9 Marking scheme: Worksheet 2

1 **a** (The force F is given by $F = BIL \sin \theta$.)
The force is a maximum when the angle θ between the wire and the magnetic field is 90°. [1]
b The force is a minimum when the angle θ between the wire and the magnetic field is 0°.
(The wire is parallel to the magnetic field.) [1]

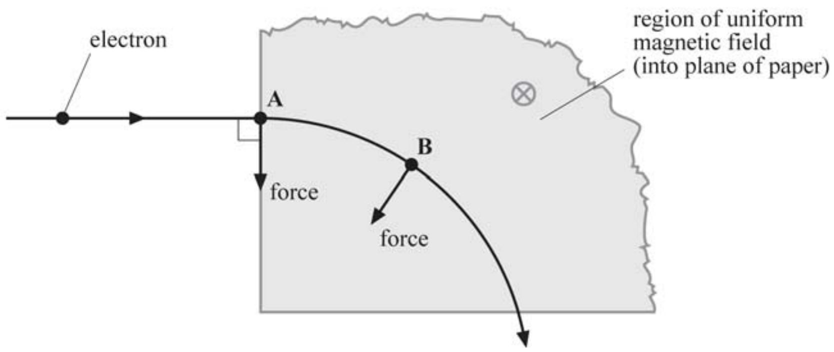
2 **a** $F = BIL \sin \theta$
$F = 0.050 \times 3.0 \times 0.04 \times \sin 90°$ [1]
$F = 6.0 \times 10^{-3}$ N [1]
b $F = 0.050 \times 3.0 \times 0.04 \times \sin 30°$ [1]
$F = 3.0 \times 10^{-3}$ N [1]
c $F = 0.050 \times 3.0 \times 0.04 \times \sin 65°$ [1]
$F = 5.44 \times 10^{-3}$ N $\approx 5.4 \times 10^{-3}$N [1]

3 **a** $F = BIL \sin \theta$ [1]
$$B = \frac{F}{IL \sin \theta} = \frac{3.8 \times 10^{-3}}{1.2 \times 0.03 \times \sin 50°}$$ [1]
$B = 0.138$ T ≈ 0.14 T [1]
b The direction is given by Fleming's left-hand rule. The wire experiences a force into the plane of the paper. [1]

4 $F = BQv$ [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]

5 **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 $$a = \frac{F}{m} = \frac{5.12 \times 10^{-15}}{9.1 \times 10^{-31}}$$ [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:
$$a = \frac{v^2}{r}$$
$$r = \frac{v^2}{a} = \frac{(8.0 \times 10^6)^2}{5.63 \times 10^{15}}$$ [1]
$r = 1.14 \times 10^{-2}$ m $\approx 1.1 \times 10^{-2}$ m (1.1 cm) [1]

6 **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: $BQv = \frac{mv^2}{r}$ [1]

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

$v = \frac{2.0 \times 10^{-3} \times 1.6 \times 10^{-19} \times 5.0 \times 10^{-2}}{9.1 \times 10^{-31}}$ [1]

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

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

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

7 **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]

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

$v = \sqrt{\frac{2 \times 2.4 \times 10^{-15}}{1.7 \times 10^{-27}}}$ [1]

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

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

$F = \frac{1.7 \times 10^{-27} \times (1.68 \times 10^6)^2}{0.05}$ [1]

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

c $F = BQv$ [1]

$B = \frac{F}{Qv} = \frac{9.60 \times 10^{-14}}{1.6 \times 10^{-19} \times 1.68 \times 10^6}$ [1]

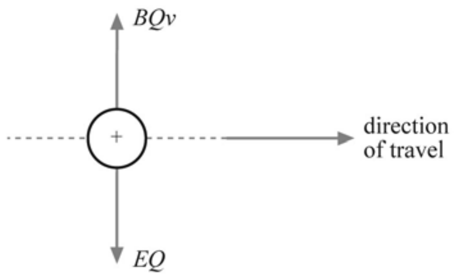
$B \approx 0.36$ T [1]

d Speed = $\frac{\text{distance}}{\text{time}}$

time = $\frac{\text{circumference}}{\text{speed}} = \frac{2\pi \times 0.05}{1.68 \times 10^6}$ [1]

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

8 In order 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 $E = \dfrac{V}{d}$. Therefore, the magnetic flux density is:

$B = \dfrac{E}{v} = \dfrac{V/d}{v} = \dfrac{(5.0 \times 10^3)/0.024}{6.0 \times 10^6}$ [1]

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

9 The centripetal force is provided by the magnetic force. [1]

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

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

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

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

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