HALE SCHOOL
PHYSICS
Electrodynamics
YEAR 12 Unit 3A
Test 2012

Test Score:

Name: Solutions	Set:	Teacher: JAA MV

INSTRUCTIONS:

- ☐ Time Allowed = 40 minutes
- ☐ Total Marks = 40 marks
- ☐ Answer all questions in the space provided.
- ☐ Rough working is permitted on the question paper.
- ☐ Show all relevant working details in order to acquire full marks.
- ☐ Graphic Calculators are Not permitted for this paper.
- ☐ ***Do Not write in pencil. (Note: a 1 mark penalty will be incurred)**
- ☐ ***Do Not borrow materials. (Note: a 1 mark penalty will be incurred)**

POST ASSESSMENT REVIEW (to be completed upon return of your marked paper)

SELF-ASSESSMENT:

Relative Weaknesses –Objective No.

Relative Strengths –Objective No.

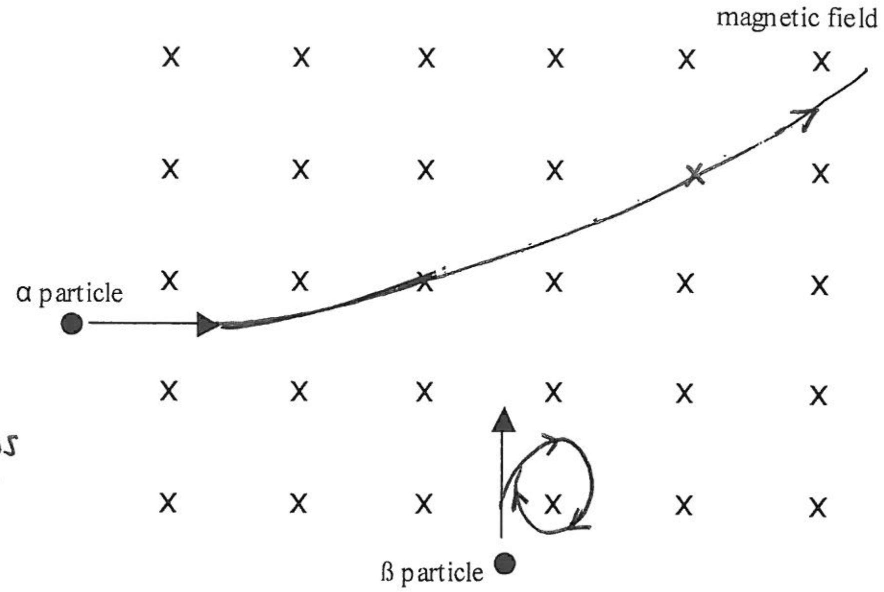
Major Concerns: (be specific)

Action Plan: (be specific)

Q1 [7 marks]

An α particle and a β particle both enter a strong uniform magnetic field with equal speeds, as indicated.

- DIRECTION α
- DIRECTION β
- RELATIVE RADIUS OF CURVATURE



1a) On the diagram, **carefully** sketch the relative paths taken by the particles. (3marks)

1b) Carefully describe explain why is the radius of curvature of the α particle different to that of the ß particle?

THE RADIUS OF α PARTICLE >> RADIUS OF β PARTICLE

SINCE $\frac{mv^2}{r} = B.v.q$ THEN $r = \frac{mv}{B.q}$ ∴ $r \propto m/q$

m/q RATIO FOR α PARTICLE IS SIGNIFICANTLY GREATER

($m_\alpha \simeq 1800\ m_\beta$ & $q_\alpha = 2 q_\beta$)

(2marks)

1c) Describe the subsequent motion of a ß particle if it enters this region parallel to the field.

THE FORCE ON THE CHARGE WILL BE ZERO ($F = B.v.q \sin\theta$)

∴ IT MOVES IN A STRAIGHT PATH THROUGH THE FIELD (UNDEFLECTED)

(1mark)

1d) Describe the subsequent motion of a ß particle if it enters this region at an angle to the field.

THE PATH WILL BE HELICAL (SPIRAL)

(1mark)

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Q2 [10 marks]

An uncharged drop of oil is given 7 excess electrons. It is then introduced into the space between two horizontal plates 25.0 mm apart with a potential difference between them of 1.50 kV. The drop of oil remains stationary.

2a) Calculate the magnitude of the electric field strength between the plates.

USING $E = \frac{V}{d}$

$= \frac{1500}{0.025}$

$\therefore E = 6.00 \times 10^{4}\ V\,m^{-1}$

(2marks)

2b) Is the top plate positive or negative? Explain your reasoning.

TOP PLATE IS POSITIVE

THE DROP IS STATIONARY BECAUSE FORCES ARE BALANCED

$\therefore$ F_{UP} (DUE TO ELECTRIC ATTRACTION TO TOP PLATE)

(2marks)

2c) Calculate the magnitude of the electric force acting on the oil drop.

SINCE $E = \frac{V}{d} = F/q$

THEN $F_E = E.q$

$= 6.00 \times 10^{4} \times 7 \times 1.6 \times 10^{-19}$

$\therefore F_E = 6.72 \times 10^{-14}$ N

(3marks)

2d) Calculate the mass of the oil drop.

SINCE DROP IS STATIONARY $F_E = F_W$

$\therefore m.g = F_E$

$\therefore m = F_E/g$

$= \frac{6.72 \times 10^{-14}}{9.8}$

$\therefore m = 6.86 \times 10^{-15}$ kg

(3marks)

Q3 [8 marks]

A deflection tube, used to analyse the deviation of an electron beam (cathode rays), has a pair of Helmholtz coils that produce a magnetic field at right angles to the beam. The path taken by the beam is indicated in diagram 1.

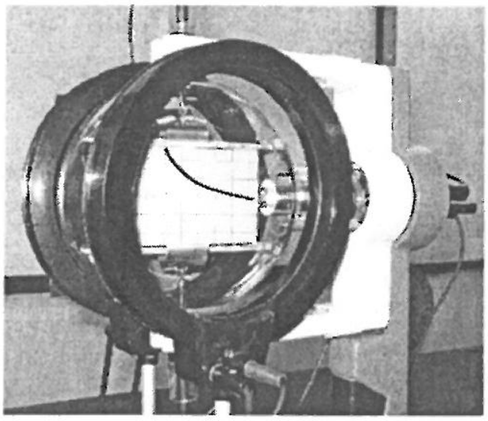
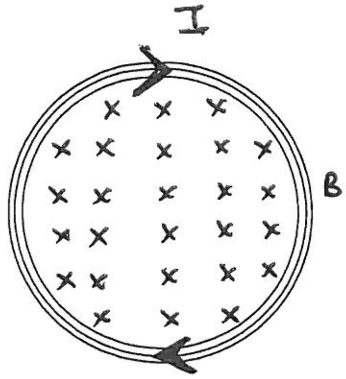


Diagram 1



Helmholtz coils (viewed from front)
Diagram 2

3a) On diagram of the Helmholtz coils (diagram 2), clearly indicate the direction of the magnetic field inside the coils and the direction of conventional current in them. (2 marks)

3b) The deflection tube produces a beam of electrons moving at high velocity that strike the fluorescent screen. The path followed by the beam can be observed on the screen.

In an experiment, the radius of the path through which the beam is deflected is determined to be 10.0 cm and the strength of the magnetic field produced within the coils is found to be 2.00 mT. Determine the velocity of the electron beam.

USING $F_c = F_B = \frac{mv^2}{r} = B.v.q$

THEN $v = \frac{B.q\,r}{m}$

$= \frac{2\times10^{-3} \times 1.6\times10^{-19} \times 0.1}{9.11\times10^{-31}}$

$\therefore$ $v = 3.51\times10^{7}\ ms^{-1}$

(3 marks)

3c) The velocity of the electrons, in the deflection tube, is determined by the accelerating voltage established between the tube's cathode and anode. Through what potential difference must the electrons be accelerated to achieve the velocity calculated in b)?

USING $V = W/q = E_K/q = \frac{\frac{1}{2}mv^2}{q}$

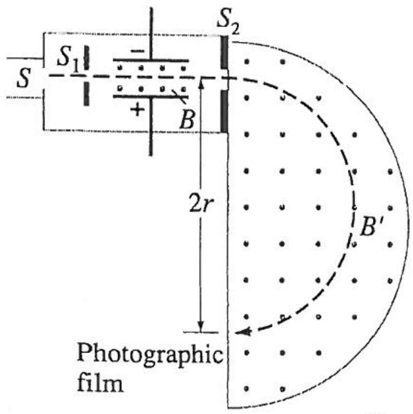
THEN $V = \frac{mv^2}{2q} = \frac{9.11\times10^{-31} \times (3.51\times10^{7})^2}{2\times1.6\times10^{-19}}$

$\therefore$ $V = 3.51\times10^{3}\ V$

(3 marks)

Q4 [9 Marks]

Electric and Magnetic fields are used in mass spectrometers, instruments to measure the masses of atoms. Ionised atoms are collimated into a narrow beam after being accelerated to a high velocity by an electric field. They are then fired into a region where there is a strong magnetic field and deflected around a semicircular arc to be detected by an ion counter (or a photographic plate). A simplified schematic diagram of such an instrument is shown.



Consider the application of a mass spectrometer when an ionised atom with a charge of 4.8×10^{-19} C and a mass of 3.64×10^{-26} kg is accelerated by a voltage of 6500 V.

4a) In relation to the diagram, what is the inferred polarity (charge) of the ion?

POSITIVE (1 mark)

4b) What is the velocity of the ionised atom on entering the Magnetic Field Chamber?

USING $V = W/q = E_K/q = \frac{\frac{1}{2}mv^2}{q}$

THEN $v^2 = \frac{2Vq}{m}$

$= \frac{2 \times 6500 \times 4.8 \times 10^{-19}}{3.64 \times 10^{-26}}$

$\therefore v = 4.14 \times 10^{5}$ ms^{-1}

(3 marks)

4c) What is the size of the magnetic force on such an ion in the deflection chamber when a Magnetic field strength of 0.72 T is operating the mass spectrometer?

USING $F = B.v.q$

$= 0.72 \times 4.14 \times 10^{5} \times 4.8 \times 10^{-19}$

$\therefore F = 1.43 \times 10^{-13}$ N

(2 marks)

4d) What is the minimum distance that the photographic plate should be from the slit in order to detect this particle?

USING $F_B = F_c = \frac{mv^2}{r} = B.v.q$

THEN $r = \frac{mv^2}{F_B} = \frac{3.64 \times 10^{-26} \times (4.14 \times 10^5)^2}{1.43 \times 10^{-3}}$

$\therefore r = 0.0436$ m

$\therefore$ MINIMUM DISTANCE $= 2r = 0.0873$ m

$= 8.73$ cm

(3 marks)

Q5 [6 Marks]

A particle accelerator is a device that uses electromagnetic fields to propel charged particles to high speeds and to contain them in well-defined beams. Particle Accelerators range in size and purpose and are at the forefront of modern science both in Australia and around the world.

Briefly describe the **primary** purpose of each of the following particle accelerators:

Particle Accelerator	Primary Purpose
Mass Spectrometer	"CHEMICAL ANALYSIS" DETERMINE MASS/IDENTITY OF UNKNOWN IONS
Large Hadron Collider	"ATOM SMASHER" - PARTICLE COLLIDER HIGH ENERGY COLLISIONS TO RE-CREATE CONDITIONS OF BIG BANG TO ANALYSE SUB ATOMIC PARTICLES
Australian Synchrotron	PRODUCE SYNCHROTRON LIGHT (RADIATION) PRODUCE HIGH INTENSITY, SPECIFIC EMR (EG XRAYS) FOR RESEARCH/EXPERIMENTS

[2 marks Each]