Answers - Magnetic Fields 2

1.

(a)	**(i)**	A (constant) force acts at right angles to the velocity / motion (of the helium nucleus).	B1	**Note**: The answer must be in terms of force and not acceleration. **Allow** 'force is towards the centre of the circle'. **Not** 'there is a *centripetal* force' - unless explained. **Not** 'force is right angles to <u>speed</u>'.
(a)	**(ii)**	No work done (by the force) / no acceleration in the direction of motion / no force in direction of motion	B1	**Allow** force / acceleration is at right angles to velocity / motion.
(b)		$BQv = \frac{mv^2}{r}$ or $mv = BQr$ momentum = $0.20 \times 10^{-3} \times 3.2 \times 10^{-19} \times 0.15$ momentum = 9.6×10^{-24} (kg m s^{-1})	C1 C1 A1	**Allow** $v = 1.45.. \times 10^3$ (m s^{-1}); $p = 1.45.. \times 10^3 \times 6.6 \times 10^{-27}$
(c)		$v = 9.6 \times 10^{-24}/6.6 \times 10^{-27}$ or $v = 1.45... \times 10^3$ (m s^{-1}) KE = $\frac{1}{2} \times 6.6 \times 10^{-27} \times (1.45... \times 10^3)^2$ KE $= 7.0 \times 10^{-21}$ (J)	C1 A1	Possible ecf from **(b)** **Allow** 1 sf answer **Alternative**: ($E = p^2/2m$); KE = $\frac{(9.6\times10^{-24})^2}{2\times6.6\times10^{-27}}$ C1 KE = 7.0×10^{-21} (J) A1
(d)		The helium nucleus moves to the <u>right.</u> The path is a clockwise curve / looped (in the plane of the paper).	B1 B1	**Not** if the path is shown as a straight line. **Allow** 2 marks for clockwise curve / loop to the right. **Allow** 1 mark for a sketch showing an 'upward curve to the right'

2.

a		Positive as E-field is downwards/top plate is positive/like charges repel/AW	**1**	**1**
b	**i**	k.e. = QV; = 300 x 1.6 x 10^{-19} = (4.8 x 10^{-17} J)	**2**	
	ii	$1/2mv^2$ = 4.8 x 10^{-17}; = 0.5 x 2.3 x 10^{-26} x v^2 so v^2 = 4.17 x 10^9; (giving v = 6.46 x 10^4 m s^{-1})	**2**	**4**
c		E = V/d ; so d = V/E = 600/4 x 10^4 = 0.015 m	**2**	**2**
d	**i**	semicircle to right of hole *ecf(a); (a) and d(i) to be consistent*	**1**	
	ii	mv^2/r; = BQv;	**2**	
		giving r = mv/BQ = 2.3 x 10^{-26} x 6.5 x 10^4/(0.17 x 1.6 x 10^{-19});	**1**	
		r = 55 mm ;so distance = 2r = 0.11 m	**2**	**6**

3.

(a)	**(i)**	(weight = *BIL*) $6.8\times10^{-5} = 0.070\times I\times0.01$ (Any subject) I = 0.097 (A)	C1 A1	
	(ii)	The force on the cables will keep changing direction	B1	
(b)	**(i)**	$BQv = mv^2 / r$ $r = \dfrac{mv}{BQ}$	M1 A1	**Allow** *e, q* instead of *Q* **Note**: *r* must be the subject of this equation
	(ii)	($p = mv = BQr$, KE = ½ p^2/m) KE $\propto r^2$ ratio = $\dfrac{4.8^2}{1.2^2}$ ratio = 16	C1 A1	**Allow** full credit for correct alternative approaches **Allow** 16 : 1

4.

(a)		The induced e.m.f. is (directly) proportional / equal to the rate of change of (magnetic) flux linkage.	B1	**Allow** $E = \frac{\Delta\Phi}{\Delta t}$ with all terms defined; E = induced e.m.f., Φ = (magnetic) flux linkage and t = time.
(b)		North / N (pole). There is a repulsive force (between magnet and coil and the work done against this repulsive force is transferred to electrical energy in the coil).	B1	**Allow** - A south (pole) would cause attraction (between the coil and magnet) or there is gain in KE (of magnet which cannot happen hence it must be north pole).
(c)	**(i)**	There is no change in (magnetic) flux (linkage) or there is no change in the (magnetic) flux density.	B1	**Allow** 'no change in (magnetic) field strength'.
	(ii)	E = 0 between 0 to 3 cm, 5 – 8 cm and 10 - 12 cm. Two 'pulses' where B is changing. The pulses have opposite signs.	B1 M1 A1	Tolerance: ± ¼ large square **Note**: The pulses must have E = 0 at 3 cm, 5 cm, 8 cm and 10 cm; tolerance ± ¼ large square.

5.

a		direction of induced emf (or current) ✓ opposes change (of magnetic flux) that produces it ✓	2	
b	i	(volumes are equal and mass of Q is greater than that of P) density of steel > density of aluminium ✓	1	Allow density of Q greater (than density of P).
b	ii	use of $s = ½\, g\, t^2$ gives $t^2 = \frac{2\times1.0}{9.81}$ (from which t = 0.45 s) ✓ (vertical) acceleration [**or** acceleration due to gravity] is independent of mass of falling object [**or** correct reference to $F = mg = ma$ with m cancelling] ✓	2	Backwards working is acceptable for 1st mark. 2nd mark must refer to mass. Do not allow "both in free fall" for 2nd mark.

c	i	moving magnet [**or** magnetic field] passes through tube ✓ there is a change of flux (linkage)(in the tube) [**or** flux lines are cut **or** appropriate reference to $\varepsilon = N\,(\Delta\Phi/\Delta t)$]✓ [**Alternative:** (conduction) electrons in copper (or tube) acted on by (moving) magnetic field of Q ✓ induced emf (or current) is produced by redistributed electrons ✓]	2	In this part marks can be awarded for answers which mix and match these schemes.

c	ii	emf produces current (in copper) ✓ this current [*allow* emf] produces a magnetic field ✓ this field opposes magnetic field (or motion) of Q [**or** acts to reduce relative motion **or** produces upward force] ✓ no emf is induced by P because it is not magnetised (or not magnet) [**or** movement of P is not opposed by an induced emf or current] ✓	max 3	**Alternative** to 3rd mark: current gives heating effect in copper and energy for this comes from ke of Q ✓

d		time for P is unaffected because there is still no (induced) emf [**or** because P is not magnetised **or** because there is no repulsive force on P] ✓ time for Q is shorter (than in (c)) ✓ current induced by Q would be smaller ✓ because resistance of brass ∝ resistivity and is therefore higher [**or** resistance of brass is higher because resistivity is greater] ✓ giving weaker (opposing) magnetic field [**or** less opposition to Q's movement] ✓	max 3	Condone "will pass through faster" for 2nd mark. If emf is stated to be smaller for Q, mark (d) to max 2.

6.

(a)		current $I\left(=\frac{F}{Bl}\right)=\frac{1.4\times10^{-3}\times9.81}{45\times10^{-3}\times40\times10^{-3}}$ ✓ = 7.6(3) A ✓	**2**
(b)	(i)	magnetic flux change Φ (= BA) = 45 × 10-3 × 40 × 10^{-3} × 20 × 10^{-3} ✓ = 3.6 × 10^{-5} Wb ✓	
	(ii)	use of $\epsilon=\frac{\Delta\Phi}{\Delta t}$ ✓ gives time taken Δt = $\frac{3.6\times10^{-5}}{0.15\times10^{-3}}$ ✓ = 0.24 s ✓ **[alternative for (ii)** $v\left(=\frac{\epsilon}{Bl}\right)=\frac{0.15\times10^{-3}}{45\times10^{-3}\times40\times10^{-3}}$ ✓ = 8.33 × 10^{-2} (m s^{-1}) ✓ $\Delta t=\frac{l}{v}=\frac{20\times10^{-3}}{8.33\times10^{-2}}$ = 0.24 s ✓]	**5**

7.

a	**i**	BA / = 0.05 x 0.05 x 0.026 ; = 6.5 x 10^{-5}; Wb/T m^2	**3**	
	ii	BA sin 45°/BAcos 45° = 4.6 x 10^{-5} Wb *ecf (a)i*	**1**	
	iii	0	**1**	**5**
b	**i**	a point where curve crosses t-axis	**1**	
	ii	voltage is proportional to the rate of change of flux linking the coil; rate of	**1**	
		flux change is zero/very small when the flux linking the coil is a maximum	**1**	
	iii	sinusoidal curve; of double the amplitude; and half the period	**3**	**6**

8.

(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
(a)(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 $(= n\Phi = nBA) = 40 \times 0.42 \times 3.6 \times 10^{-3}$ $= 6.0(5) \times 10^{-2}$ ✓ Wb turns ✓	Unit mark is independent. Allow 6×10^{-2} Accept 60 mWb turns if this unit is made clear. Unit: allow Wb	2
(b)(ii)	change in flux linkage = $\Delta(n\Phi) = 6.05 \times 10^{-2}$ (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