Point Charges & Electric Potential

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

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

1 **(a)** force per unit positive charge acting on a stationary charge B1 [1]

(b) (i) $E = Q / 4\pi\varepsilon_0 r^2$ C1
$Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2$ M1
$Q = 1.25 \times 10^{-5}\,C = 12.5\,\mu C$ A0 [2]

(ii) $V = Q / 4\pi\varepsilon_0 r$
$= (1.25 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2})$ C1
$= 4.5 \times 10^5\,V$ A1 [2]
(Do not allow use of V = Er unless explained)

2 **(a) (i)** as *r* decreases, energy decreases/work got out (due to) M1
attraction so point mass is negatively charged A1 [2]

(ii) electric potential energy = charge × electric potential B1
electric field strength is potential gradient B1
field strength = gradient of potential energy graph/charge A0 [2]

(b) tangent drawn at (4.0, 14.5) B1
gradient = 3.6×10^{-24} A2
(*for < ±0.3 allow 2 marks, for < ±0.6 allow 1 mark*)
field strength= $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$
$= 2.3 \times 10^{-5}\,V\,m^{-1}$ *(allow ecf from gradient value)* A1 [4]
(*one point solution for gradient leading to 2.3 × 10^{-5} Vm^{-1} scores 1 mark only*)

3 **(a)** oil drop charged by friction/beta source B1
between parallel <u>metal</u> plates B1
plates are horizontal (1)
adjustable potential difference/field between plates B1
until oil drop is stationary B1
$mg = q \times V/d$ B1
symbols explained (1)
oil drop viewed through microscope (1)
m determined from terminal speed of drop (when p.d. is zero) (1)
(*any two extras, 1 each*) B2 [7]

(b) 3.2×10^{-19} C A1 [1]

4 **(a)** **(i)** zero field (strength) inside spheres B1 [1]

(ii) *either* field strength is zero
or the fields are in opposite directions M1
at a point between the spheres A1 [2]

(b) **(i)** field strength is (–) potential gradient *(not V/x)* B1 [1]

(ii) **1.** field strength has maximum value B1
at *x* = 11.4 cm B1 [2]

2. field strength is zero B1
either at *x* = 7.9 cm *(allow ±0.3 cm)*
or at 0 to 1.4 cm *or* 11.4 cm to 12 cm B1 [2]

5 (a) **)** work done in bringing unit positive charge — M1
from infinity (to that point) — A1 [2]

(b) **b) (**i) field strength is potential gradient — B1 [1]

(ii) field strength proportional to force (on particle Q) — B1
potential gradient proportional to gradient of (potential energy) graph so — B1
force is proportional to the gradient of the graph — A0 [2]

(c) energy = $5.1 \times 1.6 \times 10^{-19}$ (J) — C1
potential energy = $Q_1Q_2 / 4\pi\varepsilon_0 r$ — C1
$5.1 \times 1.6 \times 10^{-19} = (1.6 \times 10^{-19})^2 / 4\pi \times 8.85 \times 10^{-12} \times r$ — C1
$r = 2.8 \times 10^{-10}$ m — A1 [4]

(d) (i) work is got out as x decreases — M1
so opposite sign — A1 [2]

(ii) energy would be doubled — B1
gradient would be increased — B1 [2]

6 **(a)** region (of space) where a particle / body experiences a force — B1 [1]

(b) similarity: e.g. force $\propto 1 / r^2$
potential $\propto 1 / r$ — B1 [1]

difference: e.g. gravitation force (always) attractive — B1
electric force attractive or repulsive — B1 [2]

(c) *either* ratio is $Q_1Q_2 / 4\pi\varepsilon_0 m_1 m_2 G$ — C1
$= (1.6 \times 10^{-19})^2 / 4\pi \times 8.85 \times 10^{-12} \times (1.67 \times 10^{-27})^2 \times 6.67 \times 10^{-11}$ — C1
$= 1.2 \times 10^{36}$ — A1 [3]

or $F_E = 2.30 \times 10^{-28} \times R^{-2}$ (C1)
$F_G = 1.86 \times 10^{-64} \times R^{-2}$ (C1)
$F_E / F_G = 1.2 \times 10^{36}$ (A1)