Mark Scheme

Q1.

Question Number	Answer	Mark
	C	1

Q2.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is B A *is not correct because this is a uniform field so F constant* C *is not correct because this is a uniform field so F constant* D *is not correct because this is a uniform field so F constant*	*F*	1

Q3.

Question Number	Answer	Mark
	A	1

Q4.

Question Number	Answer	Mark
	D	1

Q5.

Question Number	Answer	Mark
	D	1

Q6.

Question Number	Answer	Mark
	D	1

Q7.

Question Number	Answer	Mark
	D	1

Q8.

Question Number	Answer	Mark
	C	1

Q9.

Question number	Acceptable Answers	Additional guidance	Mark
	• At least 4 radial lines (1) • arrow pointing outwards (1) • straight, symmetrical and equally distributed (1)	Ignore dotted lines	3

Question Number	Acceptable Answers	Additional guidance	Mark
	Maximum 3 marks • There cannot be a p.d. across his body (1) • Electric field strength inside cage is zero (1) • As no potential gradient (1) • Current/electrons/charge would conduct through suit **Or** the current would not pass through body (1)	Accept reference to Faraday cage for MP2	**3max**

Q11.

Question Number	Acceptable Answers	Additional guidance	Mark
	• tangent at correct point (1) • triangle with base at least 0.4 m (1) • 5.3×10^6 (Vm^{-1}) (range 4.9×10^6 to 6.1×10^6) (1) • So would ionise as value greater than 3×10^6 (1) Alternative: • Correct value of V at 30 cm (1) • Use of $E = k\frac{Q}{r^2}$ and $V = k\frac{Q}{r}$ (1) • 5.3×10^6 (Vm^{-1}) (1) • So would ionise as value greater than 3×10^6 (1)	Example of calculation: Gradient = 3200000 / 0.6 $E = 5.3 \times 10^6$ V m^{-1} MP4 to be consistent with calculated value $V = 1.6 \times 10^6$ V m^{-1}	**4**

Q12.

Question Number	Answer		Mark
(b)	**Diagram mark for parallel plate**: a minimum of 3 parallel equispaced lines touching plates (ignore edge effect)	(1)	
	Diagram mark for point charge: minimum of 4 equispaced radial lines touching charged point	(1)	
	Direction of fields correct for both diagrams consistent with charges labelled	(1)	
	Parallel plate - field strength same at all points	(1)	
	Point charge - field strength decreases with (increasing)distance from point **Or** obeys inverse square law	(1)	5

Q13.

Question Number	Answer		Mark
	Use of $F_E = kQ_1Q_2/r^2$	(1)	
	Use of $W = mg$	(1)	
	Resolve vertically $T\cos\theta = mg$ **and** Resolve horizontally $T\sin\theta = F_E$	(1)	
	Attempt to combine components to give tan θ ($\tan\theta = F_E/mg$)	(1)	
	$\theta = 41°$ to $42°$	(1)	
	$T = 0.035$ N	(1)	
	Or		
	Use of $F_E = kQ_1Q_2/r^2$	(1)	
	Use of $W = mg$	(1)	
	Use of Pythagoras to find tension force	(1)	
	Tan $\theta = F_E/mg$ **Or** $\cos\theta = mg/T$ **Or** $\sin\theta = F_E/T$	(1)	
	$\theta = 41°$ to $42°$	(1)	
	$T = 0.035$ N	(1)	6
	(if they halve the separation or halve the electric force they can still get MP1 and so could score MP1,2, 3 & 4)		
	Example of calculation Weight of sphere = $0.0027\ \text{kg} \times 9.81\ \text{N kg}^{-1} = 0.026$ N Electric force $F_E = kQ_1Q_2/r^2$ $= 8.99 \times 10^9\ \text{N m}^2\ \text{C}^{-2} \times (4.0 \times 10^{-7}\ \text{C})^2 / 0.25^2\ \text{m}^2 = 0.023$ N Vertically $T\cos\theta = mg$ Horizontally $T\sin\theta = F_E$ Tan $\theta = F_E/\text{mg} = 0.023$ N/ 0.026 N $\theta = 41°$ sub into vertical equation $T = mg/\cos\theta = 0.026$ N /cos 41 $T = 0.034$ N		

Q14.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Conversion of MeV to J (1) • See $Q_1 = 79 \times 1.6 \times 10^{-19}$ and $Q_2 = 2 \times 1.6 \times 10^{-19}$ (1) • Use of $V = \frac{Q}{4\pi\varepsilon_0 r}$ and $W = QV$ (1) • $r = 4.1\times10^{-14}$ m (1)	Example of calculation $E_\alpha = 5.5\times10^{6}\text{eV}\times1.6\times10^{-19}\text{J eV}^{-1} = 8.8\times10^{-13}\text{J}$ $8.8\times10^{-13}\text{J} = \frac{79\times1.6\times10^{-19}\text{C}\times2\times1.6\times10^{-19}\text{C}}{4\pi\times8.85\times10^{-12}\text{ F m}^{-1}\, r}$ $r = \frac{3.64\times10^{-26}\text{ N m}^2}{8.8\times10^{-13}\text{ J}} = 4.1\times10^{-14}\text{ m}$	4
(ii)	• Electrons are behaving like waves (1) • wavelength $= \frac{h}{\text{momentum}}$ (1) • Electron wavelength must be similar to the atomic spacing in the foil (1)	MP3: Accept electron wavelength must be similar to the distance between (adjacent) nuclei	3

Q15.

Question Number	Answer		Mark
(a)	(Electric field strength (at a point in a field) is) the force per unit charge (accept force per coulomb of charge) Acting on a (small) positive charge.	**(1)** **(1)**	**2**
(b)(i)	Use of $E = kQ/r^2$ Electric field due to $Q_1 = 4.1(1) \times 10^6$ (N C^{-1}) Use of 11.9 cm to find field due to Q_2 **Or** Use of $E = kQ/r^2$ Use of $E1/E2 = Q1\ r22/\ Q2\ r12$ $E_1/E_2 = 1$ <u>Example of calculation</u> Electric field due to Q_1 $= (8.99 \times 10^9$ N m^2 $C^{-2}) \times (3 \times 10^{-6}$ C) / $(8.1 \times 10^{-2})^2$ $= 4.11 \times 10^6$ N C^{-1} Electric field due to Q_2 $= (8.99 \times 10^9$ N m^2 $C^{-2}) \times (6.5 \times 10^{-6}$ C) / $(11.9 \times 10^{-2})^2$ $= 4.13 \times 10^6$ N C^{-1}	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
(b)(ii)	(Force on charge is) zero/negligible/approx zero (Allow values less than 0.1 N)	**(1)**	**1**
(b)(iii)	At midpoint repulsive force due to Q_2 > repulsive force due to Q_1 **Or** the <u>resultant</u> field/force is repulsive <u>Work</u> must be done against the repulsive force/field to move the charge to this position.	**(1)** **(1)**	**2**
	Total for question		**8**

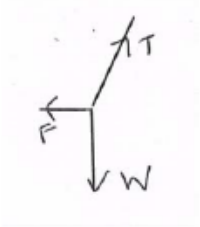
Q16.

Question Number	Answer		Mark
(a)(i)	Straight through, zero deflection, direction fired in. (Do not accept 'through' or 'directly behind' on its own)	**(1)**	**1**
(a)(ii)	(Atom consists) mainly/mostly of <u>empty space</u> **Or** Volume of atom very much greater than volume of nucleus. (do not credit if part of a list)	**(1)**	**1**
(b)	Most of the mass is in the nucleus/centre [it is not enough to say that the nucleus is dense/concentrated. Looking for idea that nearly all of the atom's mass is in the nucleus] Nucleus/centre is <u>charged</u> [ignore references to the charge being positive. Just saying the nucleus is positive does not get the mark.]	**(1)** **(1)**	**2**
(c)(i) E	Electrostatic/electromagnetic/electric/coulomb	**(1)**	**1**
(c)(ii)	Arrow starting on the path at closest point to the nucleus Arrow pointing radially away from nucleus (correct direction starting on the nucleus scores 2nd mark only)	**(1)** **(1)**	**2**
(c)(iii)	Deflection starts earlier Final deflection is greater (paths should diverge)	**(1)** **(1)**	**2**
	Total for question		**9**

Q17.

Question Number	Answer		Mark
(a)	Arrow(s) downwards	**(1)**	**1**
(b)	Use of $E = V/d$ Use of $F = EQ$ $F = 5.1 \times 10^{-16}$ N Example of calculation $F = (160\ \text{V} \times 1.6 \times 10^{-19}\ \text{C}) / 5.0 \times 10^{-2}\ \text{m}$ $F = 5.12 \times 10^{-16}$ N	**(1)** **(1)** **(1)**	**3**
(c)	Between the plates there is an acceleration/force which is vertical/upwards Constant horizontal velocity Outside the plates no (electric) field /force acts **Or** Outside the plates speed so large that gravitational effect negligible	**(1)** **(1)** **(1)**	**3**
(d)(i)	Release of (surface) electrons due to heating	**(1)**	**1**
(d)(ii)	Use of $E_k = \frac{1}{2}mv^2$ Use of $V = W/Q$ p.d. = 410 V Example of calculation $E_k = 9.11 \times 10^{-31}\ \text{kg} \times (1.2 \times 10^{7}\ \text{m s}^{-1})^2/2$ $E_k = 6.56 \times 10^{-17}$ J p.d. $= (6.56 \times 10^{-17}\ \text{J}) / (1.6 \times 10^{-19}\ \text{C})$ p.d. = 410V	**(1)** **(1)** **(1)**	**3**
	Total for question		**11**

Q18.

Question Number	Answer		Mark
(a)(i)	*W*/*mg* and *T* correct *F*/*E*/ electric force correct Example of diagram  	(1) (1)	2
(a)(ii)	See $T\cos\theta = W$ See $T\sin\theta = F$ **Or** Draws a correct triangle of forces Correctly labels θ (if a triangle is drawn it must be a closed polygon with correctly orientated direction of arrows)	(1) (1) (1) (1)	2
(b)(i)	Records 1pair of values from graph Records 2nd pair of values from graph Use of $F\,r^2$ Shows that $F_1r_1^2 = F_2r_2^2$ (accept answers with or without the powers of ten included) Example of answer Ignoring powers of 10 $115\ \text{N} \times 20^2\ \text{m}^2 = 46000$ $51\ \text{N} \times 30^2\ \text{m}^2 = 45900$	(1) (1) (1) (1)	4
(b)(ii)	Uses constant from (b) ignoring powers of ten errors **Or** uses a pair of values from graph Use of $F = kQ_1Q_2/r^2$ with 1.6×10^{-19} C $Q = 7.2 \times 10^{-9}$ C Example of answer $100\ Q^2 = 46000 \times 10^{-9}\ \text{N m}^2 / 8.99 \times 10^9\ \text{N m}^2\ \text{C}^{-2}$ $Q^2 = 5.12 \times 10^{-17}\ \text{C}^2$ $Q = 7.2 \times 10^{-9}$ C	(1) (1) (1)	3
	Total for question		**11**

Q19.

Question Number	Answer		Mark
(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**
(b)(i)	Use of $T \cos 35° = mg$ **Or** $T \sin 55° = mg$ g to kg and × 9.81 Tension = 3.2×10^{-2} (N) Example of calculation $T \cos 35° = mg$ $T = (2.7 \times 10^{-3}$ kg × 9.81 N kg^{-1}) / cos 35° $T = 0.0323$ N	**(1)** **(1)** **(1)**	**3**
(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 $F_E = 0.032 \times \sin 35°$ $F_E = 0.018$ N	**(1)** **(1)**	**2**
(b)(iii)	Use of $F = Q^2/4\pi\varepsilon_0 r^2$ **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 $Q^2 = Fr^2/k$ $Q^2 = (0.020$ N)× $(20.6 \times 10^{-2}$ m)^2/$(8.99 \times 10^9$ N m^2 C^{-2}) $Q = 3.07 \times 10^{-7}$ C	**(1)** **(1)** **(1)**	**3**
(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**

Question Number	Answer		Mark
(a)	At least three vertical lines spread over symmetrically over more than half of the plate length and touching both plates. (ignore edge ones that might curve) All equispaced and parallel [don't allow gaping to avoid oil drop] Arrow pointing downwards	**(1)** **(1)** **(1)**	**3**
(b)	Negative / - / -ve (negative and/or positive does not get the mark)	**(1)**	**1**
(c)	Upward force labelled: Electric (force) **Or** Electrostatic (force) **Or** force due to electric field **Or** electromagnetic (force) [do not accept repulsive/attractive force. If EQ used, the symbols must be defined] Downward force labelled: mg, weight, W, gravitational force (for both marks the lines must touch the drop and be pointing away from it. Ignore upthrust if drawn but one mark lost for each extra force added)	**(1)** **(1)**	**2**
(d)(i)	E = 5100 V/ 2 cm Conversion of cm to m Use of $QE = mg$ (1.18×10^{-13} kg) $Q = 4.6 \times 10^{-19}$ C (E = 255 000 (V m^{-1}) scores MP1 & 2. unit conversion missed → $Q = 4.62 \times 10^{-17}$ C scores MP1 & 3 if V is halved → $Q = 9.23 \times 10^{-19}$ C scores MP1 ,2 & 3) <u>Example of calculation</u> $E = V/d$ $F = EQ = mg$ $Q = mg / E = mgd/V$ Q = (1.20×10^{-14} kg × 9.81m s^{-2}× 0.02 m) / (5100 V) Q = 4.62×10^{-19} C	**(1)** **(1)** **(1)** **(1)**	**4**
(d)(ii)	Answer to (d)(i) divided by e 3 electrons **Or** sensible integer number less than 500 (answers with very large numbers of electrons can get MP1 only) <u>Example of calculation</u> Number of electrons = 4.62×10^{-19} C / 1.6×10^{-19} C Number = 2.9 i.e. 3 electrons.	**(1)** **(1)**	**2**
	Total for question		**12**