# 5.1 Electric Fields

## Question Paper

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|---|---|
| Course | DP IB Physics |
| Section | 5. Electricity & Magnetism |
| Topic | 5.1 Electric Fields |
| Difficulty | Hard |

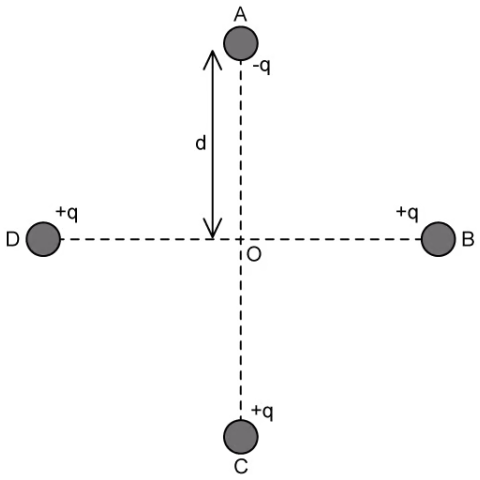
**Time allowed:** 50

**Score:** /41

**Percentage:** /100

## Question 1a

Four point charges A, B, C and D are each placed a distance *d* from O as shown. B, C and D each have a charge +*q* and A has a charge −*q*.




(a)
For the electric field at O.

(i)
Derive an expression for the the magnitude of the resultant field

[1]

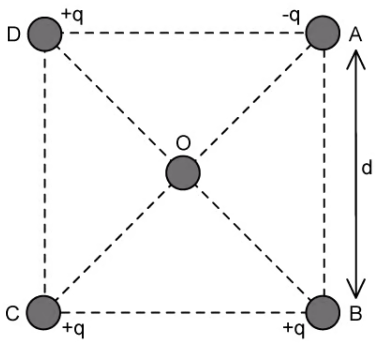
(ii)
Determine the direction of the resultant field.

[1]

**[2 marks]**

## Question 1b

The arrangement of the charges is changed to the grid shown. Each charge is now the corner of a square of side *d*.




(b)
Calculate the magnitude of the resultant electric field strength at point O.

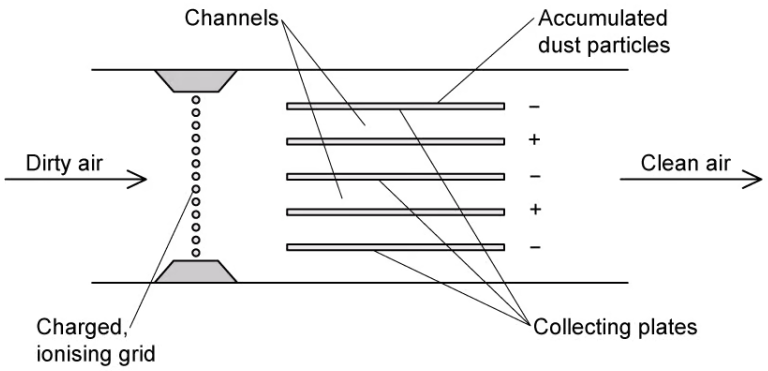
[2]

**[2 marks]**

## Question 2a

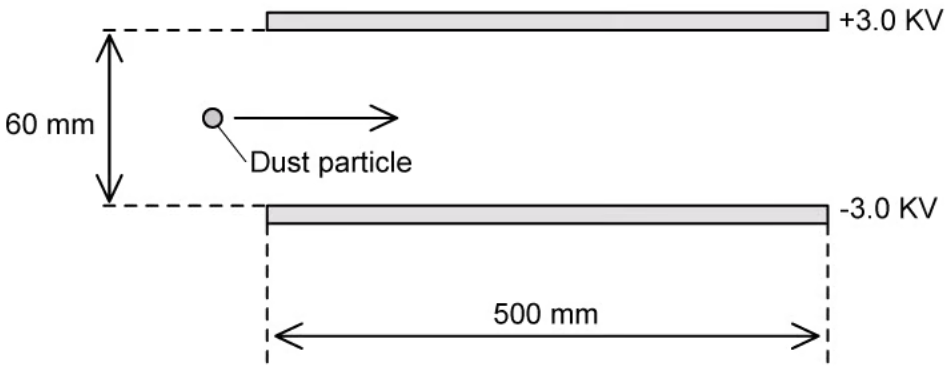
The diagram shows an air filter which uses charged collecting plates to remove dust from the air of a workshop.

The air intake passes through a charged, ionising grid which attracts dust particles, cleaning the air which is then returned back into the workshop.




A dust particle of mass $6.7 \times 10^{-15}$ kg enters the region between the collecting plates travelling horizontally with an initial velocity of 11 m $s^{-1}$. The particle carries a charge of $2.6 \times 10^{-18}$ C.

Assume that the dust particles move horizontally between the plates.




(a)
Determine the electrostatic force acting on the particle.

[3]

**[3 marks]**

## Question 2b

Some particles are not caught by the air filter, but pass straight through. Others are caught by the filter. The particles are identical in mass and charge, and they all travel parallel to the plane of the plates. The plates are initially completely clean. Assume the particles are evenly vertically distributed.

(b)
Deduce the percentage of dust particles which will be 'trapped' by the negatively charged plate. Ignore the effect of gravity.

[4]

**[4 marks]**

## Question 2c

As the air filter operates, there is a build up of particles on the negative plates. The gap between the plates therefore becomes narrower, by up to 10% of its initial height.

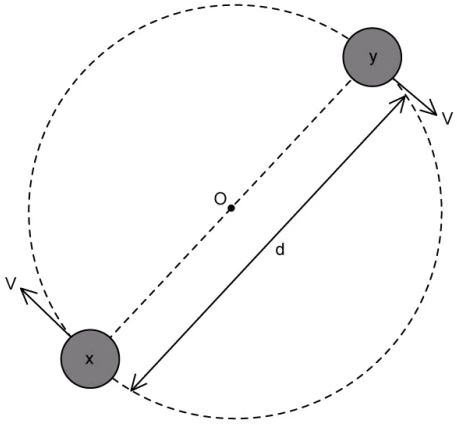
(c)
Discuss whether this narrowing makes the filter more or less effective at removing dust particles.

[3]

**[3 marks]**

## Question 3a

Two charged objects X and Y are made to circle a point O. X and Y are at a distance, $d = 1.8 \times 10^{-8}$ m and they have equal masses, where $m = 1.7 \times 10^{-9}$ kg. The objects carry an equal but opposite charge, where the magnitude $q = 3.2 \times 10^{-19}$ C.




(a)
For this motion calculate

(i)
The acceleration of X and Y.

[3]

(ii)
Hence, the time to make one complete orbit.

[2]

**[5 marks]**

## Question 3b

The particles **X** and **Y** in part (a) are replaced with a gold nucleus $^{197}_{79}Au$, and an alpha particle.

(b)
Calculate the field strength at the surface of

(i)
A gold nucleus with radius 7.0 fm.

[1]

(ii)
An alpha particle with radius 1.7 fm.

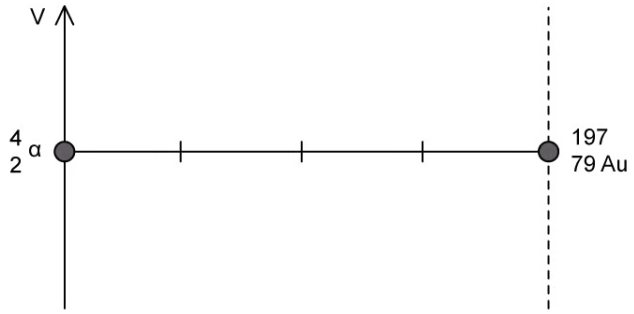
[1]

**[2 marks]**

## Question 3c

The alpha particle and gold nucleus are at rest at a distance where the electric fields only just interact with each other.

(c)
For the axes shown sketch the graph of electric potential *V* against distance along the straight line between the charges.

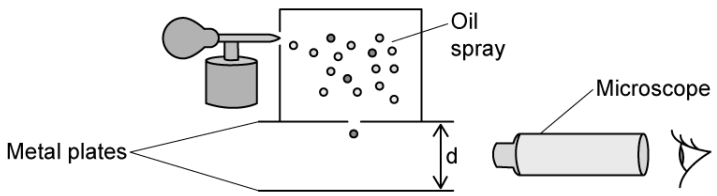



[3]

**[3 marks]**

## Question 4a

An experiment to determine the charge on an electron is shown.

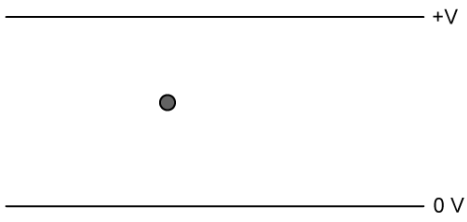



Negatively charged oil drops are sprayed into a region above two parallel metal plates which are separated by a distance, *d*. The oil drops enter the region between the plates.

(a)
A potential difference *V* is applied which causes an electric field to be set up between the plates.

(i)
Using the sketch below, which shows one oil drop falling between the plates, show the electric field between the plates.

[1]




(ii)
Hence or otherwise explain why the oil drop stops falling when *V* is increased.

[2]

**[3 marks]**

## Question 4b

The oil drop has mass = $m$ and charge = $q$. The distance between the plates = 2.5 cm.

The oil drop stops falling when potential difference, $V$ = 5000 V

(b)
Determine the charge to mass ratio of the oil drop.

[2]

**[2 marks]**

## Question 4c

Two oil drops are suspended between the plates at the same time. The oil drops can be considered as identical point charges with mass $1 \times 10^{-13}$ kg which are spaced 2.2 mm apart.

(c)
Calculate the electrostatic force between the drops.

[2]

**[2 marks]**

## Question 4d

For the oil drops in part (c)

(d)
Describe and explain the expected observations as the potential difference increases above 5000 V, using a mathematical expression to justify your answer.

[2]

**[2 marks]**

## Question 5a

A uniform copper wire contains $5.0 \times 10^{23}$ electrons and has a current of 2.0 A flowing through it.

(a)
Calculate the time it will take all the electrons present in the wire at one instant to come out of the end.

[2]

**[2 marks]**

## Question 5b

The wire in part (a) is 5.0 m in length and has a diameter of 1.22 mm.

(b)
Calculate the electron density in the copper wire.

[2]

**[2 marks]**

## Question 5c

(c)
Using the calculated values from parts (a) and (b)

(i)
Determine how long it would take an electron travelling in a wire of this material to get from London to New York, a distance of approximately 5 500 km. State your answer in a reasonable unit for the amount of time.

[1]

(ii)
Hence explain how it is possible to send information by electrical signals across these distances.

[1]

(iii)
The electrons are travelling with either constant velocity or constant acceleration. Select the most likely option and explain your answer.

[2]

**[4 marks]**