Point Charges & Electric Potential

Mark Scheme 5

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Mark Scheme 5

Time Allowed: **60 minutes**

Score: **/50**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1	(a	field strength = potential gradient	M1	
		correct sign OR directions discussed	A1	[2]
	(b)	area is 21.2 $cm^2 \pm 0.4 cm^2$	C2	
		(*if outside $\pm 0.4 cm^2$ but within $\pm 0.8 cm^2$, allow 1 mark)*		
		1.0 cm^2 represents ($1.0 \times 10^{-2} \times 2.5 \times 10^3$ =) 25 V	C1	
		potential difference = 530 V	A1	[4]
	(c)	$\frac{1}{2}mv^2 = qV$		
		$\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 530$	C1	
		$v = 1.37 \times 10^7$ ms^{-1}	A1	[2]
	(d) **(i)**	$d = 0$	B1	[1]
	(ii)	acceleration decreases then increases	B1	
		some quantitative analysis (e.g. minimum at 4.0 cm)	B1	[2]
		(*any suggestion that acceleration becomes zero or that there is a deceleration scores 0/2)*		

2	(a)	*either* ratio of work done to mass/charge *or* work done moving unit mass/charge from infinity *or* both have zero potential at infinity		B1	[1]
	(b)	gravitational forces are (always attractive)		B1	
		electric forces can be attractive or repulsive		B1	
		for gravitational, work got out as	masses come together /mass moves from infinity	B1	
		for electric, work done on charges if same sign, work got out if opposite sign as charges come together		B1	[4]

3	**(a**	**(i)**	force per unit positive charge (ratio idea essential)	B1	**[1]**
		(ii)	$E = Q / 4\pi\varepsilon_0 r^2$	M1	
			ε_0 being the permittivity of free space	A1	**[2]**
	(b)	**(i)**	$2.0 \times 10^6 = Q / (4\pi \times 8.85 \times 10^{-12} \times 0.35^2)$	C	
			$Q = 2.7 \times 10^{-5}$ C	A1	**[2]**
		(ii)	$V = (2.7 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 0.35)$	C1	
			$= 7.0 \times 10^5$ V	A1	**[2]**
	(c)		electrons are stripped off the atoms	B1	
			electrons and positive ions move in opposite directions, (giving rise to a current)	B1	**[2]**

4	**(a)**	field strength = potential gradient [- sign not required] [allow $E = \Delta V/\Delta x$ but not $E = V/d$]	**B1**	**[1]**
	(b)	No field for $x < r$	**B1**	
		for $x > r$, curve in correct direction, not going to zero	**B1**	
		discontinuity at $x = r$ (vertical line required)	**B1**	**[**3]

5 (a) (i) grav. pot. energy = GM_1M_2/R 1
energy $= \{6.67 \times 10^{-11} \times 197 \times 4 \times (1.66 \times 10^{-27})^2\}/9.6 \times 10^{-15}$ 1
$= 1.51 \times 10^{47}$ J 1 [3]

(ii) elec. pot. energy = $Q_1Q_2/4\pi\varepsilon_0R$ 1
energy $= \{79 \times 2 \times (1.6 \times 10^{-19})^2\}/4\pi \times 8.85 \times 10^{-12} \times 9.6 \times 10^{-15}$ 1
$= 3.79 \times 10^{-12}$ J 1 [3]

(For the substitution, -1 each error or omission to max 2 in (i) and in (ii))

(b) electric potential <u>energy</u> >> gravitational potential <u>energy</u> 1 [1]

(c) *either* 6 MeV = 9.6 x 10^{-13} J or 3.79 x 10^{-12} J = 24 MeV 1
not enough energy to get close to the nucleus 1 [2]

6 **(a** charge is quantised/enabled electron charge to be measured B1 **[1]**

(b) <u>all</u> are (approximately) *n* x (1.6 x 10^{-19} C) M1
so *e* = 1.6 x 10^{-19} C (allow 2 sig. fig. only A1 **[2]**
summing charges and dividing ten, without explanation scores 1/2
Total **[3]**

7 **(a)** field causes forces on the electrons M1
and the nucleus in opposite directions A1
(field causes) electrons (to be) stripped off the atom.................... B1 [3]

(b) **(i)** $E = Q/4\pi\varepsilon_0r^2$ C1
20 x 10^3 x 10^2 = Q/(4π x 8.85 x 10^{-12} x 0.21^2 ....C1
charge = 9.8 x 10^{-6} C ....A1 [3]

(ii) $V = Q/4\pi\varepsilon_0r$
= (9.8 x 10^{-6})/(4π x 8.85 x 10^{-12} x 0.21) C1
= 4.2 x 10^5 V...A1 [2]

(c) e.g. sphere not smooth, humid air, etc ....B1 [1]