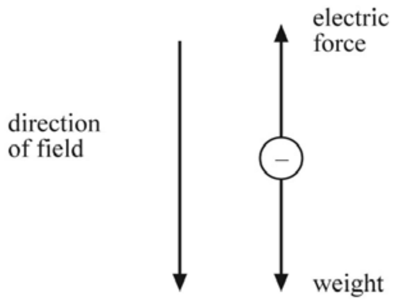
26 Marking scheme: Worksheet (A2)

1 $F = EQ = 5.0 \times 10^5 \times 3.2 \times 10^{-19}$ [1]
$F = 1.6 \times 10^{-13}$ N [1]

2 **a** $E = \dfrac{V}{d} = \dfrac{600}{3.0 \times 10^{-2}}$ [1]
$E = 2.0 \times 10^4$ V m^{-1} [1]
The field acts towards the negative plate. [1]
b The electric field is uniform between the plates (except at the 'edges'). [1]
The electric field is at right angles to the plate. [1]
c **i**



Since the droplet is stationary, the electric force on the droplet must be equal and opposite to its weight. [1]
The electric force must act upwards, so the charge on the droplet must be negative. [1]

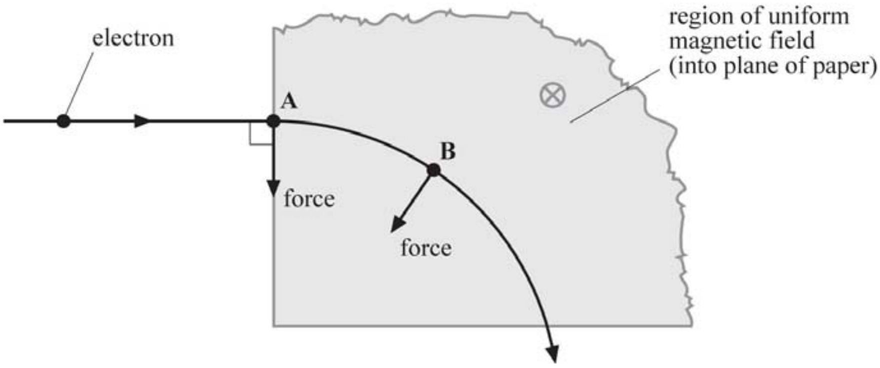
ii $E = \dfrac{F}{Q}$

$Q = \dfrac{F}{E} = \dfrac{6.4 \times 10^{-15}}{2.0 \times 10^4}$ [1]
$Q = 3.2 \times 10^{-19}$ C [1]

3 $F = BQv$ [1]
$F = 0.18 \times 1.6 \times 10^{-19} \times 4.0 \times 10^6$ [1]
$F = 1.15 \times 10^{-13}$ N $\approx 1.2 \times 10^{-13}$ N [1]

4 **a** $F = BQv$ [1]
$F = 0.004 \times 1.6 \times 10^{-19} \times 8.0 \times 10^6$ [1]
$F = 5.12 \times 10^{-15}$ N $\approx 5.1 \times 10^{-15}$ N [1]
b $a = \dfrac{F}{m} = \dfrac{5.12 \times 10^{-15}}{9.11 \times 10^{-31}}$ [1]
$a = 5.63 \times 10^{15}$ m s^{-2} $\approx 5.6 \times 10^{15}$ m s^{-2} [1]
c From circular motion, the centripetal acceleration a is given by:
$a = \dfrac{v^2}{r}$
$r = \dfrac{v^2}{a} = \dfrac{(8.0 \times 10^6)^2}{5.63 \times 10^{15}}$ [1]
$r = 1.14 \times 10^{-2}$ m $\approx 1.1 \times 10^{-2}$ m (1.1 cm) [1]

5 a



Both arrows at **A** and **B** are towards the centre of the circle. [1]

b The force on the electron is at 90° to the velocity. Hence the path described by the electron is a circle. [1]

c The magnetic force provides the centripetal force. [1]

Therefore: $BQv = \dfrac{mv^2}{r}$ [1]

$BQ = \dfrac{mv}{r}$ or $v = \dfrac{BQr}{m}$ [1]

$v = \dfrac{2.0\times10^{-3}\times1.6\times10^{-19}\times5.0\times10^{-2}}{9.1\times10^{-31}}$ [1]

$v = 1.76 \times 10^7$ m s^{-1} ≈ 1.8×10^7 m s^{-1} [1]

d $v = \dfrac{BQr}{m}$, so the speed v is directly proportional to the radius r. [1]

Radius is halved, so $v = \dfrac{1.76\times10^7}{2} = 8.8 \times 10^6$ m s^{-1} [1]

6 a $E_k = 15 \times 10^3 \times 1.6 \times 10^{-19} = 2.4 \times 10^{-15}$ J (1 eV = 1.6×10^{-19} J) [1]

$\dfrac{1}{2}mv^2 = 2.4 \times 10^{-15}$

$v = \sqrt{\dfrac{2\times2.4\times10^{-15}}{1.7\times10^{-27}}}$ [1]

$v = 1.68 \times 10^6$ m s^{-1} ≈ 1.7×10^6 m s^{-1} [1]

b $F = ma = \dfrac{mv^2}{r}$ [1]

$F = \dfrac{1.7\times10^{-27}\times(1.68\times10^6)^2}{0.05}$ [1]

$F = 9.60 \times 10^{-14}$ N ≈ 9.6×10^{-14} N [1]

c $F = BQv$ [1]

$B = \dfrac{F}{Qv} = \dfrac{9.60\times10^{-14}}{1.6\times10^{-19}\times1.68\times10^6}$ [1]

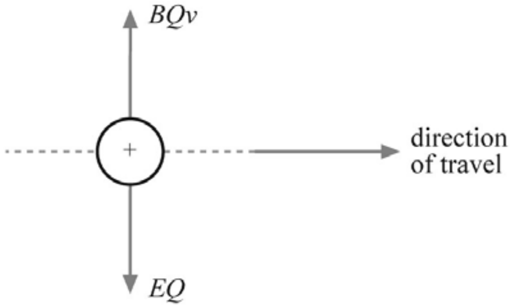
$B \approx 0.36$ T [1]

d speed = $\dfrac{\text{distance}}{\text{time}}$

time = $\dfrac{\text{circumference}}{\text{speed}} = \dfrac{2\pi\times0.05}{1.68\times10^6}$ [1]

time = 1.87×10^{-7} s ≈ 1.9×10^{-7} s [1]

7 **a** In order for the positively charged ions to emerge from the slit, the net force perpendicular to the velocity must be zero. [1]



electrical force on ion = magnetic force on ion [1]

$EQ = BQv$ [1]

The charge Q cancels.

$E = Bv$ [1]

The electric field strength is $E = \frac{V}{d}$. Therefore, the magnetic flux density is:

$$B = \frac{E}{v} = \frac{V/d}{v} = \frac{(5.0\times10^3)/0.024}{6.0\times10^6}$$ [1]

$B = 3.47 \times 10^{-2}$ T ≈ 35 mT [1]

b $v = \frac{BQr}{m}$ so $r = \frac{mv}{BQ}$ [1]

$$\Delta r = \frac{(m_1 - m_2)\,v}{BQ}$$ [1]

8 **a** The centripetal force is provided by the magnetic force. [1]

Therefore: $Bev = \frac{mv^2}{r}$ [1]

$Be = \frac{mv}{r}$ or $v = \frac{Ber}{m}$ [1]

$$T = \frac{\text{circumference}}{\text{speed}} = \frac{2\pi r}{Ber/m}$$ [1]

The radius r of the orbit cancels. Hence: $T = \frac{2\pi m}{Be}$

The time T is independent of both the radius of the orbit r and the speed v. [1]

b The faster electron travels in a circle of larger radius. [1]

