LONDON SCIENCE COLLEGE

Name:

Date:

ELECTRIC FIELDS
TEST 3

A2-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

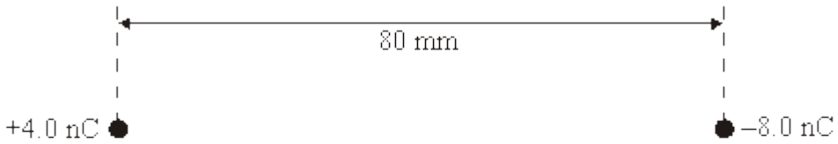
- The marks for the questions are shown in brackets

1 (a) (i) Define the *electric field strength*, *E*, at a point in an electric field.

(ii) State whether *E* is a scalar or a vector quantity.

(3)

(b) Point charges of +4.0 nC and –8.0 nC are placed 80 mm apart, as shown in the figure below.



(i) Calculate the magnitude of the force exerted on the +4.0 nC charge by the –8.0 nC charge.

(ii) Determine the distance from the +4.0 nC charge to the point, along the straight line between the charges, where the electric potential is zero.

(4)

(c) Point **P** in the figure above is equidistant from the two charges.

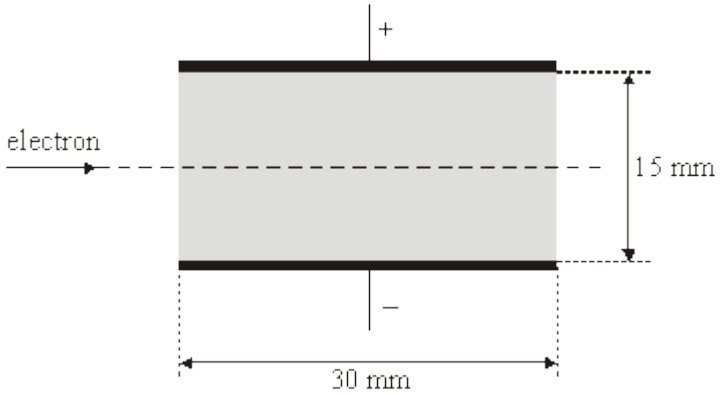
(i) Draw two arrows on the figure above at **P** to represent the directions and relative magnitudes of the components of the electric field at **P** due to each of the charges.

(ii) Hence draw an arrow, labelled **R**, on the figure above at **P** to represent the direction of the resultant electric field at **P**.

(3)

(Total 10 marks)

2 (a) An electron travels at a speed of 3.2×10^7 ms^{-1} in a horizontal path through a vacuum. The electron enters the uniform electric field between two parallel plates, 30 mm long and 15 mm apart, as shown in the figure below. A potential difference of 1400 V is maintained across the plates, with the top plate having positive polarity. Assume that there is no electric field outside the shaded area.



(i) Show that the electric field strength between the plates is 9.3×10^4 Vm^{-1}.

(ii) Calculate the time taken by the electron to pass through the electric field.

(iii) Show that the acceleration of the electron whilst in the field is 1.6×10^{16} m s^{-2} and state the direction of this acceleration.

(5)

(b) Determine the magnitude and direction of the velocity of the electron at the point where it leaves the field.

(3)

(Total 8 marks)

3 (a) Complete the table of quantities related to fields. In the second column, write an SI unit for each quantity. In the third column indicate whether the quantity is a scalar or a vector.

quantity	SI unit	scalar or vector
gravitational potential		
electric field strength		
magnetic flux density		

(3)

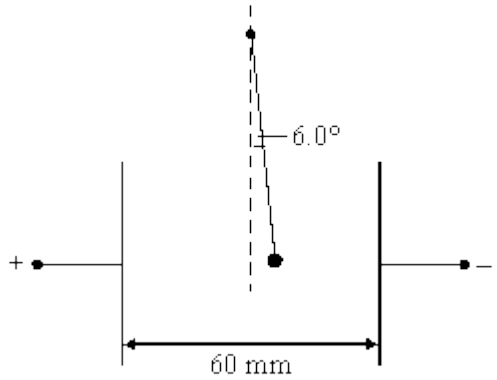
(b) (i) A charged particle is held in equilibrium by the force resulting from a vertical electric field. The mass of the particle is 4.3×10^{-9} kg and it carries a charge of magnitude 3.2×10^{-12} C. Calculate the strength of the electric field.

(ii) If the electric field acts upwards, state the sign of the charge carried by the particle

(3)

(Total 6 marks)

4 A small charged sphere of mass 2.1×10^{-4} kg, suspended from a thread of insulating material, was placed between two vertical parallel plates 60 mm apart. When a potential difference of 4200 V was applied to the plates, the sphere moved until the thread made an angle of 6.0° to the vertical, as shown in the diagram below.



(a) Show that the electrostatic force F on the sphere is given by

$F = mg \tan 6.0°$

where m is the mass of the sphere.

(3)

(b) Calculate

(i) the electric field strength between the plates,

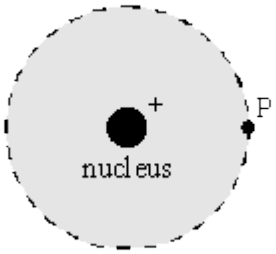
(ii) the charge on the sphere.

(3)

(Total 6 marks)

5 The mass of the nucleus of an isolated copper atom is 63 u and it carries a charge of +29 *e*. The diameter of the atom is 2.3×10^{-10} m.

P is a point at the outer edge of the atom.



(a) Calculate

(i) the electric field strength at P due to the nucleus,

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(ii) the gravitational potential at P due to the nucleus.

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(5)

(b) Draw an arrow on the above diagram to show the direction of the electric field at the point P.

(1)

(Total 6 marks)

6 (a) This part of the question is about protons.

(i) Calculate the electrostatic potential energy, in J, of **two** protons at a distance apart of 1.0×10^{-15} m.

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_____

(ii) Two protons moving in opposite directions at the same initial speed collide head-on with each other. The least distance apart of the two protons is 1.0×10^{15} m. By considering conservation of energy, estimate the initial kinetic energy, in MeV, of each proton.

(5)

(b) State the quark composition of

(i) a proton,

(ii) a positive pion, π^+.

(2)

(c) A proton collides with another proton moving in the opposite direction at the same speed, creating a positive pion and a further particle X in the process. This process is represented by the equation

$$p + p \rightarrow p + p + \pi^+ + X.$$

(i) State the charge, Q, and baryon number, B, of X.

Q

B

(ii) State the identity and quark composition of X.

(iii) Explain why two protons with initial kinetic energies as in part (a)(ii) could not produce the reaction in part (c).

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(5)

(Total 12 marks)

7 (a) (i) Define *electric field strength*, and state whether it is a scalar quantity or a vector quantity.

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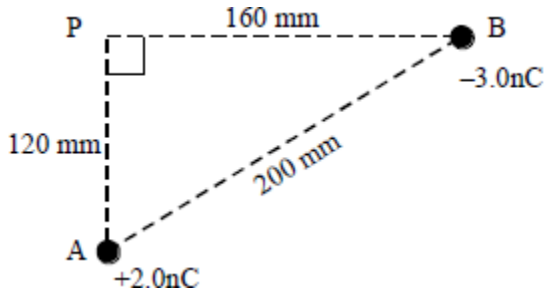
(ii) Complete the diagram below to show the electric field lines in the region around two equal positive point charges. Mark with a letter N the position of any point where the field strength is zero.

(6)

(b) Point charges A, of +2.0 nC, and B, of –3.0 nC, are 200 mm apart in a vacuum, as shown by the figure. The point P is 120 mm from A and 160 mm from B.



(i) Calculate the component of the electric field at P in the direction AP.

(ii) Calculate the component of the electric field at P in the direction PB.

(iii) Hence calculate the magnitude and direction of the resultant field at P.

(6)

(c) (i) Explain why there is a point X on the line AB in part (b) at which the **electric potential** is zero.

(ii) Calculate the distance of the point X from A.

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(4)

(Total 16 marks)

8 The electric potential at a distance *r* from a positive point charge is 45 V. The potential increases to 50 V when the distance from the point charge decreases by 1.5 m. What is the value of *r*?

A 1.3m ⬭

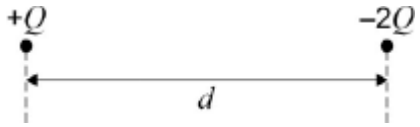
B 1.5m ⬭

C 7.9m ⬭

D 15m ⬭

(Total 1 mark)

9 The diagram shows two particles at distance d apart. One particle has charge $+Q$ and the other $-2Q$. The two particles exert an electrostatic force of attraction, F, on each other. Each particle is then given an additional charge $+Q$ and their separation is increased to distance $2d$.



Which of the following gives the force that now acts between the two particles?

A an attractive force of $\frac{F}{4}$ ⬭

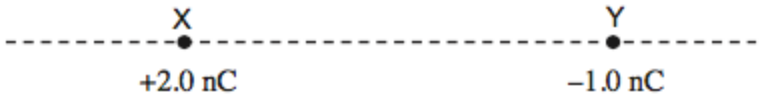
B a repulsive force of $\frac{F}{4}$ ⬭

C an attractive force of $\frac{F}{2}$ ⬭

D a repulsive force of $\frac{F}{2}$ ⬭

(Total 1 mark)

10 A +2.0 nC point charge X is at a fixed distance from a –1.0 nC point charge Y. The force between the two charges is F.

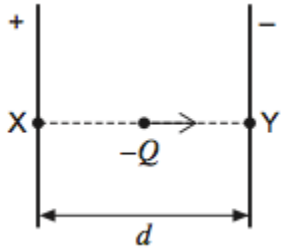


If an **additional** charge of +2.0 nC is supplied to both X and Y, which line, **A** to **D**, in the table gives the magnitude and direction of the force on X?

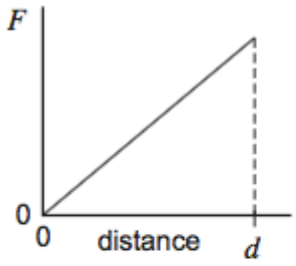
	Magnitude	**Direction**
A	$2F$	from X to Y
B	$4F$	from X to Y
C	$2F$	from Y to X
D	$4F$	from Y to X

(Total 1 mark)

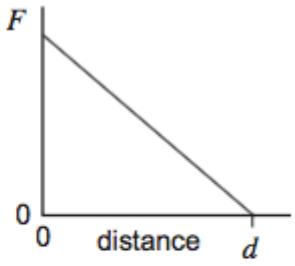
11 The diagram shows a charge $-Q$ being moved from point X to point Y between two charged parallel plates separated by a distance d.



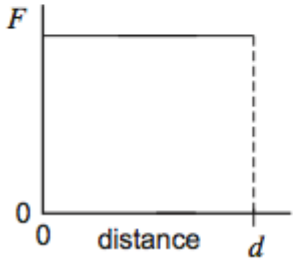
Which one of the following graphs best illustrates how the magnitude of force F on the charge varies with distance as it moves towards Y?



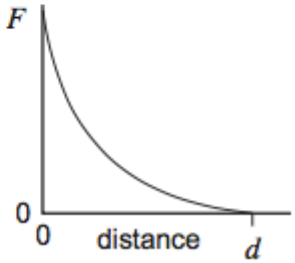
A



B



C



D

(Total 1 mark)