Question			Expected Answers	Marks	Additional Guidance
1	a		magnetic flux = magnetic flux density x area (perpendicular to field direction)	B1	Allow equation with the symbols identified correctly Do not allow magnetic field or magnetic field strength
	b		Φ = NBA = 500 x 0.035 x 2.5 x 10^{-3} = 0.044 (0.04375) unit: Wb	C1 A1 B1	 [allow for one mark 8.75 x 10^{-5} (Wb) i.e. B x A] Allow: Wb turns and T m^2 and V s
	c	(i)	The component of B perpendicular to the area changes / the idea that the area changes relative to the field direction detail of how it varies / depends on cos θ / maximum when field is perpendicular to B / zero when area is parallel to B	B1 B1	Allow the idea that the direction of the field relative to the area of the coil varies with the orientation of the coil Do not allow reference to cutting of the flux by the coil
		(ii)	Induced / e.m.f is proportional / to <u>the rate</u> of change of (magnetic) flux	B1	Allow the emf produced is equal to the rate of change of flux or flux cutting
		(iii)	e.m.f. **max** when ϕ is **zero** or at 0.005 /0.015 /0.025 s e.m.f **zero** when ϕ is a **max** or at 0.0 / 0.01/ 0.02 s e.m.f. and ϕ have the same frequency allow e.m.f and ϕ out of phase by π/2/ emf follows a sin curve emf is the gradient of the graph **MAX 3**	(B1) (B1) (B1) (B1) (B1) B3	

		(iv)	ε = (change in flux linkage) / time = 0.04375 / 0.005 (8.8 x 10^{-5} x 500) / 0.005 = 8.75 (V)	 **C1** **A1**	 [if N omitted then give one mark (ε = 0.0175)] [if 10^{-5} omitted then minus 1] [reading error from graph is penalised -1 (should be 8.8 and not 8.4)]
		(v)	Max e.m.f. is twice the original value as the rate of flux change is twice the original	**B1** **B1**	Do not allow just larger Allow: the change in magnetic flux occurs in half the time Allow the max gradient will double
			Total	**[14]**	

Question			Answer	Marks	Guidance
2	(a)		(Fleming's) left-hand rule	B1	
	(b)		The force is at right angles to the velocity (hence no work is done on the ions) / no (component of) force in the direction of motion / no (component of) acceleration in the direction of motion (AW)	B1	**Allow**: 'force is right angles to the motion'
	(c)	(i)	$F = \frac{mv^2}{r}$ force = $\frac{1.2\times10^{-26}\times(4.0\times10^{5})^{2}}{0.15}$ force = 1.3×10^{-14} (N)	C1 A1	**Note**: Answer to 3 sf is 1.28×10^{-14} (N)
		(ii)	$F = BQv$ $1.28 \times 10^{-14} = B \times 1.6 \times 10^{-19} \times 4.0 \times 10^{5}$ B = 0.20 (T)	C1 A1	Possible ecf from **(c)(i)** **Allow**: 1 sf answer of 0.2 (T)
		(iii)	number per second = $\frac{4.8\times10^{-9}}{1.6\times10^{-19}}$ number per second = 3.0×10^{10} (s^{-1})	C1 A1	**Allow**: 1 sf answer of 3×10^{10} (s^{-1})
	(d)		(height is smaller) hence less abundance (than lithium-7) position suggests that the ions are less massive / lighter fewer neutrons (than lithium-7)	B1 B1	**Allow**: fewer / less (than lithium-7)
			Total	**10**	

Question			Answers	Marks	Guidance
3	(a)		torque = one of the forces × perpendicular distance (between the forces)	B1	
	(b)	(i)	Into (plane of) paper	B1	**Not**: 'down'
		(ii)	force = BIL = 0.060 × 0.03 × 0.015 force = 2.7×10^{-5} (N)	B1	
		(ii)	torque = $2.7 \times 10^{-5} \times 0.015$ torque = 4.1×10^{-7} (N m) or 4.05×10^{-7} (N m)	C1 A1	Possible ecf from **(b)(ii)1** Do not allow 4.0×10^{-7} (N m) - rounding error
	(c)	(i)	$F = BQv$ $2.0 \times 10^{-13} = 0.14 \times Q \times 4.5 \times 10^{6}$ charge = 3.2×10^{-19} (C) or 3.17×10^{-19} (C)	C1 A1	**Allow**: Any subject
		(ii)	$F = mv^2 / r$ $2.0 \times 10^{-13} = \frac{2.7 \times 10^{-26} \times (4.5 \times 10^{6})^2}{r}$ radius = 2.7 (m) or 2.73 (m)	C1 C1 A1	 **Allow**: Any subject
		(iii)	$BQv = mv^2/r$ Hence, radius ∝ mass	B1 B1	 **Allow**: $r \propto m$
			Total	**12**	

Question			Answers	Marks	Guidance
4	(a)		magnetic flux = (magnetic) flux density × (cross-sectional) area Idea of (magnetic) field normal to the plane of the area	M1 A1	Allow full credit for magnetic flux = *BA*, where *B* = magnetic flux density normal to area and *A* = (cross-sectional) area
	(b)	(i)	constant rate of change of (magnetic) flux / flux density	B1	**Not**: 'graph has constant gradient'
		(ii)	e.m.f. = rate of change of flux linkage e.m.f. $\frac{1.4\times10^{-2}\times\pi\times(3.2\times10^{-2})^2\times180}{2.5}$ e.m.f. = 3.2×10^{-3} (V) or 3.24×10^{-3} (V)	C1 C1 A1	**Allow**: $E=\frac{\Delta N\phi}{\Delta t}$ Deduct 1 mark if *B* is misread from the graph and then ecf **Allow**: 2 marks for an answer 3.24×10^{n} (if $n\neq-3$) **Allow**: 2 marks for 1.78×10^{-5} (when 180 has been missed out)
	(c)	(i)	*P* = *VI* current in secondary = 15/6 or 2.5 (A) primary voltage = 6.0 × turn ratio = 6.0 × 40 = 240 (V) V_p = 240 (V) or I_s = 2.5 (A) primary current = 2.5/40 or 15/240 input current = 6.3×10^{-2} (A) or 6.25×10^{-2} (A)	C1 A1	The C1 mark is for either of these values
		(ii)	There is no change in flux density / (magnetic) flux / (magnetic) flux linkage	B1	**Not**: 'There is no change in the magnetic field'
			Total	**9**	