Magnetic forces (2a) – charges moving in magnetic fields

A Physics data....

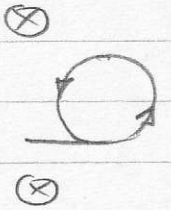
mass of electron
$m_e = 9.1 \times 10^{-31}$ kg

electron charge
$e = -1.6 \times 10^{-19}$ C.

$m_{proton} = m_{neutron} = 1.6 \times 10^{-27}$ kg

1. Going round in circles...

An atomic nucleus is fired at a speed of 1.5×10^6 m/s into a magnetic field strength 0.8 T, and moves in a circle, of radius 4 cm.



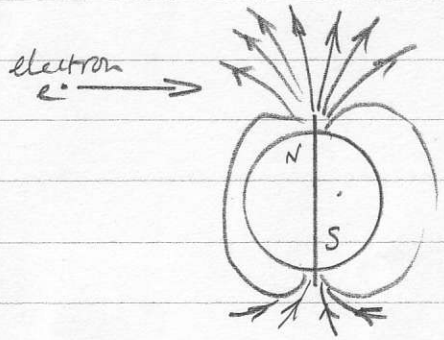
(a) Explain how you know the nucleus has a positive charge (2 reasons!) (2)

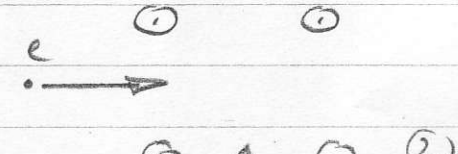
(b) Calculate the charge/mass ratio of the nucleus. (4) [6]

2. Northern Lights

Diagram 1 shows part of the Earth's magnetic field above the N pole

Diagram 2 shows the field seen from above the N pole, with a high speed (3×10^7 m/s) electron entering it from the side. The Earth field strength here is 1×10^{-6} Tesla.





(a) Sketch the path of the electron (2)

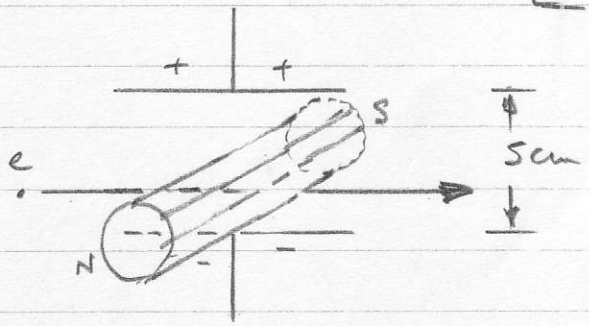
(b) Calculate its radius (4)

(c) Charged particles entering the Earth's magnetic fields can produce patterns of light in the sky. Can you explain how these are produced? (3) [9]

3. Feeling Crossed

(a) A beam of electrons is accelerated by a p.d. of 750 V. Calculate velocity (3)

(b) The beam passes between plates 5 cm apart, carrying a p.d. of 5 kV. Calculate the electric force on the electrons (2)



(c) What strength of magnetic field is needed at right angles to the electric field to make the electron beam straight? (3)

(d) Sketch the arrangement shown in the diagram, and show the directions of both fields, and the electric + magnetic forces on the electrons (4) [12]

Magnetic forces {2b} charges in magnetic fields

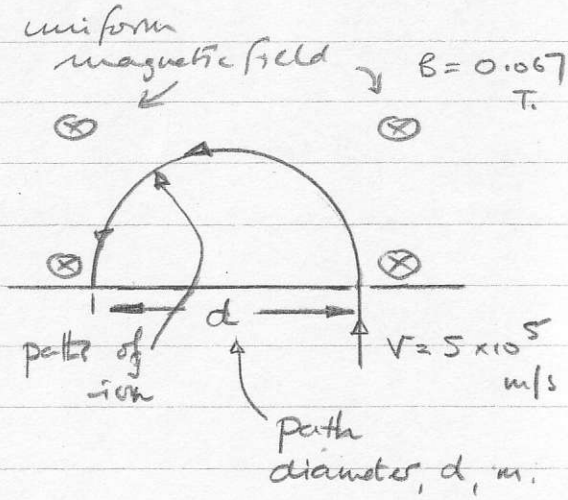
A Phys.i

data ... as 2a.

4. **Mass Spectrometer**

This is used to "weigh" charged particles.

A helium nucleus ^4_2He (2p, 2n = total of 4) is fired into a uniform B-field, and follows a circular path, as shown.



(a) Explain, carefully, why a charged particle follows a circular path in a uniform magnetic field. (5)*

(b) Show that the ^4_2He nucleus has mass = 6.4×10^{-27} kg and charge + 3.2×10^{-19} C. (2)

(c) Calculate the diameter of the path followed by ^4_2He. (4)

(d) The nucleus of another isotope of Helium is fired in at the same velocity, and has a path diameter of 0.22 m.

How many protons and neutrons are in this isotope? (4)

(e) Draw a labelled diagram to show the paths of these 2 isotopes (2)

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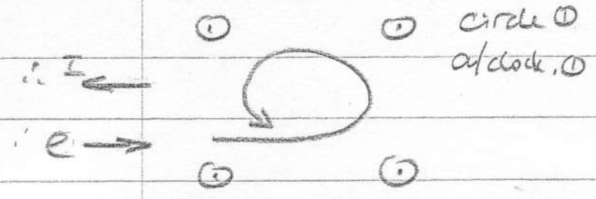
* Special offer on this answer, for a limited period only.

Electromagnetism (2) Answers — charges in mag. fields — A Physics

1. (a) - nucleus is p + n ; p have + charge (1)
   - L.H. Rule tells you current is → so particle must be + (1) (2)

   (b) $F_m = BQv$ (1) $= mv^2/r$ (1) →
   so charge/mass ratio, $Q/m = v/Br = \frac{1.5 \times 10^6}{0.8 \times 4 \times 10^{-2}} = 47 \times 10^6$ (1) Coulombs/kg. **6**

2. (a) from above N pole



   (b) $F_m = Bev = m_e v^2/r$ (1)(1)
   so radius $r = m_e v / Be$ (1)
   $= 9.1 \times 10^{-31} \times (3 \times 10^7)^{14} / 1 \times 10^{-6} \times 1.6 \times 10^{-19}$
   $= 171$ (1) m. (4)

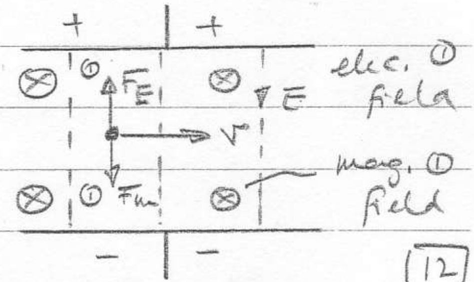
   (c) high speed particle hits molecules of gas (1) in Earth's upper atmosphere, and excites them (1) (knocks an electron to higher energy level), when electron falls back (1) to normal level the energy is emitted as light (3) **9**

3. (a) Elec. P.E → K.E .... $eV = \frac{1}{2} m_e v^2$ (1)(1) → $v = 16.2 \times 10^6$ m/s (1) (3)

   (b) $F_E = eE = eV/d$ (1) $= 1.6 \times 10^{-19} \times 5000 / 5 \times 10^{-2}$ (1) $= 1.6 \times 10^{-14}$ N (2)

   (c) for straight beam $F_E = F_m = Bev$ (1)
   so B needed $= F_E / ev$ (1) $=$
   $= \frac{1.6 \times 10^{-14}}{1.6 \times 10^{-19} \times 16.2 \times 10^6}$
   $= 6.3 \times 10^{-3}$ Tesla (1) (3)

   (d)



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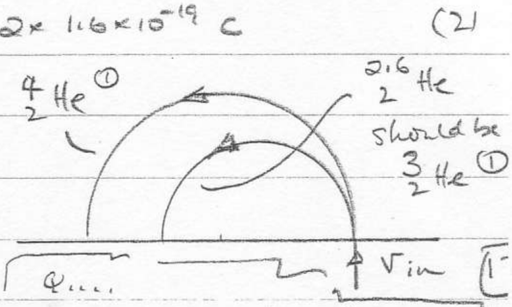
4 (a) Mag. field exerts a force (1) on the particle, that is always at 90° to path (1), so particle changes direction, speed stays constant (1), so force stays constant (1), because force depends only on speed (1): constant F, at 90° to path → circular path (5)

   (b) mass of (2p + 2n) (1) $= 4 \times 1.6 \times 10^{-27}$ kg $Q = 2p$ (1) $= 2 \times 1.6 \times 10^{-19}$ C (2)

   (c) $F_m = BQv$ (1) $= \frac{mv^2}{r}$ (1) $= F_c$
   so radius $r = mv/BQ = \frac{6.4 \times 10^{-27} \times 5 \times 10^5}{0.067 \times 3.2 \times 10^{-19}} = 0.15$ m
   so diameter $d = 0.3 = 30$ cm (1) (4)

   (d) for isotope, p = 2, so Q = same (1). m = different
   $m = \frac{BQr}{v}$ (1) $= \frac{0.067 \times 3.2 \times 10^{-19} \times 0.11}{5 \times 10^5} = 4.7 \times 10^{-27}$ kg
   This is $\frac{4.7 \times 10^{-27}}{1.6 \times 10^{-27}} = 2.95 = 3$ particles $= 2p, 1n$.

   (e)



Q....

1	2	3	4	Total
6	9	12	17	44

+ corrected May '01, 3b+c, 4c tot.

10.97