M1.(a) (i) meter deflects then returns to zero ✓
current produces (magnetic) field / flux ✓
change in field / flux through Q induces emf ✓
induced emf causes current in Q (and meter) ✓

Deflection to right (condone left) then zero is equivalent to 1st mark.

Accept momentary deflection for 1st point.

"Change in field / flux induces current in Q" is just ✓ from the last two marking points.

max 3

(ii) meter deflects in opposite direction (or to left, or ecf) ✓
field / flux through P is reduced ✓
induces emf / current in opposite direction ✓

Ignore references to magnitude of deflection.

max 2

(b) (i) flux linkage (= $n\Phi = nBA$) = 40 × 0.42 × 3.6 × 10^{-3}
= 6.0(5) × 10^{-2} ✓

Unit mark is independent.

Allow 6 × 10^{-2}.

Wb turns ✓

Accept 60 mWb turns if this unit is made clear.

Unit: allow Wb.

2

(ii) change in flux linkage = $\Delta(n\Phi)$= 6.05 × 10^{-2} (Wb turns) ✓

induced emf $\left(=\frac{\Delta(n\phi)}{\Delta t}\right) = \frac{6.05 \times 10^{-2}}{0.50}$ = 0.12(1) (V) ✓

Essential to appreciate that 6.05 × 10^{-2} is change in flux linkage for 1st mark. Otherwise mark to max 1.

2

[9]

M2.A

[1]

M3.(a) (i) 60 (degrees) ✓

1

(ii) angle required is 150° ✓

which is 5π / 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 (= *BANω*) = 0.55 × 157 = 86(.4) (V) ✓

M4.D

5	a		(magnetic) <u>field</u> is applied perpendicular to path **or** direction **or** velocity of charged particles ✓ (magnetic) <u>force</u> acts perpendicular to path **or** direction **or** velocity of charged particles ✓ force depends on speed of particle **or** on *B* [or $F \propto v$ or $F = BQv$ explained] ✓ force provides (centripetal) acceleration towards centre of circle [**or** (magnetic) force is a centripetal force] ✓ $BQv = \frac{mv^2}{r}$ **or** $r = \frac{mv}{BQ}$ shows that *r* is constant when *B* and *v* are constant ✓	max 4

5	b	i	radius *r* of path = $\frac{\text{circumference}}{2\pi} = \frac{27 \times 10^3}{2\pi}$ = 4.30×10^3 (m) (allow 4.3 km) ✓	3

			centripetal force $\left(= \frac{mv^2}{r}\right) = \frac{1.67 \times 10^{-27} \times (3.00 \times 10^7)^2}{4.30 \times 10^3}$ ✓ = 3.50×10^{-16} (N) ✓	

5	b	ii	magnetic flux density $B\left(= \frac{F}{Qv}\right) = \frac{3.50 \times 10^{-16}}{1.60 \times 10^{-19} \times 3.00 \times 10^7}$ ✓ = 7.29×10^{-5} ✓ T ✓	3

5	c		magnetic field must be increased ✓ to increase (centripetal) force **or** in order to keep *r* constant ✓ [**or** otherwise protons would attempt to travel in a path of larger radius] [**or**, referring to , *B* must increase when *v* increases to keep r constant]	2

M6.B

M7.B

M8.B

M9.D

M10.D

M11.A