7 A light dependent resistor (LDR) and a resistor are connected to a battery, as shown.

(Total for Question 7 = 1 mark)

8 A potential difference is applied across two parallel plates. A particle carrying a charge of +0.1 C is placed between the plates and experiences a force F.

The distance between the plates is halved. The potential difference remains constant.

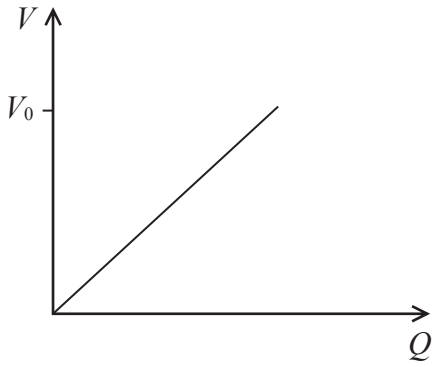
Which of the following is now equal to the electric field strength between the plates?

- ☒ **A** $5F$
- ☒ **B** $10F$
- ☒ **C** $20F$
- ☒ **D** $40F$

(Total for Question 8 = 1 mark)

9 A capacitor is connected to a power supply and charged to a potential difference V_0.

The graph shows how the potential difference V across the capacitor varies with the charge Q on the capacitor.



At a potential difference V_0 a small charge ΔQ is added to the capacitor. This results in a small increase in potential difference ΔV across the capacitor.

Which of the following gives the approximate increase in energy stored on the capacitor due to this extra charge?

☒ **A** $\Delta V \times \Delta Q$

☒ **B** $\frac{\Delta V \times \Delta Q}{2}$

☒ **C** $V_0 \times \Delta Q$

☒ **D** $\frac{V_0 \times \Delta Q}{2}$

(Total for Question 9 = 1 mark)

10 Which of the following is a unit of magnetic flux?

☒ **A** $\mathrm{N\,C^{-1}}$

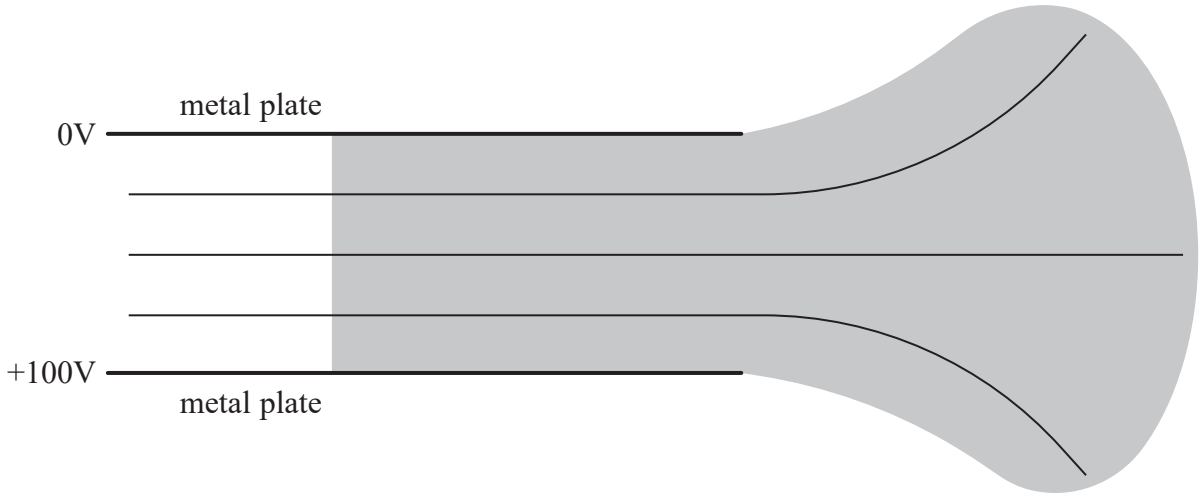
☒ **B** $\mathrm{T\,m^{-2}}$

☒ **C** $\mathrm{V\,s}$

☒ **D** $\mathrm{Wb\,m^2}$

(Total for Question 10 = 1 mark)

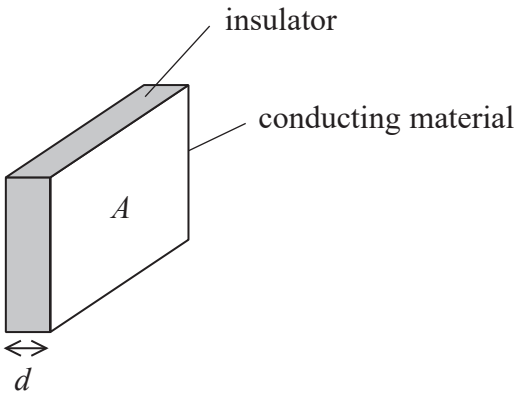
13 The diagram shows two parallel metal plates with a potential difference (p.d.) of 100 V across them. Three equipotential lines are shown.



(a) Draw lines to represent the electric field in the shaded area.

(4)

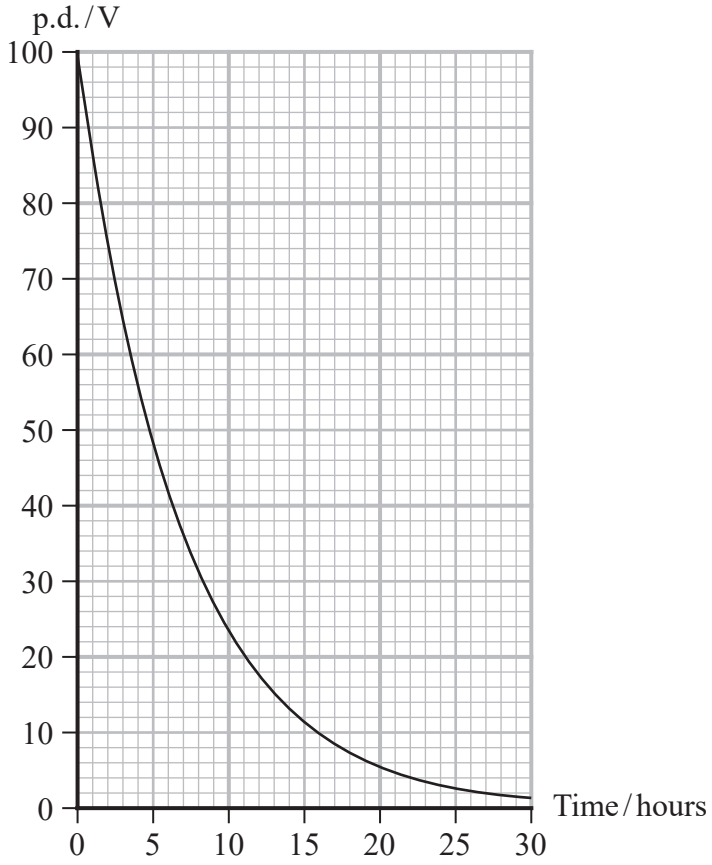
(b) A parallel plate capacitor consists of a thin layer of insulator of thickness *d* between two plates of conducting material of area *A*.



The capacitor has a capacitance 0.1 μF and is charged to a p.d. of 100 V by connecting it to an electrical supply.

The capacitor is then disconnected from the supply and the p.d. between the two plates slowly decreases. This is because the insulator is not perfect and a small charge can flow through it.

The graph shows how the p.d. varies with time.



The insulator is a type of plastic and should have a resistivity greater than $10^{14}\,\Omega\,m$.

Deduce whether the plastic used in this capacitor has a resistivity greater than this value.

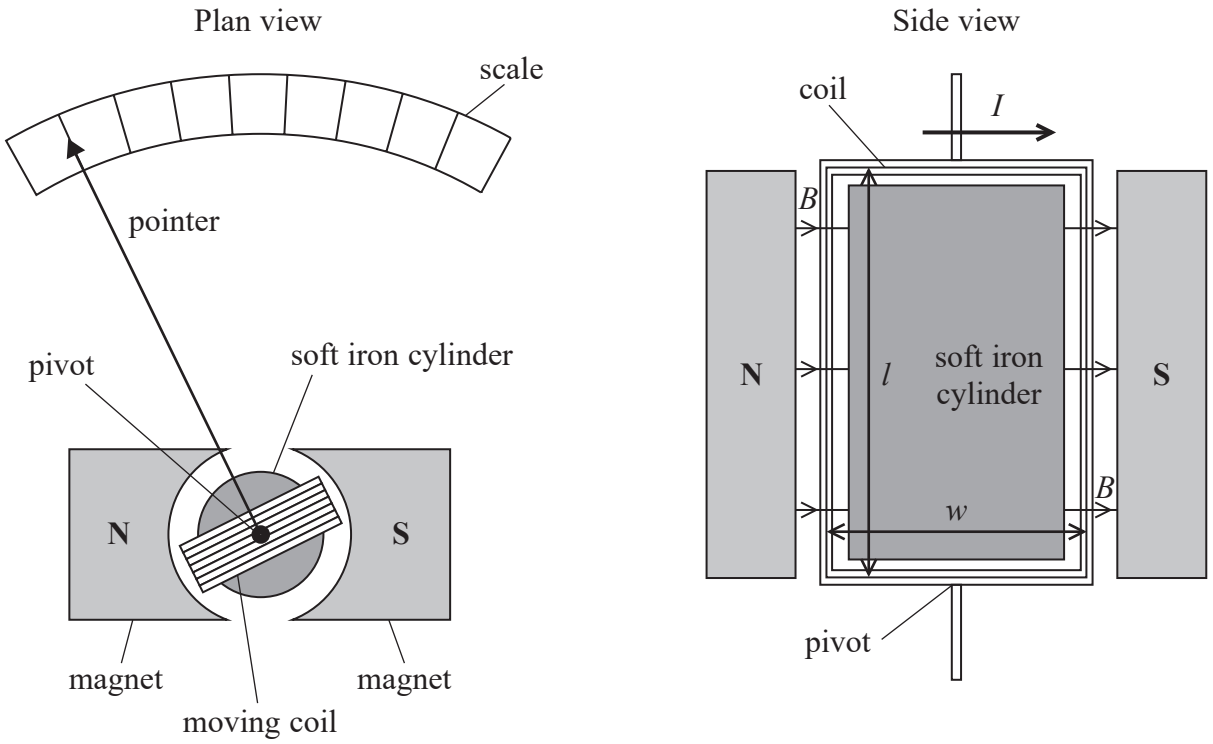
$A = 5.6 \times 10^{-3}\,m^2$

$d = 0.6 \times 10^{-6}\,m$

(5)

(Total for Question 13 = 9 marks)

17 The diagrams show the plan view and side view of a moving coil ammeter.



The fixed soft iron cylinder and magnets produce a uniform magnetic field of magnetic flux density B. The coil is able to rotate within this magnetic field. The coil has width w and length l. There is a current I in the coil in the direction shown in the side view diagram.

(a) (i) Explain which way the coil will rotate.

(2)

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(ii) Show that the moment M on the coil about the pivot, due to the magnetic field, is given by

$$M = BAIN$$

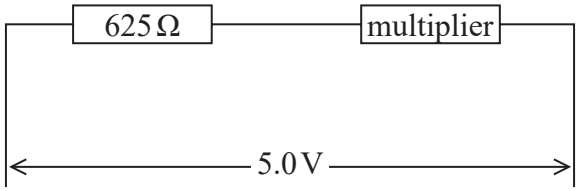
where
A is the cross-sectional area of the coil
N is the number of turns of wire on the coil.

(4)

(b) An ammeter of this type has a resistance of 625 Ω and will measure a maximum current of 1.6 mA.

The ammeter can be adapted to measure potential difference by adding a resistor in series with the ammeter. This resistor is known as a multiplier.

The ammeter is adapted so that it can measure potential differences up to 5.0 V as shown.



The following multipliers are available:

200 Ω 2500 Ω 3125 Ω 3750 Ω

Deduce which multiplier should be used.

(3)

(c) The coil within a very sensitive moving coil ammeter can be damaged when the ammeter is transported. The two ends of the coil are connected together when the ammeter is transported. This reduces the movement of the coil and makes it less likely to be damaged.

A student suggests that this is due to Faraday's law and Lenz's law.

Explain how these laws apply to this situation.

(4)

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(Total for Question 17 = 13 marks)

TOTAL FOR PAPER = 90 MARKS

in the box for the correct answer and then

(Total for Question 2 = 1 mark)

3 The distance between a proton and an electron is r. The electrostatic force is F.

The distance between the proton and electron is doubled.

Which of the following is equal to the electrostatic force at this separation?

☒ **A** $2F$

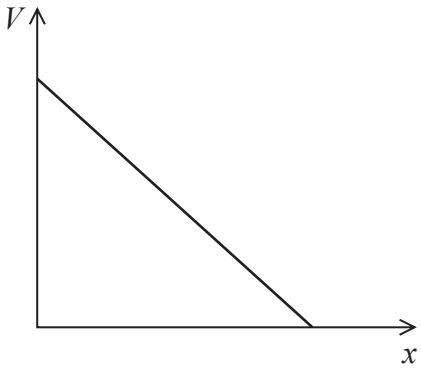
☒ **B** $\frac{F}{2}$

☒ **C** $\frac{F}{3}$

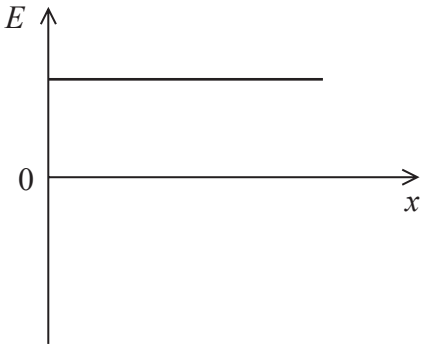
☒ **D** $\frac{F}{4}$

(Total for Question 3 = 1 mark)

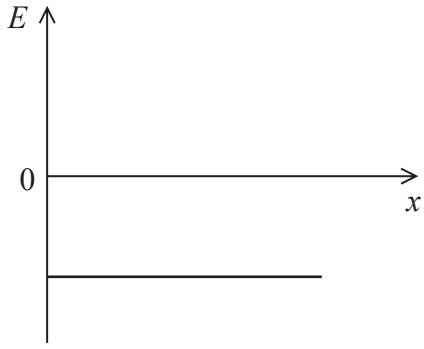
6 The graph shows how an electric potential V varies with distance x.



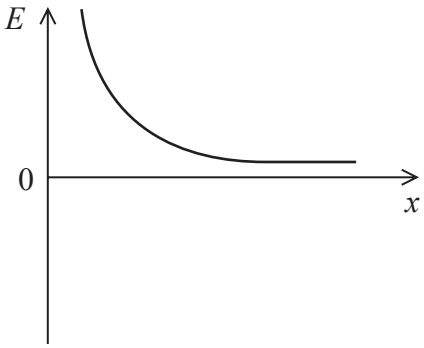
Which of the following shows the corresponding variation of electric field strength E with x?



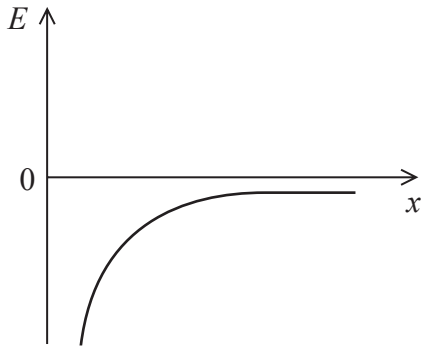
☒ **A**



☒ **B**



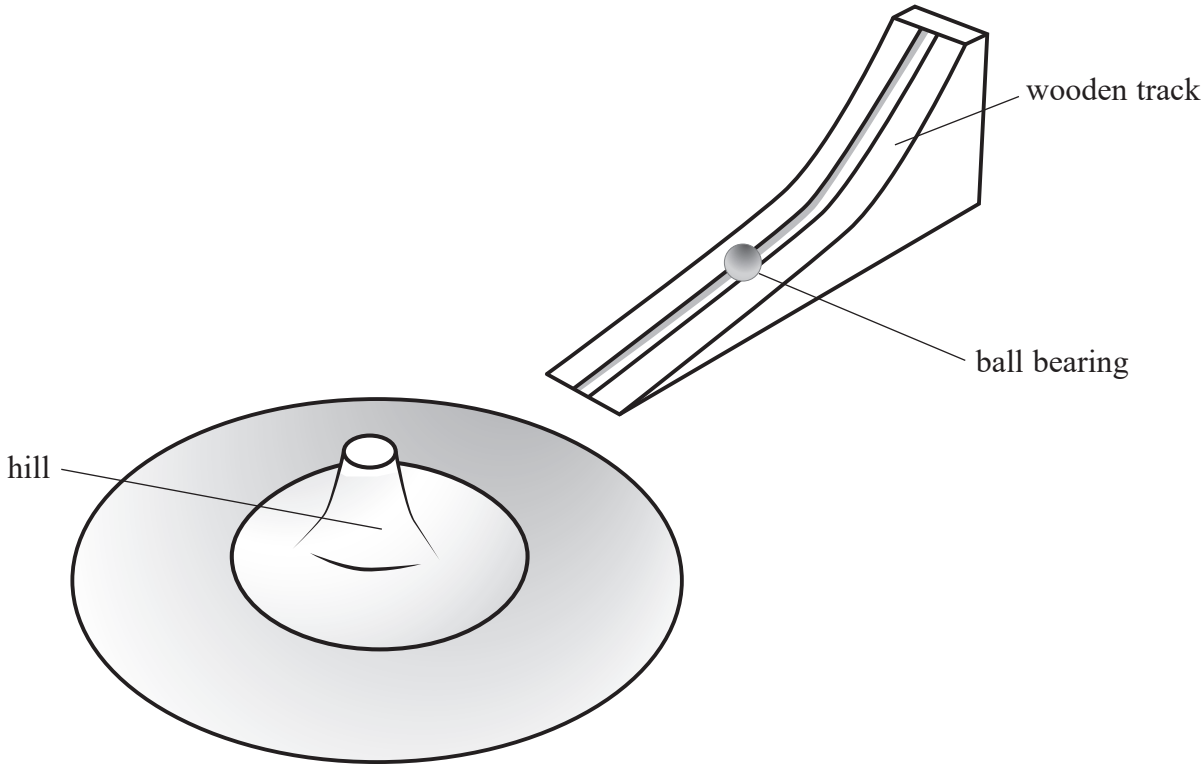
☒ **C**



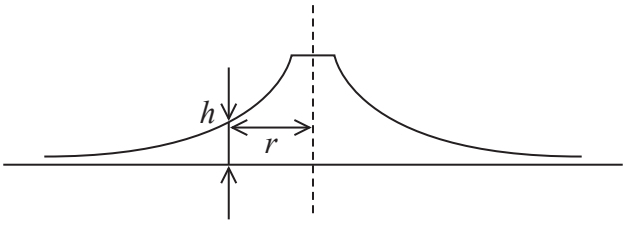
☒ **D**

(Total for Question 6 = 1 mark)

14 The diagram shows a model used to demonstrate alpha particle scattering. A ball bearing is set rolling on a wooden track. The track is positioned so that the ball bearing rolls onto a metal sheet with a curved surface known as a 'hill'.



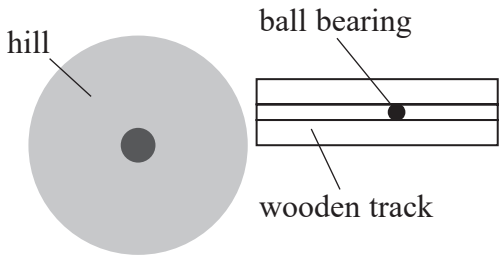
The diagram shows a vertical cross-section through the hill. The surface is curved so that the height of a point h on the curved surface is inversely proportional to the distance r from the centre of the hill.



(a) Explain why the hill is suitable as a model for the electric field surrounding the nucleus of an atom.

(3)

(b) A plan view of the arrangement is shown.



The wooden track is moved to different positions and the ball bearing is released.

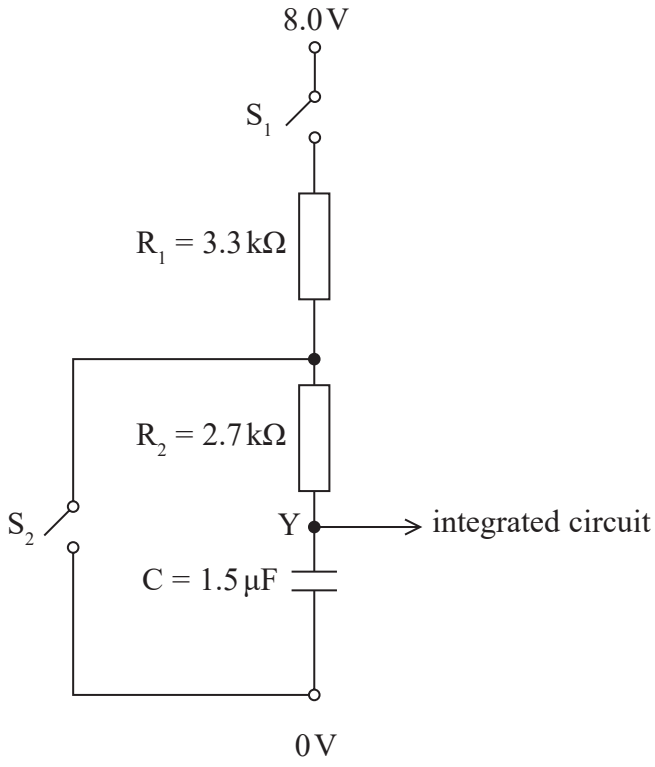
Describe the results of the alpha particle scattering experiment and how these can be demonstrated by moving the wooden track to different positions.

(4)

(Total for Question 14 = 7 marks)

15 The properties of capacitors make them useful in timing circuits.

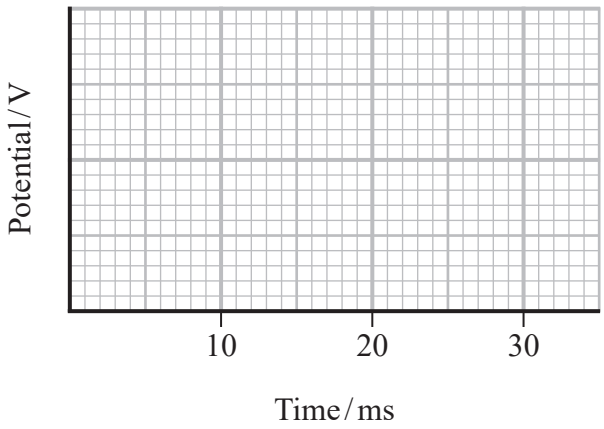
The following circuit is used to provide an input Y to an integrated circuit.



(a) Initially the capacitor is uncharged. The switch S_1 is closed.

Sketch a graph to show how the potential at point Y varies with time.

(3)



(b) When the potential at Y is 8.0 V, the switch S_2 is closed.

(i) Calculate the time taken for the potential at Y to decrease to 2.0 V.

(3)

Time taken = ...

(ii) Calculate the energy stored on the capacitor when the potential at Y is 2.0 V.

(2)

Energy stored = ...

(c) When the potential at Y is 2.0 V, the switch S_2 is opened.

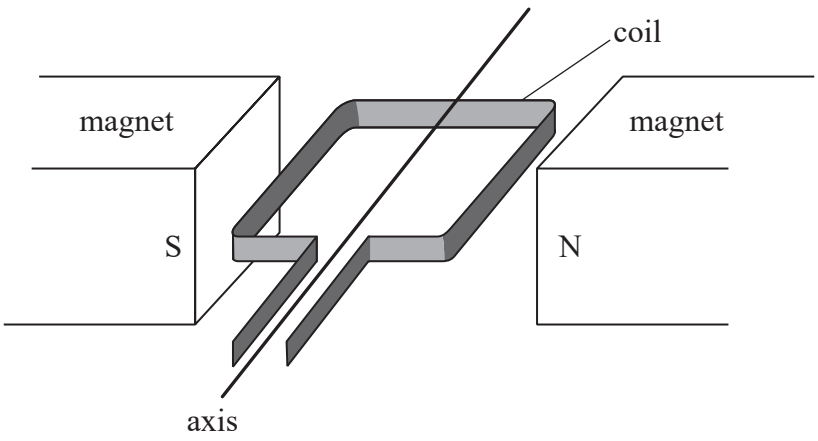
Calculate the power dissipated by the resistance R_1 when the potential at Y is 2.0 V.

(3)

Power dissipated = ...

(Total for Question 15 = 11 marks)

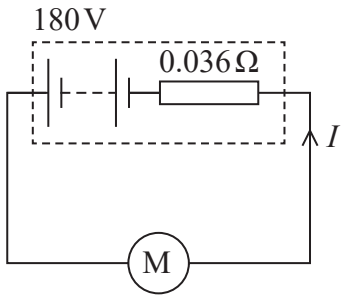
17 Hybrid electric vehicles (HEV) use the same device both as a generator to charge the car battery and as an electric motor to support the propulsion system. A simplified diagram of the device is shown. The coil can rotate freely around the axis.



*(a) Describe how the device can be used as both a generator and an electric motor.

(6)

(b) The circuit diagram shows a car battery connected to an electric motor for a HEV.
The battery has an electromotive force (e.m.f.) 180 V and internal resistance 0.036 Ω.



The motor has a maximum power of 88 kW.

(i) Show that the current I drawn by the electric motor when operating at this power would be given by the equation

$$0.036I^2 - 180I + 88\,000 = 0$$

(3)

(ii) Solving the equation above produces an answer of $I = 550$ A. At maximum power, the car can accelerate from rest to sixty miles per hour in under 7 s.

The maximum charge capacity of the battery within this HEV is 6.1 amp-hour.

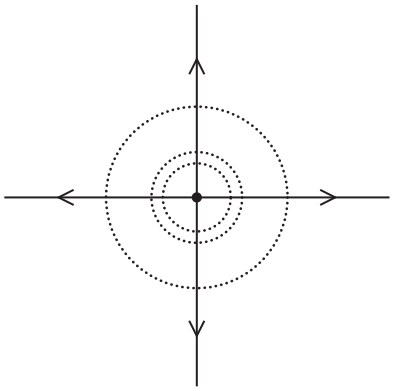
Deduce whether the battery could maintain this current for up to 7 s.

(2)

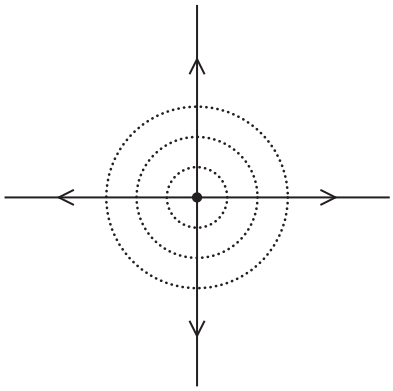
(Total for Question 17 = 11 marks)

8 A point object has a charge +Q.

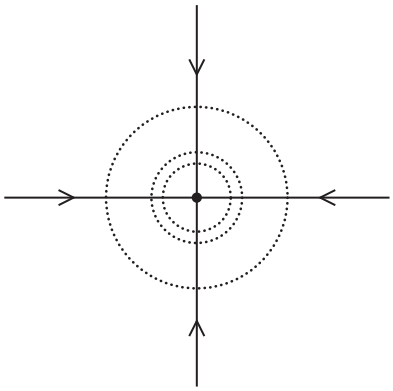
Which of the following diagrams shows equipotential lines differing by a constant potential difference, and electric field lines around the object?



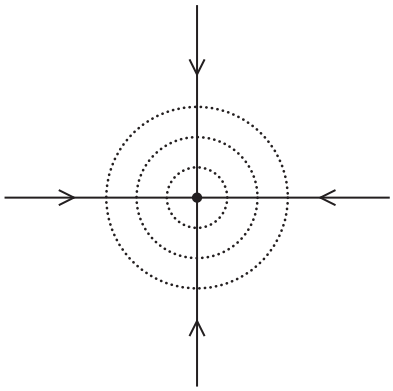
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the information below.

Alpha particle scattering investigations were first carried out in the early part of the 20th century.

9 An alpha particle with initial kinetic energy 8.8×10^{-13} J approaches a nucleus of a gold $\left({}^{197}_{79}\text{Au}\right)$ atom.

Which of the following is an equation for the closest distance r, in metres, between the alpha particle and the nucleus?

☒ **A** $r = 8.99 \times 10^{9} \left(\dfrac{2 \times 1.6 \times 10^{-19} \times 79 \times 1.6 \times 10^{-19}}{8.8 \times 10^{-13}} \right)$

☒ **B** $r = \dfrac{2 \times 1.6 \times 10^{-19} \times 197 \times 1.6 \times 10^{-19}}{8.99 \times 10^{9} \times 8.8 \times 10^{-13}}$

☒ **C** $r = 8.99 \times 10^{9} \left(\dfrac{8.8 \times 10^{-13}}{4 \times 1.6 \times 10^{-19} \times 79 \times 1.6 \times 10^{-19}} \right)$

☒ **D** $r = 8.99 \times 10^{9} \left(\dfrac{2 \times 79}{8.8 \times 10^{-13}} \right)$

(Total for Question 9 = 1 mark)

10 Which of the following conclusions could **not** be made as a result of these investigations?

☒ **A** The atom is mostly empty space.

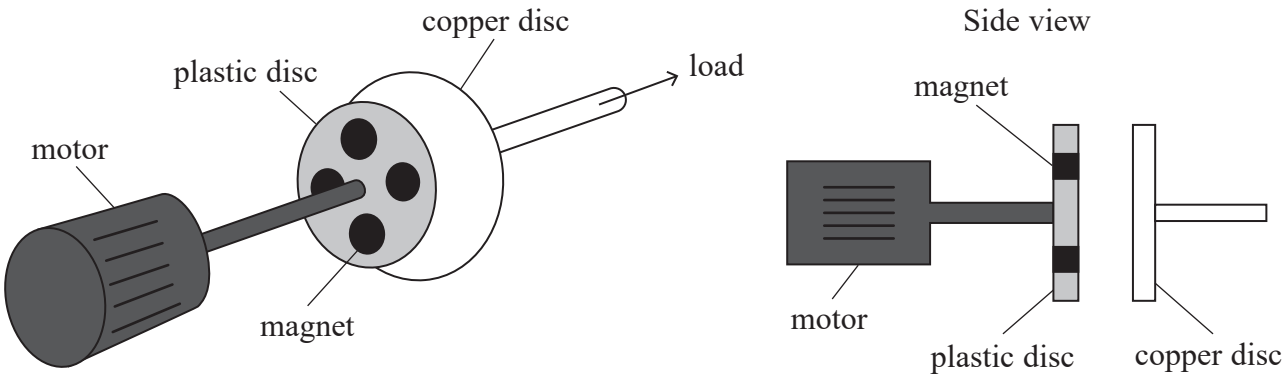
☒ **B** The atom is neutral.

☒ **C** The nucleus is charged.

☒ **D** The nucleus is very small compared to the atom.

(Total for Question 10 = 1 mark)

16 A device called a clutch can be used to connect a motor to a load. The diagram shows a design called an eddy current clutch.



Several magnets are embedded in the plastic disc and it is rotated by the motor.

(a) (i) Explain why a current is induced in the copper disc when the motor is switched on.

(2)

(ii) Explain, using Lenz's law, why the copper disc rotates.

(3)

(b) The motor rotates at 500 revolutions per minute.

Calculate the angular speed ω of the motor.

(2)

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.....

$\omega =$ .....

(c) The table shows how the turning effect exerted on a load varies with ω for a particular distance between the copper disc and the plastic disc.

ω / rad s^{-1}	Turning effect / N cm
52.4	1.0
104.7	2.0
157.1	2.8

Explain the trend shown by the data.

(4)

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(Total for Question 16 = 11 marks)