1 B **[1]**

2 A **[1]**

3 B **[1]**

4 B **[1]**

5 B **[1]**

6 A **[1]**

7 (a) (i) force acts towards left or in opposite direction to field lines ✓
because ion (or electron) has negative charge
(∴ experiences force in opposite direction to field) ✓

Mark sequentially.
Essential to refer to negative charge (or force on + charge is to right) for 2nd mark.

2

(ii) (use of $W = F s$ gives) force $F = \frac{4.0 \times 10^{-16}}{63 \times 10^{-3}}$ ✓

$= 6.3(5) \times 10^{-15}$ (N) ✓

If mass of ion m is used correctly ***using algebra*** *with F = ma, allow both marks (since m will cancel). If numerical value for m is used, max 1.*

2

(iii) electric field strength $E\left(=\frac{F}{Q}\right)=\frac{6.35\times10^{-15}}{3\times1.6\times10^{-19}}$ = 1.3(2) ✓ 10^4 (N C^{-1}) ✓

[**or** $\Delta V\left(=\frac{\Delta W}{Q}\right)=\frac{4.0\times10^{-16}}{3\times1.60\times10^{-19}}$ (833 V)

$E\left(=\frac{\Delta V}{d}\right)=\frac{833}{63\times10^{-3}}$ = 1.3(2) ✓ 10^4 (V m^{-1}) ✓]

Allow ECF from wrong F value in (ii).

1

(b) (i) (vertically) downwards on diagram ✓
reference to Fleming's LH rule **or** equivalent statement ✓

Mark sequentially.

1st point: allow "into the page".

2

(ii) number of free electrons in wire = *A* × *l* × number density
= $5.1\times10^{-6}\times95\times10^{-3}\times8.4\times10^{28}=4.1\ (4.07)\times10^{22}$ ✓

Provided it is shown correctly to at least 2SF, final answer alone is sufficient for the mark. (Otherwise working is mandatory).

1

(iii) $B\left(=\frac{F}{Qv}\right)=\frac{1.4\times10^{-25}}{1.60\times10^{-19}\times5.5\times10^{-6}}$ ✓ = 0.16 (0.159) (T) ✓

[**or** $B\left(=\frac{F}{I\,l}\right)=\frac{1.4\times10^{-25}\times4.07\times10^{22}}{0.38\times95\times10^{-3}}$ ✓ = 0.16 (0.158) (T) ✓]

In 2nd method allow ECF from wrong number value in (ii).

2

[10]

8 A **[1]**

9 (a) (i) (vertically) downwards **(1)**

1

(ii) force F is perpendicular to both B and I [**or** equivalent correct explanation using Fleming LHR] **(1)**

magnitude of F changes as size of current changes **(1)**

force acts in opposite direction when current reverses [**or** ac gives alternating force] **(1)**

continual reversal of ac means process is repeated **(1)**

max 3

(b) appreciation that maximum force corresponds to peak current **(1)**

peak current = $2.4 \times \sqrt{2}$ = 3.39 (A) **(1)**

F_{max} (= $B\, I_{pk}\, L$) = $0.22 \times 3.39 \times 55 \times 10^{-3}$ **(1)** (= 4.10×10^{-2} N)

3

(c) wavelength (λ) of waves = $\left(= \frac{c}{f}\right) = \frac{64}{80}$ = 0.80 (m) **(1)**

length of wire is $\lambda/2$ causing fundamental vibration **(1)**

[**or** λ of waves required for fundamental (= 2 × 0.40) = 0.80 m **(1)**

natural frequency of wire $\left(= \frac{c}{\lambda}\right) = \frac{64}{0.80}$ = 80 (Hz) **(1)**]

wire resonates (at frequency of ac supply) [**or** a statement that fundamental frequency (or a natural frequency) of the wire is the same as applied frequency] **(1)**

3

[10]

10 B

[1]

11 (a) (i) 60 (degrees) ✓

1

(ii) angle required is 150° ✓

which is $5\pi / 6$ [**or** 2.6(2)] (radians) ✓

Correct answer in radians scores both marks.

2

(b) (i) (magnitude of the induced) emf ✓

Accept "induced voltage" or "rate of change of flux linkage", but not "voltage" alone.

1

(ii) frequency $\left(=\frac{1}{T}\right)=\frac{1}{40\times10^{-3}}$ ✓ (= 25 Hz)

no of revolutions per minute = 25 × 60 = 1500 ✓

1500 scores both marks.

Award 1 mark for 40s → 1.5 rev min^{-1}.

2

(iii) maximum flux linkage $(=BAN)$ = 0.55 (Wb turns) ✓

angular speed $\omega\left(=\frac{2\pi}{T}\right)=\frac{2\pi}{40\times10^{-3}}$ ✓ (= 157 rad s^{-1})

peak emf (= $BAN\omega$) = 0.55 × 157 = 86(.4) (V) ✓

[**or**, less accurately, use of gradient method ✓

{e.g $\varepsilon\left(=\frac{\Delta(N\Phi)}{\Delta t}\right)=\frac{0.5 - (-0.5)}{(16 - 4)\times10^{-3}}=\frac{1.0}{12\times10^{-3}}$ } = 83 (± 10) (V) ✓ ✓

(max 2 for (iii) for values between 63 and 72 V or 94 and 103V)]

3

(c) sinusoidal shape of constant period 40 ms ✓

Mark sequentially.

Graph must cover at least 80ms.

correct phase (i.e. starts as a minus sin curve) ✓

For 2nd mark, accept + sin curve.

Perfect sin curves are not expected.

2

(d) $BAN = 0.55$ ∴ flux density $B = \dfrac{0.55}{4.0 \times 10^{-3} \times 550}$ ✓

= 0.25(0) (T) ✓

OR *by use of ε from (b)(iii) and f from (b)(ii) substituted in* $\varepsilon = BAN(2\pi f)$.

2

(Total 13 marks)

12 B

[1]

13 A

[1]