AQA Examination-style questions

1 (a) The equation $F = BIl$, where the symbols have their usual meanings, gives the magnetic force that acts on a conductor in a magnetic field.

Give the unit of each of the quantities in the equation: F, B, I, l.

State the condition under which the equation applies. *(2 marks)*

(b) **Figure 1** shows a horizontal copper bar of 25 mm × 25 mm square cross-section and length l carrying a current of 65 A.

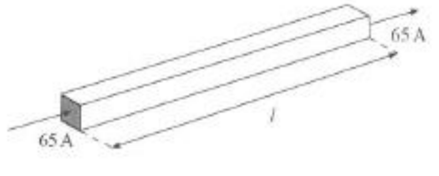

Figure 1

(i) Calculate the minimum value of the flux density of the magnetic field in which it should be placed if its weight is to be supported by the magnetic force that acts on it.

density of copper = $8.9 \times 10^3\,\mathrm{kg\,m^{-3}}$

(ii) Copy the diagram and draw an arrow to show the direction in which the magnetic field should be applied if your calculation in part (i) is to be valid. Label this arrow M. *(5 marks)*

AQA, 2003

2 A 'bus bar' is a metal bar which can be used to conduct a large electric current. In a test, two bus bars, **X** and **Y**, of length 0.83 m are clamped at either end parallel to each other, as shown in **Figure 2**.

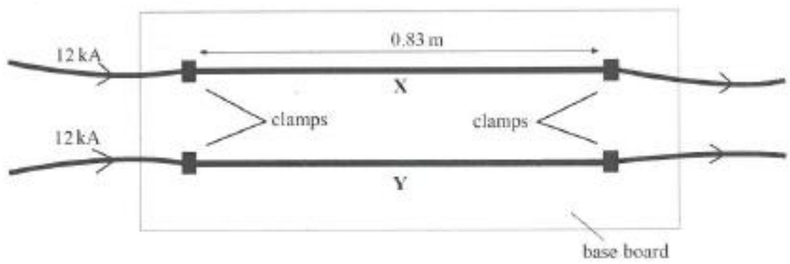

Figure 2

(a) When a constant current of 12 kA is carried by each bus bar, they exert a force of 180 N on each other. This force is due to the magnetic field created by the current carried by each bus bar.

(i) Calculate the magnetic flux density due to the current in one bus bar at the position of the other bus bar.

(ii) The magnetic flux density at any given distance from a straight conductor is proportional to the current through the conductor. Calculate the force on each bus bar if X carried a current of 6 kA and Y carried a current of 12 kA in the same direction. *(6 marks)*

(b) When the same alternating current is passed through the two bus bars, both vibrate strongly.

(i) Explain why the bars vibrate.

(ii) State **one** way the amplitude of the vibrations could be reduced without reducing the current. *(4 marks)*

AQA, 2007

3 (a)

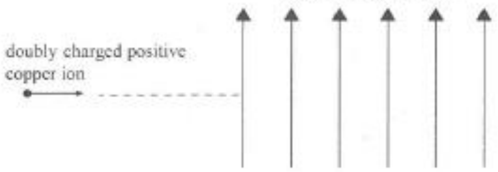

Figure 3

Figure 3 shows a doubly charged positive ion of the copper isotope $^{63}_{29}Cu$ that is projected into a vertical magnetic field of flux density 0.28 T, with the field directed upwards. The ion enters the field at a speed of $7.8 \times 10^5\,m\,s^{-1}$.

(i) State the initial direction of the magnetic force that acts on the ion.

(ii) Describe the subsequent path of the ion as fully as you can. Your answer should include both a qualitative description and a calculation.

mass of $^{63}_{29}Cu$ ion $= 1.05 \times 10^{-25}$ kg *(5 marks)*

(b) State the effect on the path in part (a) if the following changes are made separately.

(i) The strength of the magnetic field is doubled.

(ii) A singly charged positive Cu ion replaces the original one. *(3 marks)*

AQA, 2004

4 **Figure 4** shows a diagram of a mass spectrometer.

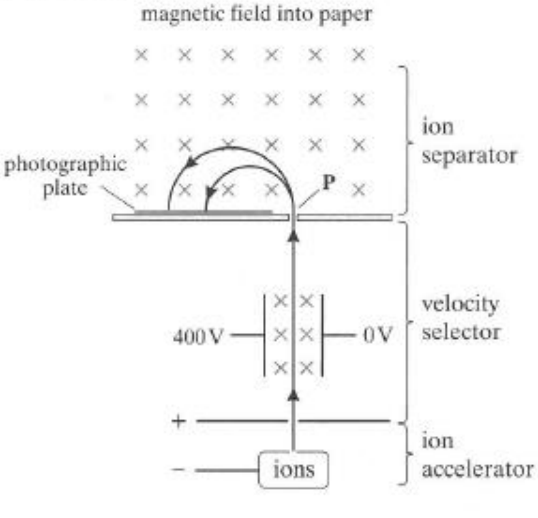

Figure 4

(a) The magnetic field strength in the velocity selector is 0.14 T and the electric field strength is $20000\,V\,m^{-1}$.

(i) Define the unit for magnetic flux density, the tesla.

(ii) Show that the velocity selected is independent of the charge on an ion.

(iii) Show that the velocity selected is about $140\,km\,s^{-1}$. *(5 marks)*

(b) A sample of nickel is analysed in the spectrometer. The two most abundant isotopes of nickel are $^{58}_{28}Ni$ and $^{60}_{28}Ni$. Each ion carries a single charge of $+1.6 \times 10^{-19}$ C.

The $^{58}_{28}Ni$ ion strikes the photographic plate 0.28 m from the point **P** at which the ion beam enters the ion separator.

Calculate:

(i) the magnetic flux density of the field in the ion separator,

(ii) the separation of the positions where the two isotopes hit the photographic plate. *(5 marks)*

AQA, 2003

5 The protons in an accelerator were directed at a solid target, causing antiprotons and negative pions, as well as other particles and antiparticles, to emerge at high speed from the target. A uniform magnetic field was used to separate the negative particles from the uncharged and positive particles, as shown in **Figure 5**.

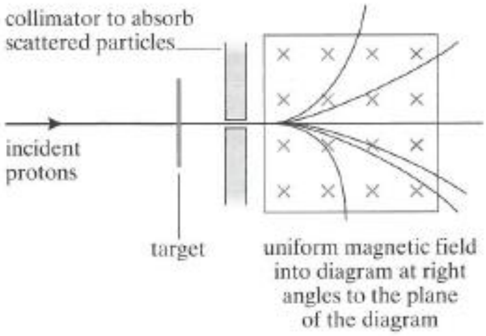

Figure 5

(a) Show that the speed, v, of a charged particle moving in a circular path of radius r in a uniform magnetic field B is given by

$$v = \frac{BQr}{m}$$

where m is the mass of the particle and Q is its charge. *(1 mark)*

(b) An antiproton and a negative pion follow the same path in the magnetic field. Explain why they have the same momentum but different speeds. *(3 marks)*

(c) State, in terms of quarks and antiquarks, the composition of each of the following: antiproton, negative pion. *(3 marks)*

AQA, 2004

6 **Figure 6** shows the arrangement of an apparatus for determining the masses of ions. In an evacuated chamber, positive ions from an ion source pass through the slit at **P** with the same velocity v. After passing **P**, the ions enter a region over which a uniform magnetic field is applied. The ions travel in a semi-circular path of diameter d and are detected at points such as **R**.

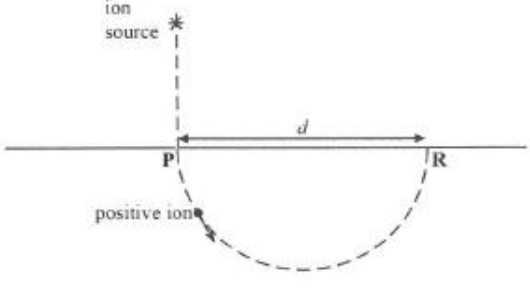

Figure 6

(a) (i) State the direction of the applied magnetic field.

(ii) Explain why the ions travel in a semi-circular path whilst in the magnetic field.

(iii) By considering the force that acts on an ion of mass m and charge Q, having velocity v, show that the diameter d of the path of the ions is given by

$$d = \frac{2mv}{BQ}$$

where B is the flux density of the magnetic field. *(7 marks)*

(b) In an experiment using singly ionised magnesium ions travelling at a velocity of $7.5 \times 10^4\,\mathrm{m\,s^{-1}}$, d was 110 mm when B was 0.34 T. Use this result to calculate the charge to mass ratio of these ions. *(2 marks)*

(c) (i) Some ions of the same element, whilst travelling at the same velocity as each other at **P**, may arrive at a point that is close to, but slightly different from, **R**. Explain why this might happen.

(ii) Other ions of the same element, also travelling at the same velocity at **P** as all of the others, may travel in a path whose diameter is half that of the others. Explain why this might happen. *(3 marks)*

AQA, 2007

7 **Figure 7** shows the path of protons in a proton synchrotron.

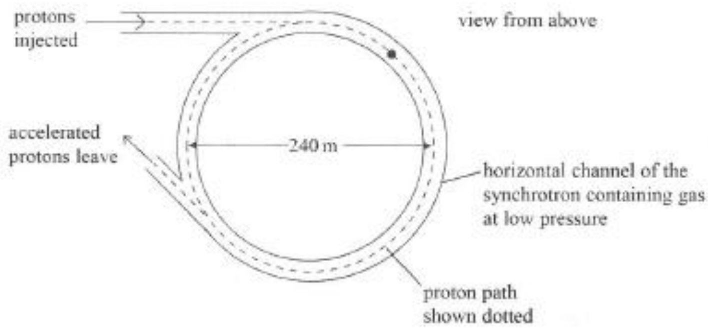

Figure 7

The protons are injected at a speed of $1.2 \times 10^5\,\mathrm{m\,s^{-1}}$ and a magnetic field is applied to make them move in a circular path.

(a) Calculate the magnetic flux density of the field required for protons to move in the circular path when their speed is $1.2 \times 10^5\,\mathrm{m\,s^{-1}}$.

(b) Explain how the magnetic flux density required to maintain the circular path has to change as the kinetic energy of the protons increases. *(5 marks)*

AQA, 2007