A Level AQA Physics

15 Electric fields – answers

Question	Answers	Extra information	Mark	AO Spec reference
01.1	Direction of arrow from centre of gold nucleus outwards	Judge by eye	1	3.7.1 AO1
01.2	6.2 MeV = $6.2\times10^{6}\times1.6\times10^{-19}$ J $E_k=\frac{1}{2}mv^2$ $v^2=\frac{2\times E_k}{m}=\frac{2\times6.2\times10^{6}\times1.6\times10^{-19}}{6.64\times10^{-27}\text{ kg}}$ $v=1.73\times10^{7}\text{ m s}^{-1}$		1 1	3.1.1 3.2.1.2 AO2
01.3	$\Delta W=Q\Delta V$ so EPE = $V\times Q$ $\frac{1}{2}mv^2=\frac{Qq}{4\pi\varepsilon_0 r}$ $\frac{1}{2}mv^2=\frac{Ze\times2e}{4\pi\varepsilon_0 r_c}$ $r_c=\frac{Ze^2}{\pi\varepsilon_0 mv^2}$	Must be clear how the 4 cancelled – watch for 2 disappearing	1 1 1	3.7.3.3 AO3
01.4	$Z=79$ $r_c=\frac{Ze^2}{\pi\varepsilon_0 mv^2}=\frac{79\times(1.6\times10^{-19})^2}{\pi\times8.85\times10^{-12}\times6.64\times10^{-27}\times(1.73\times10^{7})^2}$ $r_c=3.7\times10^{-14}$	allow e.c.f. from 01.2 if Z = 197 is used, deduct one mark (then r_c would = 9.13×10^{-14})	1 1	3.7.3.3 AO2
02.1	Lines leaving spheres perpendicular to surface Arrows point away from positive Suitable pattern between repelling spheres		1 1 1	3.7.3.2 AO1

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02.2	One problem with One related solution e.g., difficulty of affecting the field using metal instruments Use wooden/plastic 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	PS1.1 ATc AO3
02.3	$F \propto \frac{1}{r^2}$ or $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ Fr^2 = constant or mr^2 = constant 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) $0.025^2 \times 0.053 \times 9.81 = 3.2\times10^{-4}$ $0.030^2 \times 0.0368 \times 9.81 = 3.2\times10^{-4}$	Constant = 33 000 g mm^2 (if you don't change units)	1 1 1	3.7.3.1 AO2
02.4	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ $Q^2 = Fr^2 4\pi\varepsilon_0$ $Q^2 = 3.2 \times 10^{-4} \times 4\pi \times 8.85 \times 10^{-12}$ $Q = 1.9 \times 10^{-7}$ C	Allow using a pair of values from table for full marks	1 1	3.7.3.1 AO2
03.1	The potential difference between the lines is constant but the distance is not		1	3.7.3.3 AO2
03.2	At least 4 lines drawn perpendicular to surface of the cable and equipotentials Arrows pointing away from the cable		1 1	3.7.3.2 AO1
03.3	$V \propto \frac{1}{r}$ Vr = constant $300 \times 10 = 200 \times d$ d = 15 cm		1 1	3.7.3.3 AO2

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03.4	**P** is at a distance of 12.5 cm $300 \times 10 = 12.5 \times V$ $V = 240\,V$		1 1	3.7.3.3 AO2
04.1	At least 6 lines drawn – equidistant Arrows pointing down	ignore field outside/near edge of plates	1 1	3.7.3.2 AO1
04.2	Path deflected upwards	Ignore size of deflection	1	3.7.3.2 AO1
04.3	Use of $E = \frac{F}{Q} = \frac{V}{d}$ or $F = ma$ $F = \frac{VQ}{d}$ $ma = \frac{VQ}{d}$ $a = \frac{VQ}{md}$ $a = \frac{1500 \times 1.6\times10^{-19}}{9.11\times10^{-31} \times 0.025} = 1.1\times10^{16}\,m\,s^{-2}$		1 1 1	3.7.3.2 3.4.1.5 AO2
04.4	Time between plates = $\frac{\text{length of plates}}{\text{speed of electrons}}$ $t = \frac{0.04}{3\times10^{7}} = 1.3\times10^{-9}\,s$ Use of *suvat* for vertical displacement $s = ut + \frac{1}{2}at^2$ **and** $u = 0$ $s = \frac{1}{2} \times 1.1\times10^{16} \times (1.3\times10^{-9})^2$ $s = 0.01\,m = 10\,mm$ 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	3.4.1.4 AO2

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05.1	Use of $C = \frac{Q}{V}$ $V = \frac{Q}{4\pi\varepsilon_0 R}$ $C = Q \times \frac{4\pi\varepsilon_0 R}{Q} = 4\pi\varepsilon_0 R$	Clear substitution seen for second mark	1 1	3.7.4.1 3.7.3.3 AO2
05.2	$C = 4\pi\varepsilon_0 R = 4 \times \pi \times 8.85\times10^{-12} \times 0.20 = 2.2 \times 10^{-11}$ F (Farads)		1 1	3.7.4.1 AO1
05.3	$E = \frac{V}{r}$ $V = Er = 3\times10^6 \times 0.20 = 6\times10^5$ V		1 1	3.7.3.2 AO2
05.4	Use of $Q = VC = 2.2\times10^{-11} \times 6\times10^5 = 1.3\times10^{-5}$ C Number of excess charges $= \frac{1.3\times10^{-5}\text{ C}}{1.6\times10^{-19}\text{ C}} = 8.3\times10^{13}$	Be aware of possible e.c.f. from answer to 05.2 and 05.3 Could also use $V = \frac{Q}{4\pi\varepsilon_0 R}$	1 1	3.7.4.1 AO2
06.1	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^2}$ $F = \frac{(1.6\times10^{-19})^2}{4\pi \times 8.85\times10^{-12} \times (5.3\times10^{-11})^2}$ $F = 8.2\times10^{-8}$ N		1 1	3.7.3.1 AO2
06.2	8.2×10^{-8} N	e.c.f. same as 06.1 ignore minus sign	1	3.7.3.1 AO1
06.3	$F = ma$ $a = \frac{F}{m} = \frac{8.2\times10^{-8}\text{ N}}{9.11\times10^{-31}\text{ kg}} = 9.0\times10^{22}\text{ m s}^{-2}$		1	3.4.1.5 AO2

OXFORD Revise

Question	Answers	Extra information	Mark	AO Spec reference
06.4	Total energy, $E = E_k + E_p$ $\Delta W = Q\Delta V$ $E = \frac{1}{2}mv^2 - \frac{e^2}{4\pi\varepsilon_0 r}$ since $\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$ $mv^2 = \frac{e^2}{4\pi\varepsilon_0 r}$ $E = \frac{e^2}{2 \times 4\pi\varepsilon_0 r} - \frac{e^2}{4\pi\varepsilon_0 r} = -\frac{e^2}{8\pi\varepsilon_0 r}$ $E = \frac{(1.6\times10^{-19})^2}{4\pi \times 8.85\times10^{-12} \times 5.3\times10^{-11}}$ $E = 2.2\times10^{-18}$ J $E = \frac{2.2\times10^{-18}\text{ J}}{1.6\times10^{-19}\text{ J}} = 13.57$ eV	Also credit for full marks use of $\frac{1}{2}mv^2$ and $V = \frac{Q}{4\pi\varepsilon_0 r}$ $(E_p = Q\frac{Q}{4\pi\varepsilon_0 r})$	1 1 1 1	3.7.3.3 3.1.1 AO3
07.1	Lines drawn at $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ points **and** correctly labelled		1	3.7.3.3 AO1
07.2	$E = \frac{V}{d}$ $= \frac{40}{0.01} = 400\text{ V m}^{-1}$		1 1	3.7.3.2 AO1
07.3	$\Delta W = Q\Delta V$ $= 1.6\times10^{-19} \times 40\text{ V} = 6.4\times10^{-18}$ J		1 1	3.7.3.3 AO2

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OXFORD Revise

Question	Answers	Extra information	Mark	AO Spec reference
07.4	Max 3 from: Electron is attracted by B/repelled by A/experiences force to the right Electron decelerates (initially) Electron does not reach A/stops/reverses direction Stops at half way point (20 eV) When it returns it has 20 eV		max 3	3.7.3.3 AO3
08.1	Is the work done per unit **positive** charge when it is moved from infinity to that point	Must include positive	1	3.7.3.3 AO1
08.2	$V \propto \frac{1}{r}$ 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 1	3.7.3.3 AO2
08.3	$V = \frac{Q}{4\pi\varepsilon_0 r}$ $Q = V \times 4\pi\varepsilon_0 r = 18 \times 4 \times \pi \times 8.85 \times 10^{-12}$ $Q = 2.0 \times 10^{-9}$ C Q = 2 nC		1 1	3.7.3.3 3.1.1 AO2
08.4	Draw a tangent to the curve at 3 cm Calculate the gradient of the tangent, e.g., $\frac{1180}{0.068} = 1.7 \times 10^4\ \mathrm{V\,m^{-1}}$ $\pm 0.3 \times 10^4\ \mathrm{V\,m^{-1}}$	Allow 170 if units quoted as $\mathrm{V\,cm^{-1}}$	1 1 1	3.7.3.3 AO3
08.5	V at 6 cm = 300 V $\Delta W = Q\Delta V = 4 \times 10^{-9} \times 300 = 1.2 \times 10^{-6}$ J		1 1	3.7.3.3 AO2

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OXFORD Revise

Skills box answers

Question	Answer
1	$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_d}{r^2}$ $Q = +25\times10^{-6}$ C; $q = +100\times10^{-6}$ C $e_0 = 8.85\times10^{-12}$ F m^{-1}; $r = 60\times10^{-3}$ m $F = \frac{2.5\times10^{-5}\,(1.00\times10^{-4})}{(6.0\times10^{-2})^2}$ $F = 5.5\times10^{4}$ N
2(a)	The force is attractive because the charges have opposite signs.
2(b)	$F = \frac{1}{4\pi\times8.85\times10^{-12}}\,\frac{4.0\times10^{-9}\times(-8.0\times10^{-9})}{(80\times10^{-3})^2}$ $F = 4.5\times10^{-5}$ N
3	$F \propto \frac{1}{r^2}$ so if the distance doubles, the force will decrease by $\frac{1}{(2)^2}$. The new force will be 10 N.