction of arrows)	2
(b)(i)	Records 1pair of values from graph (1) Records 2nd pair of values from graph (1) Use of $F\,r^2$ (1) Shows that $F_1r_1^2 = F_2r_2^2$ (1) (accept answers with or without the powers of ten included) Example of answer Ignoring powers of 10 $115\text{ N} \times 20^2\text{ m}^2 = 46000$ $51\text{ N} \times 30^2\text{ m}^2 = 45900$	4
(b)(ii)	Uses constant from (b) ignoring powers of ten errors **Or** uses a pair of values from graph (1) Use of $F = kQ_1\,Q_2\,/r^2$ with 1.6×10^{-19} C (1) $Q = 7.2 \times 10^{-9}$ C (1) Example of answer $100\,Q^2 = 46000 \times 10^{-9}\text{ N m}^2 / 8.99 \times 10^9\text{ N m}^2\text{ C}^{-2}$ $Q^2 = 5.12 \times 10^{-17}\text{ C}^2$ $Q = 7.2 \times 10^{-9}$ C	3
	Total for question	**11**

Q25.

Question Number	Acceptable Answers		Additional guidance	Mark
	Maximum 3 marks • There cannot be a p.d. across his body • Electric field strength inside cage is zero • As no potential gradient • Current/electrons/charge would conduct through suit **Or** the current would not pass through body	 (1) (1) (1) (1)	 Accept reference to Faraday cage for MP2	**3max**

Q26.

Question Number	Answer		Mark
(a)	Use of $Q = CV$ $Q = 0.18$ C <u>Example of calculation</u> $Q = 150 \times 10^{-6}$ F $\times$ 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
(b)	Use of $W = ½ CV^2$ **Or** of $W = ½ QV$ **Or** of $W = ½ Q^2/C$ $W = 110$ J Allow ecf from (a) if ½ QV or ½ Q^2/C used <u>Example of calculation</u> $W = ½ \times 150 \times 10^{-6}$ F $\times$ (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
(c)(i)	R = 86 (Ω) <u>Example of calculation</u> $R = V/I$ = 1200 V / 14 A $R = 85.7$ Ω	**(1)**	**1**
(c)(ii)	$Q = 0.25\ Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\ e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7 × 10^{-3} s scores 1 mark] **Or** Use of RC Use of 2 × 0.69 × RC $t = 0.018$ s <u>Example of calculation</u> $Q = 0.25\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.25\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.25) = - t/ (86 Ω × 150 × 10^{-6} F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**

Q27.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to: • The magnetic force on the electrons acts at right angles to the plane containing *B* and *v* **(1)** • Hence the force is always towards the centre of the circle **(1)** So providing a centripetal force on the electron or a centripetal acceleration that maintains circular motion **(1)**		**3**

Q28.

Question Number	Answer		Mark
(b)	**Diagram mark for parallel plate**: a minimum of 3 parallel equispaced lines touching plates (ignore edge effect)	(1)	
	Diagram mark for point charge: minimum of 4 equispaced radial lines touching charged point	(1)	
	Direction of fields correct for both diagrams consistent with charges labelled	(1)	
	Parallel plate - field strength same at all points	(1)	
	Point charge - field strength decreases with (increasing)distance from point **Or** obeys inverse square law	(1)	**5**

Q29.

Question number	Acceptable answers	Additional guidance	Mark
	B		**1**

Q30.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• Use of $R=\rho l/A$ (1) • Using $A=0.5\times28$ ($\times10^{-6}$ m^2) (1) • Use of $V=IR$ (1) • $I = 22$ (mA) (1)	<u>Example of calculation</u> $R=\frac{1.6\Omega m\times0.6\times10^{-3}m}{0.5\times10^{-3}m\times28\times10^{-3}m}$ $R=68.6\Omega$ $1.5V=I\times68.6\Omega$ $I=1.5V/68.6\Omega$ $I=0.022A=22mA$	4

Question Number	Acceptable answers	Additional guidance	Mark
(ii)	• Use of $F=BIL$ ecf values from (i) (1) • Force = 5.3×10^{-6} N (1)	Use of show that values gives 4.8×10^{-6} N <u>Example of calculation</u> $F=0.40T\times0.022A\times0.6\times10^{-3}m$ $F=5.3\times10^{-6}N$	2