Oxford Cambridge and RSA

A Level Physics A

H556/02 Exploring physics

Question Set 29

1 **(a)** Fig. 22.1 shows two horizontal metal plates in a vacuum.

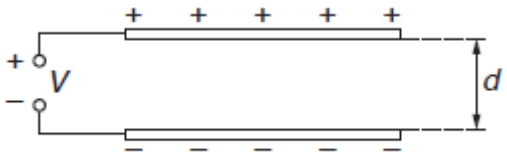

Fig. 22.1

The plates are connected to a power supply. The potential difference V between the plates is constant. The magnitude of the charge on each plate is Q. The separation between the plates is d.

Fig. 22.2 shows the variation with d of the charge Q on the positive plate.

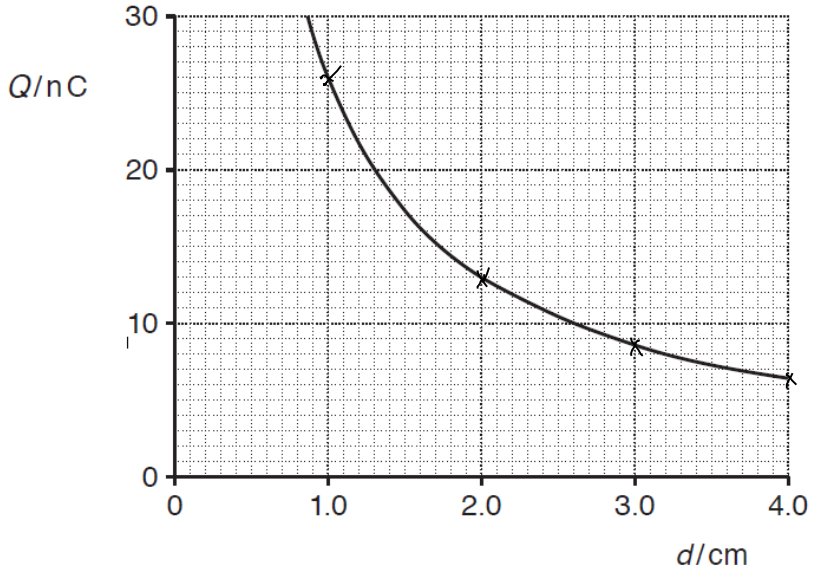

Fig. 22.2

(i) Use Fig. 22.2 to propose and carry out a test to show that Q is inversely proportional to d.

Test proposed:

If $Q = \frac{k}{d}$ then $Qd = k$ = constant. Therefore, take several points on the line and check that Qd = constant

Working:

Point 1 → 1 x 26 = 26
Point 2 → 2 x 13 = 26
Point 3 → 3 x 8.5 = 26
Point 4 → 4 x 7.5 = 26

All constant so inversly proportional ✓ **[2]**

(ii) Use capacitor equations to show that Q is inversely proportional to d.

$Q = CV$ and $C = \frac{\varepsilon_0 A}{d}$ ⇒ $Q = \frac{\varepsilon_0 A V}{d}$ **[2]**

(b) Fig. 22.3 shows a negatively charged oil drop between two oppositely charged horizontal plates in a vacuum.

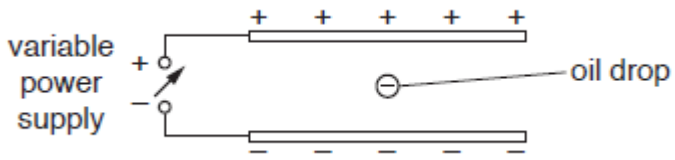

Fig. 22.3

The plates are fixed and connected to a variable power supply. The weight of the oil drop is 1.8×10^{-14} N.

(i) The power supply is adjusted so that the potential difference between the plates is 200 V when the oil drop becomes **stationary**.

State the magnitude of the vertical electric force F_E acting on the charged oil drop.

F_E = 1.8×10^{-14} N **[1]**

(ii) The potential difference between the plates is now increased to 600 V.
The oil drop accelerates upwards.

Calculate the acceleration a of the oil drop.

$200 = \frac{F_E}{Q} \Rightarrow Q = \frac{F_E}{200} = \frac{1.8 \times 10^{-14}}{200}$

$= 9 \times 10^{-17}$ C

$600 = \frac{F_E}{Q} \Rightarrow F_e = 600 \times 9 \times 10^{-17}$

$= 5.4 \times 10^{-14}$ N

Resultant force $= 5.4 \times 10^{-14} - 1.8 \times 10^{-14} = 3.6 \times 10^{-14}$ N

$F = ma \Rightarrow a = \frac{F}{m} = \frac{3.6 \times 10^{-14}}{1.8 \times 10^{-14}/9.8} = 19.6$

a = 20 m s^{-2} **[3]**

(c)* Fig. 22.4 shows an arrangement used by a student to investigate the forces experienced by a small length of charged gold foil placed in a uniform electric field.

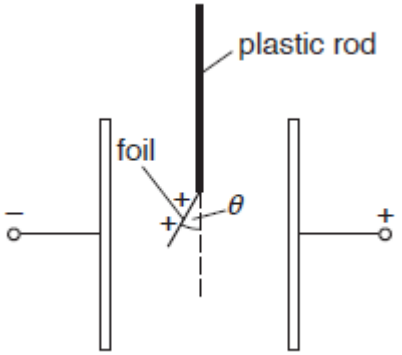

Fig. 22.4

The two vertical metal plates are connected to a high-voltage supply.

The foil is given a positive charge by briefly touching it to the positive plate.

The angle θ made with the vertical by the foil in the electric field is given by the expression

$$\tan\theta = \frac{qE}{W}$$

where q is the charge on the foil, E is the electric field strength between the plates and W is the weight of the foil.

The angle θ can be determined by taking photographs with the camera of a mobile phone.

Describe how the student can safely conduct an experiment to investigate the relationship between θ and E.
Identify any variables that must be controlled. **[6]**

Electric field strength E is equal to the potential difference V between the plates. To charge the plates, we need to treat them like a capacitor. The plates will charge like $V = V_0(1 - e^{-\frac{t}{RC}})$ so to get to V_0 we need to let the plates charge for a long time. Vary the voltage of the supply and let charge for a long time to get to different values of E. For each E, record θ using a camera - make sure not to touch the plates when charged. Plot $\tan\theta$ against E : if relationship correct, then should be straight line through origin.

Total Marks for Question Set 29: 14