A Level OCR Physics

Chapter 21 Electric fields

Question	Answers	Extra information	Mark	AO Spec reference
1(a)	Direction of arrow from centre of gold nucleus directly away from X	Judge by eye	1	6.2.1 AO1
(b)	6.2 MeV = $6.2\times10^{6} \times 1.6\times10^{-19}$ J $KE = 1/2\ mv^2$ $v^2 = 2\ KE/m = 2 \times 6.2\times10^{6} \times 1.6\times10^{-19} / 6.64\times10^{-27}$ kg $v = 1.73\times10^{7}$ m s^{-1}		1 1 	3.3.2 4.5.1 AO2
(c)	$\Delta W = Q\Delta V$ sp EPE = $V \times Q$ $1/2\ mv^2 = Qq/4\ \pi\varepsilon_o\ r$ $1/2\ mv^2 = Ze \times 2e/4\ \pi\varepsilon_o\ r_c$ $r_c = Ze^2/\pi\varepsilon_o\ mv^2$	Must be clear how the 4 cancelled – watch for 2 disappearing	1 1 1	6.2.4 AO3
(d)	$Z = 79$ $r_c = Ze^2/\pi\varepsilon_o\ mv^2 = 79 \times (1.6\times10^{-19})^2/\ \pi \times 8.85\times10^{-12} \times 6.64\times10^{-27} \times (1.73\times10^{7})^2$ $r_c = 3.7\times10^{-14}$		1 1	6.2.4 AO2
2(a)	Lines leaving spheres perpendicular to surface Arrows from positive Suitable pattern between repelling spheres		1 1 1	6.2.1 AO1
(b)	One problem with one related solution eg difficulty of affecting the field using metal instruments – use wooden ruler difficulty in measuring distances between curved objects – set up ruler with set squares fixed or use light and measure distance between shadows		1 1	1.1.2 AO3
(c)	$F \propto 1/r^2$ or $F = Q_1Q_2/4\pi\varepsilon_0\ r^2$ Fr^2 = constant or mr^2 = constant	Constant if you don't change units = 33 000	1 1	6.2.2 AO2

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	Data tested for at least 3 data sets and conclusion e.g. $0.02^2 \times (0.0827 \times 9.81) = 3.2\times10^{-4}$ (N m^2) $0.025^2 \times 0.053 \times 9.81 = 3.2\times10^{-4}$ $0.030^2 \times 0.0368 \times 9.81 = 3.2\times10^{-4}$		1	
(d)	$F = Q_1Q_2/4\pi\varepsilon_0 r^2$ $Q^2 = F r^2 4\pi\varepsilon_0$ $Q^2 = 3.2\times10^{-4} \times 4\pi \times 8.85\times10^{-12}$ $Q = 1.9\times10^{-7}$ C	Allow using a pair of values from table for full marks	1 1	6.2.2 AO2
3(a)	The potential difference between the lines is constant but the distance is not.		1	6.2.4 AO2
(b)	At least 4 lines drawn perpendicular to surface of the cable arrows pointing away from the cable		1 1	6.2.1 AO1
(c)	$V \propto 1/r$ Vr = constant $300 \times 10 = 200 \times d$ d = 15 cm		1 1	6.2.4 AO2
(d)	P is at a distance of 12.5 cm $300 \times 10 = 12.5 \times V$ V = 240 V		1 1	6.2.4 AO2
4(a)	At least 6 lines drawn – equidistant arrows pointing down		1 1	6.2.1 AO1
(b)	Path deflected upwards	Ignore size of deflection	1	6.2.3 AO1
(c)	Use of $E = F/Q = V/d$ or $F = ma$		1	3.2.1

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	$F/Q = V/d$ $F = VQ/d$ $ma = VQ/d$ $a = VQ/md$ a = 1500 × 1.6×10^{-19}/9.11×10^{-31} × 0.025 = 1.1×10^{16} m s^{-2}		 1 1	6.2.3 AO2
(d)	Time between plates = length of plates/ speed of electrons t = 0.04/3 × 10^{7} = 1.3 × 10^{-9} s Use of suvat for vertical displacement $s = ut + ½\ at^2$ **and** $u = 0$ s = ½ 1.1×10^{16} × (1.3×10^{-9})^2 s = 0.01 m = 10 mm or 0.0098 m = 9.8 mm Distance from top plate = 12.5 mm – 10 mm = 2.5 mm (or 2.7 mm)	Use of rounded numbers gives s = 8.5 mm and so final answer = 4 mm	 1 1 1 1	3.1.2 3.1.3 6.2.3 AO2
5(a)	Use of $C = Q/V$ $V = Q/4\pi\ \varepsilon_o R$ $C = Q\ 4\pi\ \varepsilon_o R/Q = 4\pi\ \varepsilon_o R$	Clear substitution seen for second mark	1 1	6.2.4 AO1
(b)	$C = 4\pi\ \varepsilon_o R$ = 4 × π × 8.85×10^{-12} × 0.20 = 2.2×10^{-11} F (Farads)		1 1	6.2.4 AO1
(c)	$E = V/r$ $V = Er$ = 3×10^{6} × 0.20 = 6×10^{5} V		1 1	6.2.4 6.2.2 AO2
(d)	Use of $Q = VC$ = 2.2×10^{-11} × 6×10^{5} = 1.3×10^{-5} C Number of excess charges = 1.3×10^{-5} C/1.6×10^{-19} C = 8.3×10^{13}	Be aware of possible e.c.f. from answer to 5.2 and 5.3 Could also use $V = Q/4\pi\ \varepsilon_o R$	1 1	6.1.1 AO2
6(a)	$F = Q_1\ Q_2/4\pi\ \varepsilon_o r^2$ F = (1.6×10^{-19})^2/4π × 8.85×10^{-12} × (5.3×10^{-11})^2		1	6.2.2 AO2

Question	Answers	Extra information	Mark	AO Spec reference
	$F = 8.2\times10^{-8}$ N		1	
(b)	8.2×10^{-8} N		1	6.2.2 AO1
(c)	$F = ma$ $a = F/m = 8.2\times10^{-8}$ N/9.11×10^{-31} kg = 9.0×10^{22} m s^{-2}		1	3.2.1 AO2
(d)	$E = KE + PE$ $\Delta W = Q\Delta V$ $E = ½\ mv^2 - e^2/4\ \pi\varepsilon_o\ r$ since $mv^2/r = e^2/4\ \pi\varepsilon_o\ r^2$ $mv^2 = e^2/4\ \pi\varepsilon_o\ r$ $E = e^2/2 \times 4\ \pi\varepsilon_o\ r + -e^2/4\ \pi\varepsilon_o\ r = -e^2/8\ \pi\varepsilon_o r$ $E = -(1.6\times10^{-19})^2/\ 4\pi \times 8.85\times10^{-12} \times 5.3\times10^{-11}$ $E = 2.2\times10^{-18}$ J $E = 2.2\times10^{-18}$ J/ 1.6×10^{-19} J = 13.57 eV	Also credit for full marks use of 1/2 mv^2 and $V = Q/4\ \pi\varepsilon_o\ r$ (EPE = $QQ/4\ \pi\varepsilon_o\ r$)	1 1 1 1	6.2.4 5.4.4 AO3
7(a)	$A = 120 \times 10^{-4}$ m^2 = 0.012 $C = A\varepsilon_o/d$ $C = 0.012 \times 8.85\times10^{-12}$ /0.1 = 1.1×10^{-12} F		1 1	6.2.3 AO1
(b)	$Q = CV = 1.1\times10^{-12}$ F × 40 = 4.2×10^{-11} C	possible e.c.f. here from 7(a)	1	6.1.1 AO1
(c)	$E = V/d = 40/0.01 = 400$ V m^{-1}		1 1	6.2.3 AO2
(d)	$\Delta W = Q\Delta V$ = 1.6×10^{-19} × 40 V = 6.4×10^{-18} J		1 1	6.2.3 AO2

Question	Answers	Extra information	Mark	AO Spec reference
(e)	**Level 3 (5–6 marks)** Clear description, explanation and suitable calculations. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Clear description and some explanation, or some attempt at description, explanation and calculations. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description or explanation or calculation *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit	**Indicative content:** **Description** • Electron decelerates initially • electron does not reach A / stops / reverses direction • electron stops at halfway point. • electron accelerates back to B • Final kinetic energy = initial kinetic energy **Explanations** • Electron is attracted by B /repelled by A/ experiences force to the right • Electron does not have sufficient kinetic energy to reach plate A **Calculations** • $E = F/Q$ so $F = EQ$ = 400 × 1.6×10^{-19} C = 6.4×10^{-17} N • $a = F/m$ = 6.4×10^{-17} N/9.11×10^{-31} = 7.0×10^{13} m s^{-2} to the right • KE = 20 eV and Work done by electric field = 40 eV so can only reach halfway point • Final KE = 20 eV	5–6 3–4 1–2 0	6.2.3 6.2.4 6.2.1 3.2.1 AO2 × 3 AO3 × 3
8(a)	Is the work done in bringing unit **positive** charge from infinity to that point.	Must include positive	1	6.2.4 AO1
(b)	$V \propto 1/r$		1	6.2.4

Question	Answers	Extra information	Mark	AO Spec reference
	Vr = constant Data checked at least three times and conclusion e.g. 1800 × 0.01 = 18 600 × 0.03 = 18 300 × 0.06 = 18		 1 1	AO2
(c)	$V = Q/4\,\pi\varepsilon_o\, r$ $Q = V \times 4\,\pi\varepsilon_o\, r = 18 \times 4 \times \pi \times 8.85\times10^{-12}$ $Q = 2.0 \times 10^{-9}$ C $Q = 2$ nC		1 1	6.2.4 AO2
(d)	Draw a tangent to the curve at 3 cm calculate the gradient of the tangent $E = 2.1\times10^{4}$ V m^{-1}	Accept range from 1.9 to 2.3 Vm^{-1} Allow 210 if units quoted as V cm^{-1}	1 1 1	6.2.4 AO3
(e)	V at 6 cm = 300 V $\Delta W = Q\Delta V = 4 \times 10^{-9} \times 300 = 1.2\times10^{-6}$ J		1 1	6.2.4 AO2