Question Number	Answer		Mark
1(a)	Weight/W/mg vertically down Tension/T parallel to thread and pointing away Electrical (force) horizontal to left Accept electrostatic (force), repulsive (force), coulomb (force) repelling (force). Do **not** accept just F or drag All three correct 2 marks Any two correct 1 mark The lines must start on the ball and have arrow heads to indicate direction. Minus 1 mark for each extra force line. (Candidates who draw forces on M correctly but also include forces on N score 1)		**2**
1(b)(i)	Use of $T \cos 35° = mg$ **Or** $T \sin 55° = mg$ g to kg and $\times 9.81$ Tension $= 3.2 \times 10^{-2}$ (N) Example of calculation $T \cos 35° = mg$ $T = (2.7 \times 10^{-3} \text{ kg} \times 9.81 \text{ N kg}^{-1}) / \cos 35°$ $T = 0.0323 \text{ N}$	(1) (1) (1)	**3**
1(b)(ii)	Equates electric force to $T \sin 35°$ **Or** $T \cos 55°$ **Or** $W \tan 35°$ **Or** use of pythagoras $F_E = 0.018$ **Or** 0.019 (N) ($F_E = 0.017$ N if show that value used. ecf T from (i) Example of calculation $F_E = 0.032 \times \sin 35°$ $F_E = 0.018 \text{ N}$	(1) (1)	**2**
1(b)(iii)	Use of $F = Q^2/4\pi\varepsilon_o r^2$ **Or** $F = kQ^2/r^2$ (ecf value of F from (ii) conversion cm to m $Q = (2.9 - 3.1) \times 10^{-7}$ C (candidates who half the value of r can score the first 2 marks) Example of calculation $Q^2 = Fr^2/k$ $Q^2 = (0.020 \text{ N}) \times (20.6 \times 10^{-2} \text{ m})^2/(8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2})$ $Q = 3.07 \times 10^{-7}$ C	(1) (1) (1)	**3**
1(c)	Both balls would move through the same angle/distance **Or** the balls are suspended at equal angles (to the vertical) (Because) the force on both balls is the same	(1) (1)	**2**
PhysicsAndMathsTutor.com **Total for question**			**12**

Question Number	Answer		Mark
2 a	Space/area/region where a force acts on a charged particle	**(1)**	**2**
	The force is the same at all points **Or** Field strength is constant **Or** Field lines equispaced (accept diagram with a minimum of three equispaced parallel lines, with arrows for 2nd mark)	**(1)**	
2b	Two <u>parallel</u> plates (accept wires for plates)	**(1)**	**3**
	Connected to a potential difference **Or** potential difference is applied	**(1)**	
	Practical method to show force Eg seeds in tray of glycerol, Charged foil on end of rule, Charged pith ball on thread, Beam of electrons (in teltron tube) Charged oil drops (do not credit charged object) (All 3 marks can be scored from a diagram. To score the third mark the set-up must be labelled.)	**(1)**	
	Total for question		**5**

Question Number	Answer		Mark
*3	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)		
	Current in a wire produces a magnetic field	**(1)**	
	Identifies direction of B field around either wire Eg Around wire so that it is into the page at the bottom of wire **Or** clockwise when looking from left	**(1)**	
	(Each) wire is in the magnetic field of the other wire	**(1)**	
	A current-carrying wire in a magnetic field experiences a force	**(1)**	
	Mention of Fleming's left hand rule (accept motor rule) **Or** identifies neutral point between wires.	**(1)**	
	(Marks 1 and 2 and a labelled neutral point could be communicated using the diagram. For neutral point accept 'fields cancel' but not 'fields in opposite directions')		**5**
	Total for question		**5**

Question Number	Answer	Mark
4(a)	Use of $E = V/d$ **(1)** Answer = 1.5×10^5 V m^{-1} or N C^{-1} **(1)** Eg $E = 1.5 / 10 \times 10^{-6}$	2
4(b)	Opposite forces (act on either end of molecule) **(1)** Molecule rotates / aligns with field **(1)** − at top + at bottom **(1)**	3
	Total for question	5

Question Number	Answer	Mark
5(a)	Straight lines (at least 4) touching proton **(1)** Equi spread (by eye) **(1)** Arrow on at least one pointing away from proton **(1)**	3
5(b)	Use of $F = k \, QQ/r^2$ [requires 2 subs to qualify as use] **(1)** Know $Q_p = 1.6 \times 10^{-19}$ (C) eg $QQ = (1.6 \times 10^{-19})^2$ **(1)** Answer = 7.9×10^{-8} N **(1)** Eg $F = 8.99 \times 10^9 (1.6 \times 10^{-19})^2 / (5.4 \times 10^{-11})^2$	3
	Total for question	6

Question Number	Answer		Mark
6(a)(i)	*W/mg* and *T* correct	**(1)**	
	F/E/ electric force correct	**(1)**	**2**
	Example of diagram		
6(a)(ii)	See $T\cos\theta = W$	**(1)**	
	See $T\sin\theta = F$	**(1)**	
	Or		
	Draws a correct triangle of forces	**(1)**	
	Correctly labels θ	**(1)**	**2**
	(if a triangle is drawn it must be a closed polygon with correctly orientated direction of arrows)		
6(b)(i)	Records 1 pair of values from graph	**(1)**	
	Records 2nd pair of values from graph	**(1)**	
	Use of $F\,r^2$	**(1)**	
	Shows that $F_1 r_1^2 = F_2 r_2^2$	**(1)**	**4**
	(accept answers with or without the powers of ten included)		
	Example of answer		
	Ignoring powers of 10		
	$115\,\text{N} \times 20^2\,\text{m}^2 = 46000$		
	$51\,\text{N} \times 30^2\,\text{m}^2 = 45900$		
6(b)(ii)	Uses constant from (b) ignoring powers of ten errors		
	Or uses a pair of values from graph	**(1)**	
	Use of $F = k Q_1 Q_2 / r^2$ with 1.6×10^{-19} C	**(1)**	
	$Q = 7.2 \times 10^{-9}$ C	**(1)**	**3**
	Example of answer		
	$100\,Q^2 = 46000 \times 10^{-9}\,\text{N m}^2 / 8.99 \times 10^9\,\text{N m}^2\,\text{C}^{-2}$		
	$Q^2 = 5.12 \times 10^{-17}\,\text{C}^2$		
	$Q = 7.2 \times 10^{-9}\,\text{C}$		
	Total for question		**11**

Question Number	Answer	Mark
7(a)	At least 3 parallel straight lines	(1)
	<u>ALL</u> Equispaced (except ignore a large gap in middle) [be firm]	(1)
	Arrow left to right	(1)
7(b)	Use of eV [eg 1.6 x10^{-19} or 2000/4000]	(1)
	(=) ½ mv^2	(1)
	Use of 2000	(1)
7(c)	Use of $v = s/t$ [eg = 1.5 / 23 (x 10^{-6})]	(1)
	(= 65000)	
	Sub into previous equation	(1)
	m = 1.5 x 10^{-25} kg	(1)
7(d)	Some of the molecules in sample will travel further/less/not midway	(1)
	Duration of laser pulse	(1)
	Might emerge not horizontal	(1)
	Molecules may be doubly/integer ionised	(1)
	Time very small	(1)
	Not perfect vacuum / collides with other molecules	(1)
		(max2)
	Total for question	11