AQA Examination-style questions

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 marks)*

(b) Point charges of +4.0 nC and –8.0 nC are placed 80 mm apart, as shown in **Figure 1**.

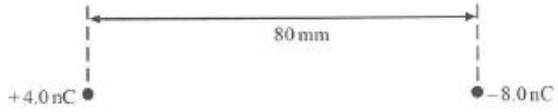

Figure 1

(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 marks)*

(c) Point P in the diagram is equidistant from the two charges.

(i) Draw two arrows on a copy of the diagram 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 your diagram at P to represent the direction of the resultant electric field at P. *(3 marks)*

AQA, 2006

2 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 **Figure 2**.

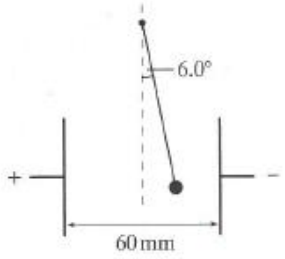

Figure 2

(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 marks)*

(b) Calculate:

(i) the electric field strength between the plates,

(ii) the charge on the sphere. *(3 marks)*

AQA, 2003

3 **Figure 3** shows some of the equipotential lines that are associated with a point negative charge Q.

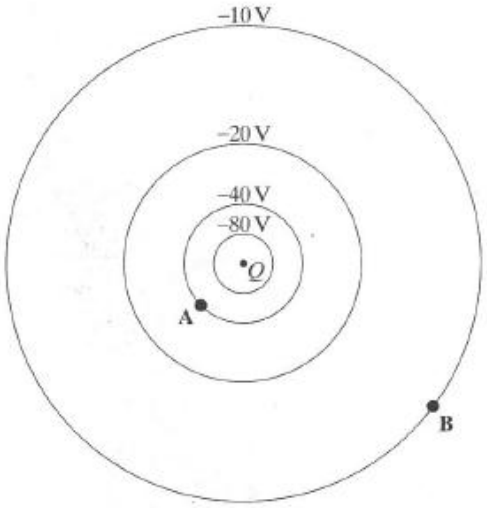

Figure 3

(a) (i) Explain why the potentials have a negative sign.

(ii) Draw on a copy of the diagram three electric field lines. Use arrows to show the direction of the field. *(4 marks)*

(b) (i) Use data from the diagram, which is full size, to show that the charge Q is about -4.5×10^{-11} C.

(ii) Calculate the electric field strength at B. *(4 marks)*

(c) (i) Calculate the energy, in J, transferred when an electron moves from A to B in the field.

(ii) State and explain

- why the kinetic energy of the electron increases as it moves from A to B,
- how the de Broglie wavelength of the electron changes as it moves from A to B.

(6 marks)

AQA, 2003

4 **Figure 4** shows the parallel deflecting plates with some dimensions of the ink-jet cartridge. In order to land in the centre of the gutter the ink droplet must leave the plates at an angle of 35°. On entering the electric field the ink droplet carries a charge of -2×10^{-10} C and travels with a horizontal velocity of 20 m s^{-1}.

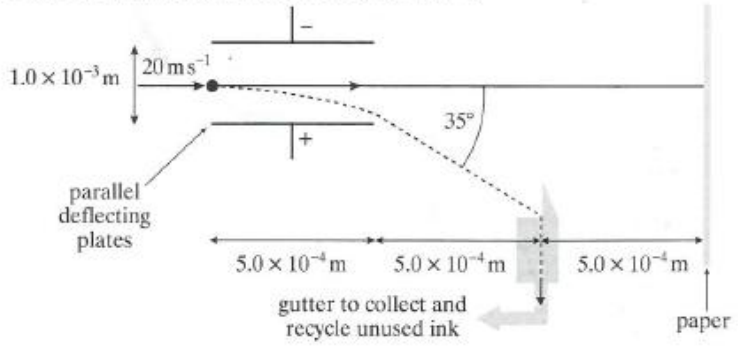

Figure 4

(a) (i) Draw a vector diagram to show the components and the resultant of the velocity of the charged ink droplet as it leaves the deflecting field. Determine the size of the vertical component.

(ii) Find the time for which the ink droplet is between the deflecting plates and hence calculate its vertical acceleration during this time.

(iii) For an ink droplet of mass 2.9×10^{-10} kg, calculate the electric force acting on the ink droplet whilst it is between the deflecting plates.

(iv) Calculate the electric field strength between the deflecting plates.

(v) Calculate the potential difference between the deflecting plates. *(12 marks)*

(b) The uncharged, undeflected ink droplets travel beyond the deflecting plates towards the paper. With the aid of a suitable calculation, discuss whether or not the printer manufacturer needs to take into consideration the droplet falling under gravity. *(4 marks)*

AQA, 2003

5 Dry air ceases to be an insulator if it is subjected to an electric field strength of 3.3 kV mm^{-1} or more.

(a) (i) Show that the electric field strength E and the potential V at the surface of a charged sphere of radius R are related by

$$E = \frac{V}{R}$$

(ii) The dome of a Van de Graaff generator has a radius of 0.20 m. Calculate the maximum potential of this dome in dry air. *(5 marks)*

(b) Two high-voltage conductors are joined together using a small sphere, as shown in **Figure 5**.

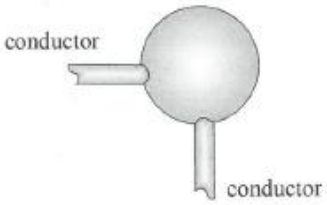

Figure 5

The conductors are used to transmit alternating current at an rms potential of 100 kV.

(i) Calculate the peak potential of the conductor.

(ii) Calculate the minimum diameter of the sphere necessary to ensure the surrounding air does not conduct. *(3 marks)*

AQA, 2004

6 (a) **Figure 6** shows a small charged metal sphere carrying a charge Q. The potential of the sphere is 8000 V. Copy Figure 6.

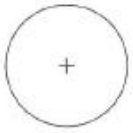

Figure 6

(i) Draw on your diagram at least six lines to show the direction of the electric field in the region around the charged sphere.

(ii) Draw on your diagram the equipotential lines for potentials of 4000 V and 2000 V.

(iii) The equation for the field strength at a distance r from the sphere is $\frac{Q}{4\pi\varepsilon_0 r^2}$
State the name of the quantity represented by ε_0. *(5 marks)*

(b) **Figure 7** shows an arrangement for determining the charge on a small sphere.

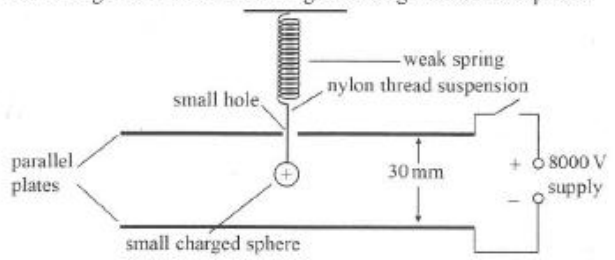

Figure 7

The sphere is suspended from a spring of spring constant $0.18\,N\,m^{-1}$. It hangs between two parallel plates which can be connected to a high voltage supply.

(i) Explain why nylon thread is used for the suspension.

(ii) Calculate the extension of the spring when a sphere of mass 1.5 g is suspended from it.

(iii) Calculate the magnitude of the electric field strength between the plates when the 8000 V supply is switched on.

(iv) When the 8000 V supply is switched on, the sphere moves down a further 4.5 mm. Calculate the charge on the sphere. *(8 marks)*

(c) One problem with this arrangement is the oscillations of the sphere that occur when the switch is closed.

(i) Show that the period of the oscillations produced is about 0.6 s.

(ii) In practice the oscillations are damped. Sketch a graph showing how the amplitude of the oscillations changes with time for the damped oscillation. *(5 marks)*

AQA, 2007

7 The Earth has an electric charge. The electric field strength outside the Earth varies in the same way as if this charge were concentrated at the centre of the Earth. The axes in **Figure 8** represent the electric field strength, E, and the distance from the centre of the Earth, r. The electric field strength at **A** has been plotted.

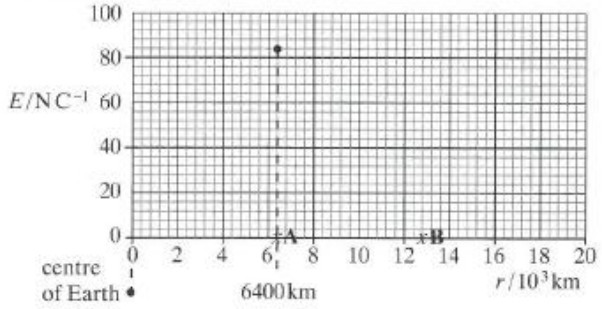

Figure 8

(a) (i) Determine the electric field strength at **B** and then complete the graph to show how the electric field strength varies with distance from the centre of the Earth for distances greater than 6400 km.

(ii) State how you would use the graph to find the electric potential difference between the points **A** and **B**. *(4 marks)*

(b) (i) Calculate the total charge on the Earth.

(ii) The charge is distributed uniformly over the Earth's surface. Calculate the charge per square metre on the Earth's surface. *(4 marks)*

AQA, 2002