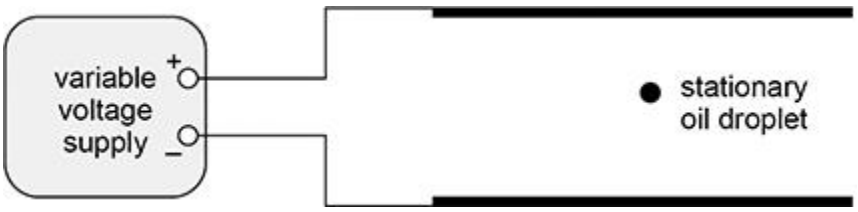
Name of the Student:_____
Max. Marks : 18 Marks **Time : 18 Minutes**

Q1.

Robert Millikan experimented with oil drops to determine a value for the electronic charge.

The diagram below shows a stationary oil droplet between two horizontal metal plates. The plates are connected to a variable voltage supply so that the upper plate is positive. The oil droplet has mass m and charge Q.



(a) State and explain the sign of the charge on the oil droplet.

_____

_____

_____

(1)

The variable voltage supply is set to zero volts. The oil drop falls. The constant speed v_1 of the falling oil droplet is found to be 3.8×10^{-5} m s^{-1} and the following measurements are recorded:

density of oil = 910 kg m^{-3}
viscosity of air = 1.8×10^{-5} N s m^{-2}

(b) Show that the mass m of the oil droplet is about 8×10^{-16} kg.

(3)

(c) The variable voltage supply is adjusted so that the oil droplet rises at a constant speed v_2. The potential difference (pd) across the plates is V and the distance between the plates is d.

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In his experiment, Millikan measured the constant speed v_1 of a falling droplet when the pd was zero. He compared this with the speed v_2 of the same droplet when the droplet was made to rise.

Show that $\frac{v_2}{v_1} = \frac{VQ}{dmg} - 1$

(2)

(d) The following measurements are made for the droplet in part (b) when it is rising at constant speed.

$V = 715$ V

$v_2 = 1.1 \times 10^{-4}$ m s^{-1}

The separation of the plates $d = 11.6$ mm.

Deduce, using the equation in part (c), whether the value of the charge for this droplet is consistent with the currently accepted value of the electronic charge.

(3)

(e) After Millikan published his results, it was found that he had used a value for the viscosity of air that was smaller than the actual value.

Discuss the effect this error had on Millikan's value of the electronic charge.

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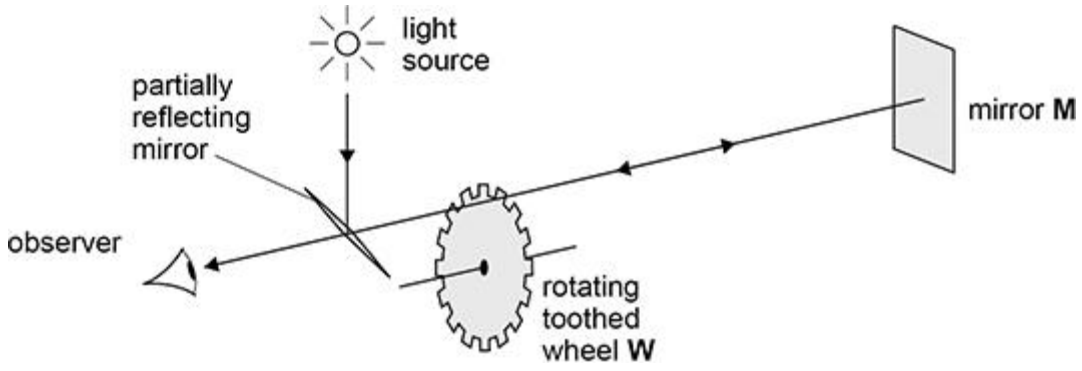
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(3)

(Total 12 marks)

Q2.

The figure below shows the arrangement used by Fizeau to determine the speed of light.



The toothed wheel **W** is rotated and the reflected light from a distant mirror **M** is observed.

The speed of light is calculated from the equation

$$c = 4dnf_0$$

where d is the distance from **W** to **M** and
n is the number of teeth on the rotating wheel **W**.

(a) State what f_0 represents in the equation.

_____

_____

_____

_____

_____

(2)

(b) The experiment is attempted using a rotating wheel with 720 teeth that can be rotated at up to 620 revolutions per minute.
The distance between **W** and **M** is $8.5\ \text{km}$.

Deduce whether the speed of light can be determined with this particular arrangement.

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_____

_____

(2)

(c) The determination of the speed of light took on extra significance when Maxwell derived the wave-speed equation

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

State how ε_0 and μ_0 are related to the types of field in the wave.

ε_0 _____

_____

_____

μ_0 _____

_____

_____

(2)

(Total 6 marks)

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