Question			Answer	Marks	Guidance
1	**(a)**		Arrow to the left	B1	
	(b)	**(i)**	1500 (eV)	B1	**Note**: 2.4×10^{-16} (J) on the answer line scores zero
		(ii)	(KE =) $1500 \times 1.6 \times 10^{-19}$ ($= 2.4 \times 10^{-16}$ J) $2.4 \times 10^{-16} = \frac{1}{2} \times 9.11 \times 10^{-31} \times v^2$ (Allow any subject) $v = 2.3 \times 10^{7}$ (m s^{-1})	C1 C1 A1	Possible ecf from **(b)(i)** **Allow**: 2 marks for 5.3×10^{14} (answer not square-rooted) **Note**: $v = \sqrt{\dfrac{2 \times 1500}{9.11 \times 10^{-31}}} = 5.74 \times 10^{16}$ (m s^{-1}) does not score
	(c)	**(i)**	$F_{(E)} = Eq$ and $F_{(M)} = Bqv$ $Eq = Bqv$ (This mark is for equating the two equations) (Hence) $v = \dfrac{E}{B}$	 M1 A1	 **Allow** an equivalent approach **Allow** any subject
		(ii)	Force due to magnetic field > force due to electric field Electrons drift 'downwards'	B1 B1	**Allow**: magnetic force > electric force or $F_M > F_E$ or $Bqv > Eq$ or magnetic force is bigger <u>and</u> electric force is the same **Note**: This mark can be scored on Fig. 3.2
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
2	**a**	**(i)**	uniformly spaced, vertical parallel lines must begin and end on the plates with a minimum of three lines arrow in the correct direction down	**B1** **B1**	ignore any edge effects
		(ii)	$E = V / d$ $E = 60 / 5 \times 10^{-3}$ $= 12000$ ($V\ m^{-1}$)	**A1**	
	b	**(i)**	Use of energy qV and kinetic energy = $\frac{1}{2} mv^2$ $v = [(2qV)/m]^{1/2}$ $v = [(2 \times 3.2 \times 10^{-19} \times 400)/6.6 \times 10^{-27}]^{1/2}$ $v = 1.97 \times 10^5$ ($m\ s^{-1}$)	**M1** **M1** **A0**	
		(ii)	$a = F / m$ $a = Eq / m$ $a = (12000 \times 3.2 \times 10^{-19}) / 6.6 \times 10^{-27})$ $= 5.82 \times 10^{11}$ ($m\ s^{-2}$)	**C1** **A1**	Both required for the mark
		(iii)	**1** $t = \underline{(16 \times 10^{-3}) / 2 \times 10^5}$ $= 8 \times 10^{-8}$ (s) **2** $s = \frac{1}{2} a \times t^2 = \frac{1}{2} [5.82 \times 10^{11} \times (8 \times 10^{-8})^2]$ $= 1.86 \times 10^{-3}$ (m)	**M1** **A0** **C1** **A1**	Answer will depend on number of sf used by candidate. Using $u = 2 \times 10^5$ scores 0/2 Allow slight variation in answers that follow from the candidates working

	c		Eq = Bqv B = E / v = 12000 / 2 x 10^5 = 0.060 (T)	**C1** **C1** **A1**	Allow one sf unless answer is 0.061 when using v =1.97 x 10^5
	d		velocity (produced by p.d / 400 V) is less force due the magnetic field is reduced / Bqv is less / force due to the electric field is unchanged hence beam deflects <u>down</u>	**B1** **B1**	Allow the resultant force is downward Allow towards the lower plate
			Total	**[15]**	

Question			Expected Answers	Marks	Additional Guidance
3	a		$F = Q_1Q_2 / 4\pi\varepsilon_0 r^2$ $= (1.6 \times 10^{-19} \times 1.6 \times 10^{-19}) / 4\pi\varepsilon_0 (2\times 10^{-15})^2$ $= 57.5$ (N)	C1 A1	Allow use of 9×10^9 instead of $1 / 4\pi\varepsilon_0$ (using this gives 57.6) Allow ≥ 2sf (58) If correct formula quoted and then AE (e.g. not squaring r <u>or</u> not squaring Q) then allow ecf in final answer for 2/3
	b		<u>attractive</u> strong (nuclear force)	B1	Do not it holds them together
	c		as the proton travels towards the stationary proton it experiences a repulsive force that slows it down. (It needs a high velocity) to get close enough (to the proton) / for the (attractive) <u>short range</u> force to have any effect	B1 B1	
			Total	**[5]**	