Point Charges & Electric Potential

Mark Scheme 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Mark Scheme 1

Time Allowed: **56 minutes**

Score: **/46**

Percentage: **/100**

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

1 **(a)** (magnitude of electric field strength is the potential gradient — B1
use of gradient at $x = 4.0$ cm
gradient = 4.5×10^4 N C^{-1} (*allow* $\pm 0.3 \times 10^4$) — A

or

$V = \dfrac{Q}{4\pi\varepsilon_0 x}$ and $E = \dfrac{Q}{4\pi\varepsilon_0 x^2}$ leading to $E = \dfrac{V}{x}$ — (B1)

$E = 1.8 \times 10^3 / 0.04$
$= 4.5 \times 10^4$ N C^{-1} — (A1) [3]

(b) (i) 3.6×10^3 V — A [1]

(ii) capacitance $= Q / V$ — C1
$= (8.0 \times 10^{-9}) / (3.6 \times 10^3)$
$= 2.2 \times 10^{-12}$ F — A1 [2]

2 **(a)** work done bringing/moving per unit positive charge — M1
from infinity (to the point) — A1 [2]

(b) (i) slope/gradient (of the line/graph/tangent) — B1 [1]
*(allow dV/dx, but **not** ΔV/Δx or V/x)*
(allow potential gradient)
(negative sign not required)

(ii) maximum at surface of sphere A or at $x = 0$ (cm) — B1
zero at $x = 6$ (cm) — B1
then increases but in opposite direction — B1 [3]
(any mention of attraction max. 2/3)

(c) (i) M shown between $x = 5.5$ cm and $x = 6.5$ cm — B1 [1]

(ii) **1.** $\Delta V = (570 - 230) = 340$ V *(allow 330 V to 340 V)* — A1 [1]

2. $q(\Delta)V = \frac{1}{2}mv^2$ **or** change/loss in PE = change/gain in KE **or** $\Delta E_K = \Delta E_P$ — B1

$4.8 \times 10^7 \times 340 = \frac{1}{2}v^2$ — C1
$v^2 = 3.26 \times 10^{10}$
$v = 1.8 \times 10^5$ m s^{-1} *(not 1 s.f.)* — A1 [3]

3	**(a**	work done in moving unit positive charge from infinity (to the point)	M1 A1	[2]
	(b)	**(** inside the sphere, the potential would be constant	B1	[1]
		(ii) for point charge, Vx is constant co-ordinates clear and determines two values of Vx at least 4 cm apart conclusion made clear	B1 M1 A1	[3]
	(c)	$q = 4\pi\varepsilon_0 Vx$ $q = 4\pi \times 8.85 \times 10^{-12} \times 180 \times 1.0 \times 10^{-2}$ $= 2.0 \times 10^{-10}$ C	 M1 A	 [2]
4	**(a)**	work done / energy in moving unit positive charge from infinity (to the point)	M1 A1	[2]
	(b)	**(** $V = q / 4\pi\varepsilon_0 r$ at 16 kV, $q = 3.0 \times 10^{-8}$ C $r = (3.0 \times 10^{-8}) / (4\pi \times 8.85 \times 10^{-12} \times 16 \times 10^3)$ $= 1.69 \times 10^{-2}$ m (*allow 2 s.f.*) (*allow any answer which rounds to* 1.7×10^{-2})	 C1 A1	 [2]
		(ii) energy is / represented by area 'below' line energy $= ½qV$ $= ½ \times 24 \times 10^3 \times 4.5 \times 10^{-8}$ $= 5.4 \times 10^{-4}$ J	C1 C1 A	 [3]
	(c)	$V = q / 4\pi\varepsilon_0 r$ and $E = q / 4\pi\varepsilon_0 r^2$ giving $Er = V$ $2.0 \times 10^6 \times 1.7 \times 10^{-2} = V$ $V = 3.4 \times 10^4$ V	B1 C1 A	 [3]

5	**(a)**	graph: straight line at constant potential = V_0 from $x = 0$ to $x = r$	B1	
		curve with decreasing gradient	M1	
		passing through ($2r$, $0.50V_0$) and ($4r$, $0.25V_0$)	A1	[3]
	(b)	graph: straight line at $E = 0$ from $x = 0$ to $x = r$	B1	
		curve with decreasing gradient from (r, E_0)	M1	
		passing through ($2r$, ¼E_0)	A1	[3]
		(*for 3rd mark line must be drawn to x = 4r and must not touch x-axis*)		
6	**(a**	discrete and equal amounts (of charge)	B1	[1]
		allow: discrete amounts of 1.6×10^{-19}C/elementary charge/e		
		integral multiples of 1.6×10^{-19}C/elementary charge/e		
	(b)	weight = qV/d		
		$4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$	C	
		$q = 4.9 \times 10^{-19}$ C	A1	[2]
	(c)	elementary charge = 1.6×10^{-19} C (*allow* 1.6×10^{-19} C to 1.7×10^{-19} C)	M0	
		either the values are (approximately) multiples of this		
		or it is a common factor	C1	
		it is the highest common factor	A1	[2]