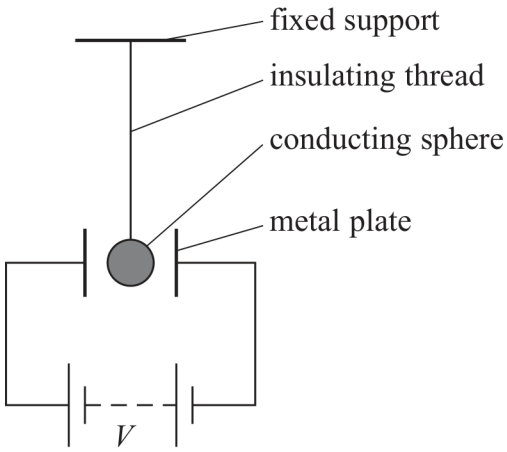
20 In the 18th century, a scientist called Gordon made the first device that used electrostatic forces to produce continuous motion.

A demonstration of the principle of Gordon's device is shown.

A light, conducting sphere of radius r is suspended from an insulating thread between two parallel metal plates. A large potential difference V is applied between the plates.



(a) There is an electrostatic force on the sphere when the sphere is charged.

The capacitance C of the sphere is given by

$$C = 4\pi\varepsilon_0 r$$

where r is the radius of the conducting sphere.

The sphere is charged by touching it onto one of the plates. The plates are a distance d apart.

Calculate the electrostatic force exerted on the sphere.

$V = 4500\,\text{V}$
$d = 5.0\,\text{cm}$
$r = 3.5\,\text{cm}$

(5)

Electrostatic force on sphere = ...

(b) After the sphere has been charged, the sphere starts to oscillate between the plates. The sphere touches each plate alternately.

Explain why the conducting sphere oscillates between the two plates.

(3)

.....

.....

.....

.....

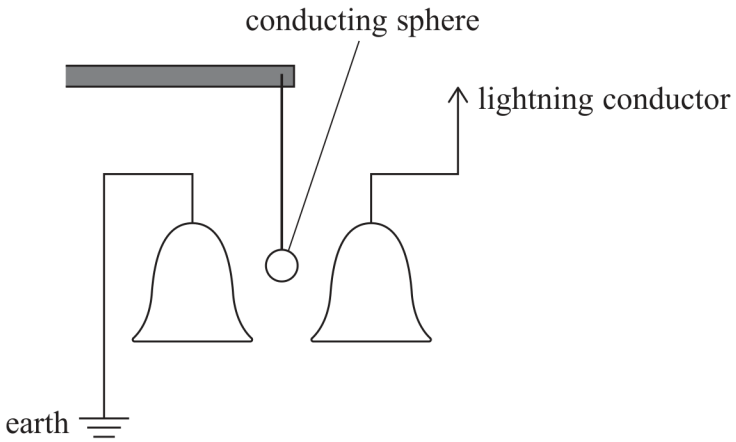
.....

.....

.....

(c) A few years later, another scientist called Franklin adapted Gordon's device. Franklin suspended a conducting sphere between two metal bells.

One metal bell was connected to earth and the other metal bell was connected to a lightning conductor, as shown. During an electrical storm, the sphere oscillates between the bells and the bells ring.



The lightning conductor is a long wire, attached to the top of a building.
The lightning conductor becomes positively charged when in an electric field.

The conducting sphere is initially uncharged.

Explain why the conducting sphere starts to move between the bells during an electrical storm.

(2)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 20 = 10 marks)