3 Two identical charged particles were placed in a vacuum 0.020 m apart. The charge on each particle was $+8.0 \times 10^{-6}$ C.

Which of the following gives the magnitude of the force, in newtons, on each particle?

☒ **A** $\dfrac{8.99 \times 10^{9} \times (8.0 \times 10^{-6})}{0.020}$

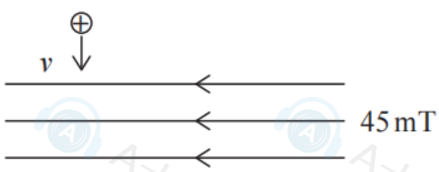
☒ **B** $\dfrac{8.99 \times 10^{9} \times (8.0 \times 10^{-6})^{2}}{0.020^{2}}$

☒ **C** $\dfrac{8.99 \times 10^{9} \times (8.0 \times 10^{-6})^{2}}{0.020}$

☒ **D** $\dfrac{8.99 \times 10^{9} \times (8.0 \times 10^{-6})}{0.020^{2}}$

(Total for Question 3 = 1 mark)

3 A proton travelling at speed v enters a uniform magnetic field.
The magnetic flux density of the field is 45 mT, as shown.



A force of 1.35×10^{-13} N is exerted on the proton.

Which of the following expressions gives v in m s^{-1}?

☒ **A** $\dfrac{1.35 \times 10^{-13}}{45 \times 1.6 \times 10^{-19}}$

☒ **B** $\dfrac{1.35 \times 10^{-13}}{45 \times 1.66 \times 10^{-27}}$

☒ **C** $\dfrac{1.35 \times 10^{-13}}{45 \times 10^{-3} \times 1.6 \times 10^{-19}}$

☒ **D** $\dfrac{1.35 \times 10^{-13}}{45 \times 10^{-3} \times 1.66 \times 10^{-19}}$

(Total for Question 3 = 1 mark)

10 A charged capacitor C_1 stores energy W_1. A charged capacitor C_2 stores energy W_2.

C_1 has half the capacitance of C_2.

C_1 is charged to half the potential difference of C_2.

Which of the following shows the ratio $\frac{W_1}{W_2}$?

☒ **A** $\frac{1}{8}$

☒ **B** $\frac{1}{4}$

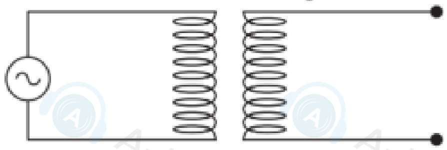
☒ **C** 4

☒ **D** 8

(Total for Question 10 = 1 mark)

DO NOT WRITE IN THIS AREA

6 Two coils, P and Q, are close to each other. An alternating supply is connected across coil P, as shown.



The number of turns on coil Q and the separation of coil P and coil Q can be changed.

Which row of the table gives the arrangement that produces the largest e.m.f. in coil Q?

		Number of turns	Separation of P and Q
☒	**A**	fewer turns in coil Q	closer together
☒	**B**	fewer turns in coil Q	further apart
☒	**C**	more turns in coil Q	closer together
☒	**D**	more turns in coil Q	further apart

(Total for Question 6 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WR

4 Which of the following gives the base units of impulse?

☒ **A** $kg\,m\,s^{-1}$

☒ **B** $kg\,m\,s^{-2}$

☒ **C** N m

☒ **D** N s

(Total for Question 4 = 1 mark)

RITE IN THIS AREA

9: In a nuclear fission reaction, a nucleus splits into a nucleus S, a nucleus T and several neutrons.

S and T have the same kinetic energy. T has twice the mass of S.

Which of the following is the ratio $\dfrac{\text{momentum of T}}{\text{momentum of S}}$?

☒ **A** $\dfrac{1}{2}$

☒ **B** $\dfrac{1}{\sqrt{2}}$

☒ **C** $\sqrt{2}$

☒ **D** 2

(Total for Question 9 = 1 mark)

6 A capacitor of capacitance C is charged to a potential difference of V_0. The capacitor then discharges through a resistor of resistance R.

After time t the potential difference across the capacitor is V.

Which of the following gives the time constant for this circuit?

☒ **A** $\dfrac{-t}{\ln(V - V_0)}$

☒ **B** $\dfrac{-t}{\ln V + \ln V_0}$

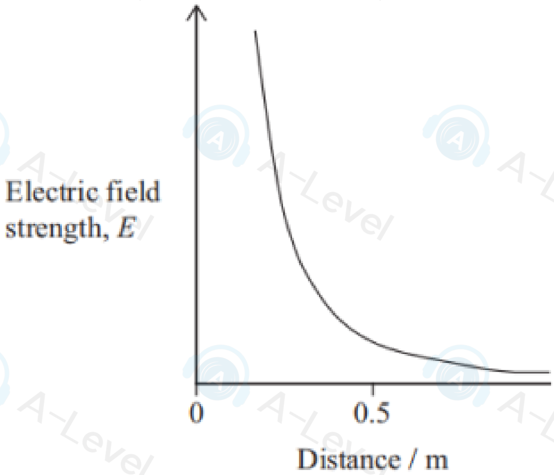
☒ **C** $\dfrac{-t}{\left(\dfrac{\ln V}{\ln V_0}\right)}$

☒ **D** $\dfrac{-t}{\ln\left(\dfrac{V}{V_0}\right)}$

(Total for Question 6 = 1 mark)

DO NOT WRITE IN THIS AREA

9 The graph shows how electric field strength varies with distance from a charged conducting sphere.



Which of the following gives the electric potential at a distance of 0.5 m from the sphere?

☒ **A** The area under the graph from 0 to 0.5 m.

☒ **B** The area under the graph from 0.5 m to infinity.

☒ **C** The gradient of the tangent to the graph at 0.5 m.

☒ **D** The value of E at 0.5 m divided by 0.5 m.

(Total for Question 9 = 1 mark)

1 Which of the following is an SI base unit?

☒ **A** ampere

☒ **B** coulomb

☒ **C** joule

☒ **D** tesla

(Total for Question 1 = 1 mark)

3: A proton is in a vacuum. At a distance r from the proton, the electric field strength due to the proton is $0.77\,\mathrm{N\,C^{-1}}$.

Which of the following gives the distance r, in m?

☒ **A** $\sqrt{\dfrac{1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times 0.77}}$

☒ **B** $\sqrt{\dfrac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times 0.77}}$

☒ **C** $\dfrac{1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times 0.77}$

☒ **D** $\dfrac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times 0.77}$

(Total for Question 3 = 1 mark)

18 The diagram shows the track of a Σ^+ particle in a bubble chamber. The particle decays at point X.

There is a magnetic field of magnetic flux density B perpendicular to the velocity of the particle.

(a) The Σ^+ particle is following a circular path of radius 1.99 m.

Calculate the value of B.

momentum of Σ^+ particle = $3.67 \times 10^{-19}\,\text{kg}\,\text{m}\,\text{s}^{-1}$

(2)

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(b) The equation shows the decay of the Σ^+ particle.

$$\Sigma^+ \rightarrow \pi^+ + n$$

(i) The Σ^+ particle is made of two up quarks and one strange quark.

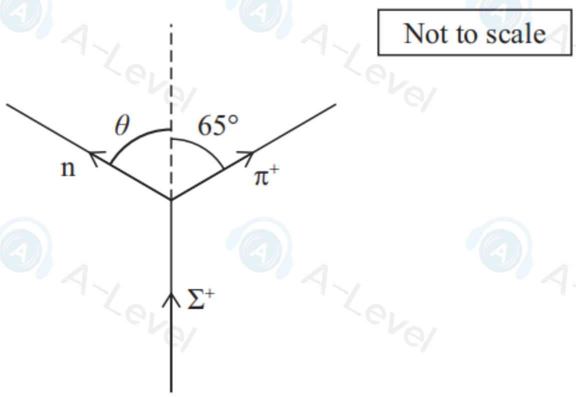
State what type of particle Σ^+ is.

(1)

(ii) Deduce whether the conservation of charge and the conservation of lepton number apply to this decay.

(4)

(iii) The diagram shows the directions of the three particles involved in the decay.



Determine the magnitude and direction of the momentum of the neutron.

momentum of Σ^+ particle = $3.67 \times 10^{-19}\,\text{kg}\,\text{m}\,\text{s}^{-1}$
magnitude of momentum of π^+ = $1.07 \times 10^{-19}\,\text{kg}\,\text{m}\,\text{s}^{-1}$

(6)

(iv) The diagram shows the track of the Σ^+ particle in the bubble chamber.

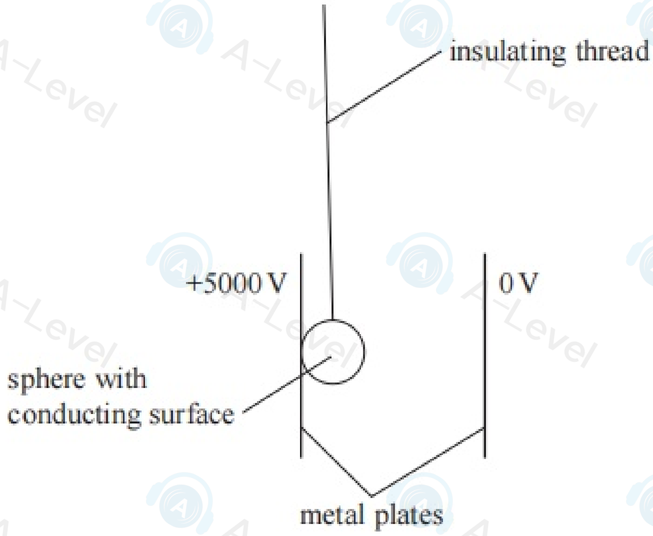
Add to the diagram to show all tracks visible in the bubble chamber after the decay at X.

You should label your diagram.

(4)

17 A potential difference of 5000 V is applied across two vertical metal plates.

A sphere with a conducting surface is suspended by an insulating thread and touches the positively charged plate as shown.



The sphere becomes positively charged.

(a) Complete the diagram to show the electric field around a positively charged sphere.

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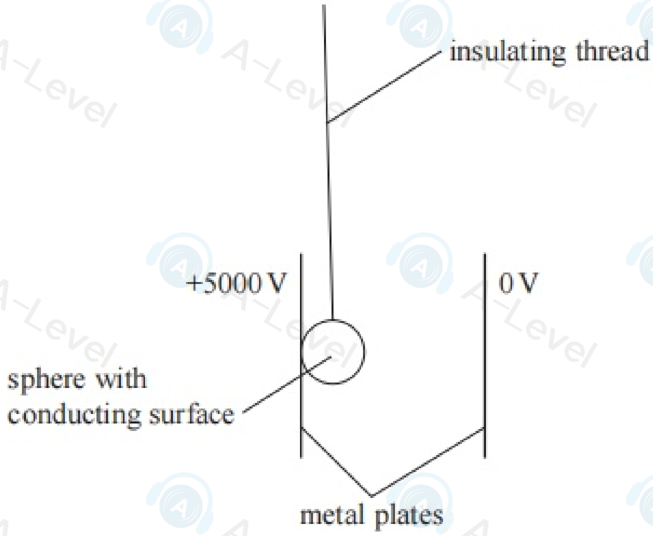

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(b) (i) Show that the charge on the sphere is about 10 nC.

potential at surface of sphere = 5000 V
radius of sphere = 20 mm

(2)

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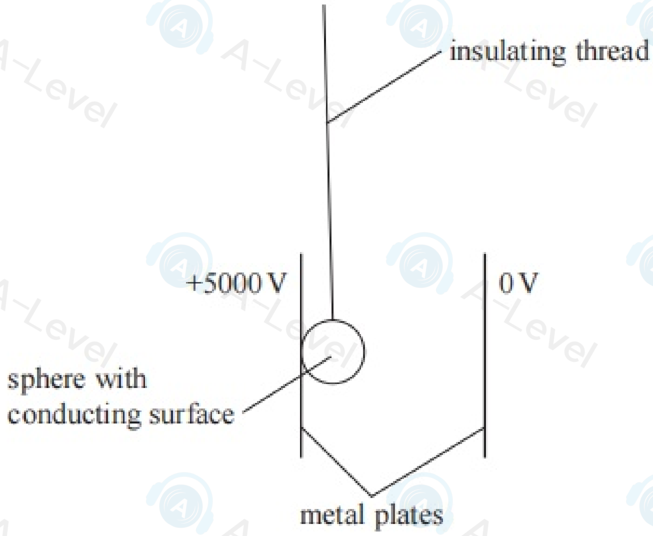

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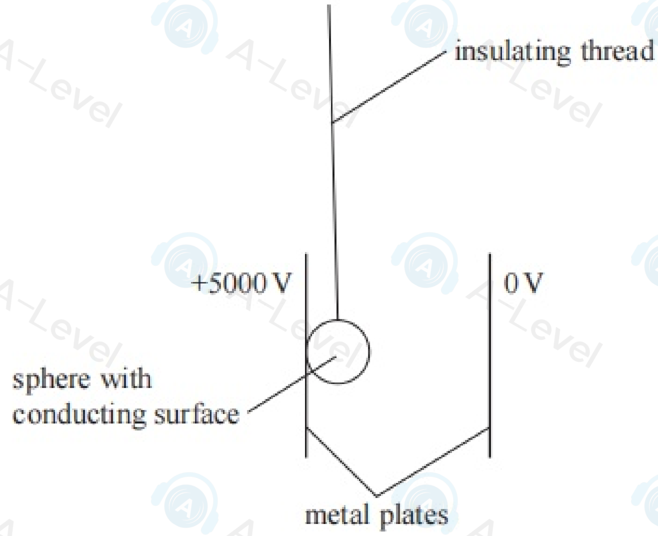

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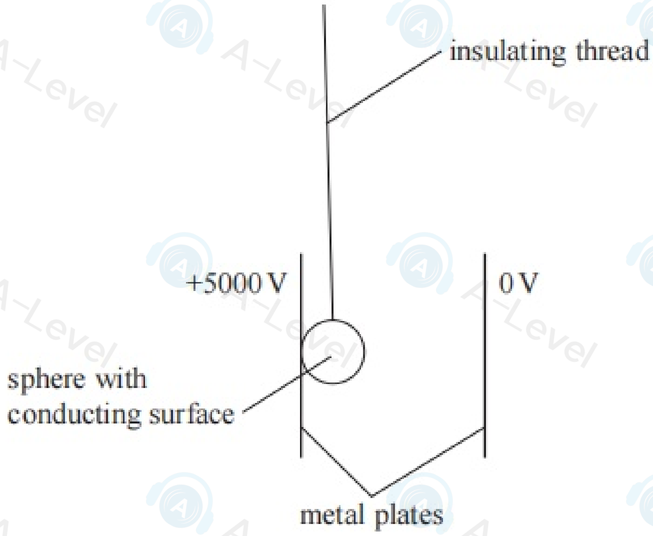

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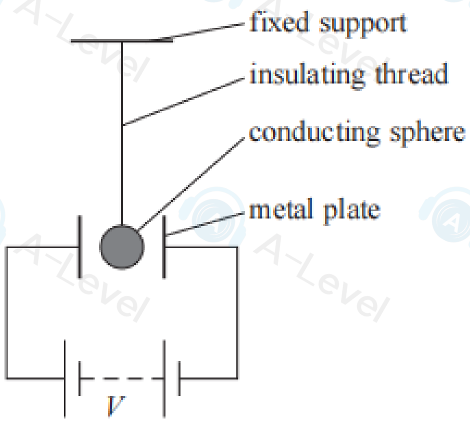
A demonstration of the principle of Gordon's device is shown.

A light, conducting sphere of radius r is suspended from an insulating thread between two parallel metal plates. A large potential difference V is applied between the plates.



(a) There is an electrostatic force on the sphere when the sphere is charged.

The capacitance C of the sphere is given by

$$C = 4\pi\varepsilon_0 r$$

where r is the radius of the conducting sphere.

The sphere is charged by touching it onto one of the plates. The plates are a distance d apart.

Calculate the electrostatic force exerted on the sphere.

$V = 4500\,\text{V}$
$d = 5.0\,\text{cm}$
$r = 3.5\,\text{cm}$

(5)

Electrostatic force on sphere = ...

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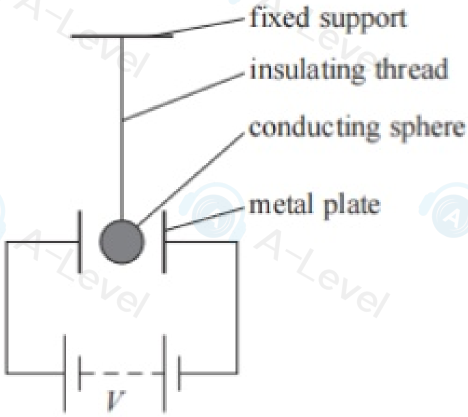

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Electrostatic force on sphere = ...

(b) After the sphere has been charged, the sphere starts to oscillate between the plates. The sphere touches each plate alternately.

Explain why the conducting sphere oscillates between the two plates.

(3)

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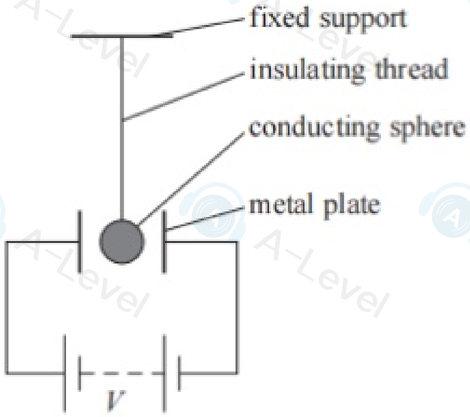

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