Mark scheme for Topic 6

1 The radius of the original orbit is $2R_E$ and becomes $4R_E$. The force will therefore decrease by $\left(\frac{2}{4}\right)^2 = \frac{1}{4}$. The answer is **A**.

2 The force will increase by 4 on **both** bodies, **D**.

Exam tip: recall Newton's third law.

3 Both wires attract Z; hence the net force is to the left, **C**.

4 **a** $\frac{1}{2}mv^2 = qV$

$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 120}{9.1 \times 10^{-31}}}$ **[2]**

$v = 6.50 \times 10^6 \approx 6.5 \times 10^6 \text{ m s}^{-1}$

b **i** Vertically up arrow. **[1]**

ii $E = \frac{250}{0.15} = 1666.7 \text{ N C}^{-1}$

$F = qE = 1.6 \times 10^{-19} \times 1666.7 = 2.7 \times 10^{-16} \text{ N}$ **[2]**

iii $F = mg = 9.1 \times 10^{-31} \times 9.8$

$= 8.9 \times 10^{-30} \text{ N}$ **[2]**

iv $\frac{2.7 \times 10^{-16}}{8.9 \times 10^{-30}} = 3.0 \times 10^{13}$ **[1]**

c **i** The magnetic force must be directed vertically down,

and so by the rule for magnetic force direction the magnetic field must be directed into the pane of the page. **[2]**

Exam tip: remember the electron has negative charge.

ii $qvB = qE \Rightarrow B = \frac{E}{v}$;

$B = \frac{1666.7}{6.5 \times 10^6} = 2.56 \times 10^{-4} \approx 2.6 \times 10^{-4} \text{ T}$; **[2]**

5 **a** The (electric) force per unit charge,

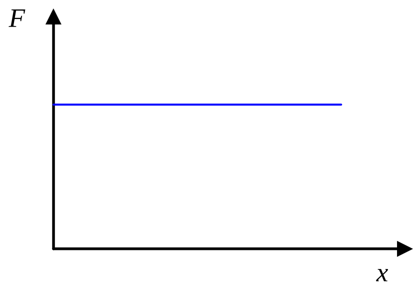
exerted on a point, positive test charge. **[2]**

b **i** Horizontal equally spaced arrows from left to right,

shown curving at the edges of the plates. **[2]**

ii Constant force.

So straight line horizontal graph.



[2]

c Use $q\Delta V = \Delta E_K$.

Deduce that $E_K = qV$ and so the kinetic energies of the proton and the electron are the same.

The ratio is 1. **[3]**

6 **a** The force on the particle is always at right angles to the velocity.

The magnetic force acts as a centripetal force, and this results in a circular path. **[2]**

b By any rule giving the direction of the force, the charge is negative. **[1]**

c A change in the kinetic energy is equal to the work done on the particle.

The work done on the particle by the magnetic force is zero,

because the force is always at right angles to the displacement

[and so the speed stays unchanged]. **[3]**

d The radius of the circular path is given by:

$$qvB = m\frac{v^2}{R} \Rightarrow R = \frac{mv}{qB},$$

$$R = \frac{1.67\times10^{-27}\times4.5\times10^{6}}{1.6\times10^{-19}\times0.25} = 0.188\,\text{m},$$

So to complete a quarter of a circle (length $\frac{2\pi R}{4} = 0.295\ \text{m}$) the time taken is

$\frac{0.295}{4.5\times10^{6}} = 6.6\times10^{-6}\ \text{s}$. **[3]**

