Point Charges & Electric Potential

Mark Scheme 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Mark Scheme 4

Time Allowed: **54 minutes**

Score: **/45**

Percentage: **/100**

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

1 **(a)** force = $q_1q_2 / 4\pi\varepsilon_0 x^2$ C1
= $(6.4 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times \{12 \times 10^{-6}\}^2)$ C
= 2.56×10^{-17} N A1 [3]

(b) potential at P is same as potential at Q B1
work done = $q\Delta V$ M1
$\Delta V = 0$ so zero work done A0 [2]

(c) at midpoint, potential is $2 \times (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 6 \times 10^{-6})$ C
at P, potential is $(6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 3 \times 10^{-6}) + (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$ C1
change in potential = $(6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$
energy = $1.6 \times 10^{-19} \times (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$ C
= 1.0×10^{-22} J A1 [4]

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

(b) **(i)** α-particle and gold nucleus repel each other B1
<u>all</u> kinetic energy of α-particle converted into electric potential energy .....B1 [2]

(ii) potential energy = $(79 \times 2 \times \{1.6 \times 10^{-19}\}^2) / (4\pi \times 8.85 \times 10^{-12} \times d)$ C1
kinetic energy = $4.8 \times 1.6 \times 10^{-13} = 7.68 \times 10^{-13}$ J C1
equating to give $d = 4.7 \times 10^{-14}$ m .....A1 [3]

(ii) $F = Qq / 4\pi\varepsilon_0 d \times 1 / d = 7.68 \times 10^{-13} \times 1 / (4.7 \times 10^{-14})$ C1
= 16 N .....A1 [2]

[Total: 9]

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

(b) (i) x = 18 cm — A1 [1]

(ii) $V_A + V_B = 0$ — C1
$(3.6 \times 10^{-9}) / (4\pi\varepsilon_0 \times 18 \times 10^{-2}) + q / (4\pi\varepsilon_0 \times 12 \times 10^{-2}) = 0$ — C1
$q = -2.4 \times 10^{-9}$ C — A1 [3]
(use of $V_A = V_B$ giving 2.4×10^{-9} C scores one mark)

(c) field strength = (–) gradient of graph — B1
force = charge × gradient / field strength *or* *force ∝ gradient* — B1
force largest at x = 27 cm — B1 [3]

4 **(a** charge is quantised / discrete quantities — B1 [1]

(b) (i) parallel so that the electric field is uniform / constant — B1
horizontal so that *either* oil drop will not drift sideways
or field is vertical
or electric force is equal to weight — B1 [2]

(ii) $qE = mg$ — C1
$q \times 850 / (5.4 \times 10^{-3}) = 7.7 \times 10^{-15} \times 9.8$ — C1
$q = 4.8 \times 10^{-19}$ C and is negative — A1 [3]

(c) charge changes by 1.6×10^{-19} C between droplets / integral multiples — M1
so charge on electron is 1.6×10^{-19} C — A0 [1]

5 **(a) (i)** *either* lines directed away from sphere
or lines go from positive to negative
or line shows direction of force on positive charge M1
so positively charged ..... A1 [2]

(ii) *either* all lines (appear to) radiate from centre
or all lines are normal to surface of sphere ..... B1 [1]

(b) tangent to curve B1
in correct position and direction ..... B1 [2]

(c) (i) $V = (0.76 \times 10^{-9}) / (4\pi \times 8.85 \times 10^{-12} \times 0.024)$ C1
$= 285$ V ..... A1 [2]

(ii) negative charge is induced on (inside of) box M1
formula applies to isolated (point) charge
OR less work done moving test charge from infinity A1
so potential is lower ..... A1 [3]

(d) *either* gravitational field is <u>always</u> attractive
or field lines must be directed towards both box and sphere ..... B1 [1]