Point Charges & Electric Potential

Mark Scheme 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Mark Scheme 2

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

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

1 (a) (i) $F_E = Q_1Q_2/4\pi\varepsilon_0 r^2$ C1
$= 8.99 \times 10^9 \times (1.6 \times 10^{-19})^2 / (2.0 \times 10^{-15})^2$
$= 58$ N A1 [2]

(ii) $F_G = Gm_1m_2/r^2$ C1
$= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2 / (2.0 \times 10^{-15})^2$
$= 4.7 \times 10^{-35}$ N A1 [2]

(b) (i) force of repulsion (much) greater than force of attraction B1
must be some other force of attraction M1
to hold nucleus together A1 [3]

(*Do not allow if $F_G > F_E$ in **(a)** or one of the forces not calculated in **(a)***)

(ii) outside nucleus there is repulsion between protons B1
either attractive force must act only in nucleus
or if not short range, all nuclei would stick together B1 [2]

2 **(a (i)** force proportional to product of (two) charges and inversely proportional to square of separation M1
reference to point charges A1 [2]

(ii) $F = 2 \times (1.6 \times 10^{-19})^2 / \{4\pi \times 8.85 \times 10^{-12} \times (20 \times 10^{-6})^2\}$ C
$= 1.15 \times 10^{-18}$ N A1 [2]

(b) (i) force per unit charge M1
on *either* a stationary charge
or a positive charge A1 [2]

(ii) electric field is a vector quantity
electric fields are in opposite directions
charges repel
Any two of the above, 1 each B2 [2]

2. graph: line always between given lines M1
crosses *x*-axis between 11.0 μm and 12.3 μm A1
reasonable shape for curve A1 [3]

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

(b) **(** *either* both potentials are positive / same sign so same sign — M1 A1 [2]
or gradients are positive & negative (so fields in opposite directions) so same sign — (M1) (A1)

(ii) the individual potentials are summed — B1 [1]

(iii) allow value of x between 10 nm and 13 nm [1]

(iv) $V = 0.43\,\text{V}$ (*allow 0.42 V → 0.44 V*) — M1
energy $= 2 \times 1.6 \times 10^{-19} \times 0.43$ — A1
$= 1.4 \times 10^{-19}\,\text{J}$ — A1 [3]

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

(b) (gain in) kinetic energy = change in potential energy — B1
$\frac{1}{2}mv^2 = qV$ leading to $v = (2Vq/m)^{\frac{1}{2}}$ — B1 [2]

(c) *either* $(2.5 \times 10^5)^2 = 2 \times V \times 9.58 \times 10^7$ — C1
$V = 330\,\text{V}$ — M1
this is less than 470 V and so 'no' — A1 [3]

or $v = (2 \times 470 \times 9.58 \times 10^7)$ — (C1)
$v = 3.0 \times 10^5\,\text{m s}^{-1}$ — (M1)
this is greater than $2.5 \times 10^5\,\text{m s}^{-1}$ and so 'no' — (A1)

or $(2.5 \times 10^5)^2 = 2 \times 470 \times (q/m)$ — (C1)
$(q/m) = 6.6 \times 10^7\,\text{C kg}^{-1}$ — (M1)
this is less than $9.58 \times 10^7\,\text{C kg}^{-1}$ and so 'no' — (A1)

5 **(a) (i)** $V = q / 4\pi\varepsilon_0 R$ B1 [1]

(ii) (capacitance is) ratio of charge and potential or q/V M1
$C = q/V = 4\pi\varepsilon_0 R$ A0 [1]

(b) $C = 4\pi \times 8.85 \times 10^{-12} \times 0.45$ C1
$= 50$ pF A1 [2]

(ii) either energy = ½ CV^2 or energy = ½ QV and $Q = CV$ C1
energy of spark = ½ × 50 × 10^{-12} {$(9.0 \times 10^5)^2 - (3.6 \times 10^5)^2$} C
= 17 J A1 [3]

6 **(a) (i)** (tangent to line gives) direction of force on a (small test) mass B1 [1]

(ii) (tangent to line gives) direction of force on a (small test) charge M1
charge is positive A1 [2]

(b) similarity:
e.g. radial fiel
lines normal to surface
greater separation of lines with increased distance from sphere
field strength ∝ 1 / (distance to centre of sphere)^2
(*allow any sensible answer*) B1

difference:
e.g. gravitational force (always) towards sphe B1
electric force direction depends on sign of charge on sphere / towards or away from sphere B1
e.g. gravitational field/force is attracti (B1)
electric field/force is attractive or repulsive (B1)
(*allow any sensible comparison*) [3]

(c) gravitational force = 1.67 × 10^{-27} × 9.81
= 1.6 × 10^{-26} N A
electric force = 1.6 × 10^{-19} × 270 / (1.8 × 10^{-2}) C
= 2.4 × 10^{-15} N A
electric force very much greater than gravitational force B1 [4]