Practice Question Set For A-Level
Subject : Physics
Paper-2 Topic: Fields And Their Consequences(Magnetic Field)

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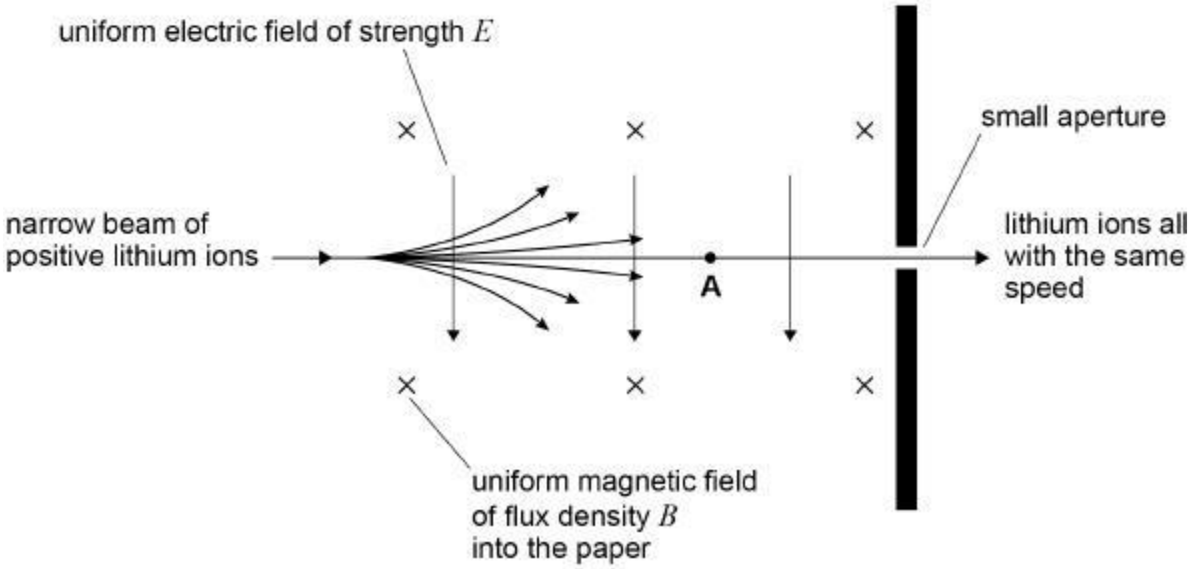
Name of the Student:____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

Mass spectrometers are used to measure the masses of ions.

Figure 1 shows one part of a mass spectrometer.

Figure 1



A narrow beam consists of positive lithium ions travelling at different speeds.
The beam enters a region where there is an electric field and a magnetic field.
The directions of the uniform electric field of strength E and the uniform magnetic field of flux density B are shown on **Figure 1**.

Most ions are deflected from their original path.
Lithium ions that travel at one particular speed are not deflected, and pass through the small aperture.

(a) The positive lithium ion **A** in **Figure 1** moves at a speed v.

Draw **two** labelled arrows on **Figure 1** to show the directions of the electric force F_E and the magnetic force F_M acting on **A**.

(1)

(b) Lithium ions travelling at 1.5×10^5 m s^{-1} pass through the small aperture.

Calculate E.

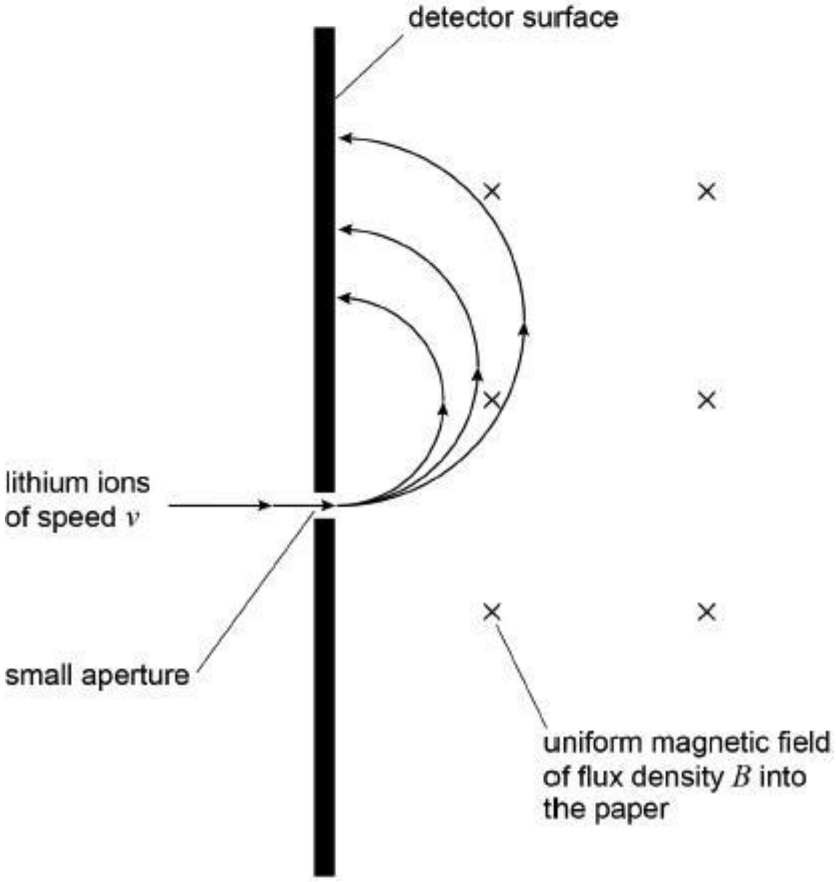
$B = 0.12\ \text{T}$

E = _______________ V m^{-1}

(2)

(c) Ions that pass through the small aperture enter a second uniform magnetic field of flux density B.
Ions of different mass are separated because they follow different paths as shown in **Figure 2**.

Figure 2



Ions of mass m and charge q travelling at speed v follow a circular path in the uniform magnetic field.

Show that the radius r of the circular path is given by

$$r = \frac{mv}{Bq}$$

(1)

(d) The ions of different mass are deflected and strike the detector surface at different distances from the small aperture as shown in **Figure 2**.

A singly-charged lithium ion $({}^{6}_{3}\mathrm{Li}^{+})$ passes through the small aperture.

Calculate the distance between the small aperture and the point where this ion strikes the detector surface.

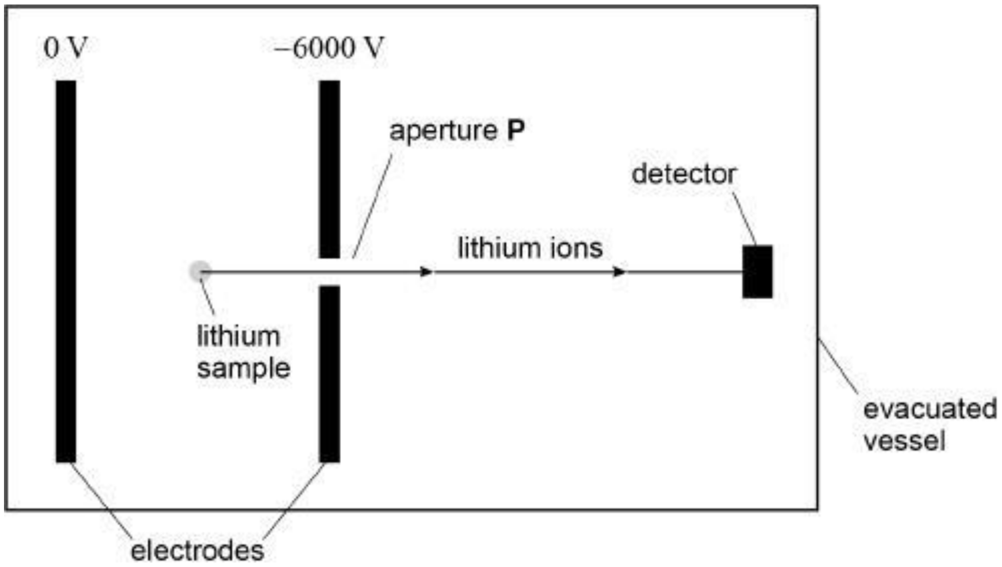
$v = 1.5 \times 10^{5}$ m s^{-1}
B = 0.12 T
mass of ${}^{6}_{3}\mathrm{Li}^{+}$ ion = 1.0×10^{-26} kg

distance = _______________ m

(2)

(e) **Figure 3** shows a different type of mass spectrometer working with lithium ions.

Figure 3



A stationary $^{7}_{3}\mathrm{Li}^{+}$ ion in the lithium sample is at the mid-point between the parallel electrodes. The $^{7}_{3}\mathrm{Li}^{+}$ ion accelerates towards aperture **P**.

Determine the speed of the ion when it emerges through aperture **P**.

mass of $^{7}_{3}\mathrm{Li}^{+}$ ion = 1.2×10^{-26} kg

speed = _______________ m s^{-1}

(3)

(f) $^{6}_{3}\mathrm{Li}^{+}$ and $^{7}_{3}\mathrm{Li}^{+}$ ions are produced in the sample simultaneously and travel a distance L from aperture **P** to the detector.
For each type of ion, the time interval between production and detection is measured.

Discuss how the masses of the ions can be deduced from the measurement of these time intervals.

____

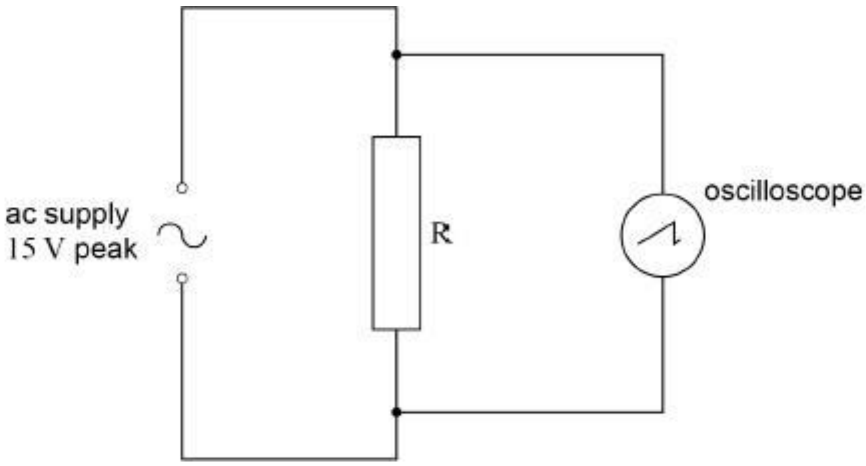
(2)

(Total 11 marks)

Q2.

Figure 1 shows an oscilloscope connected across resistor R which is in series with an ac supply. The supply provides a sinusoidal output of peak voltage 15 V.

Figure 1



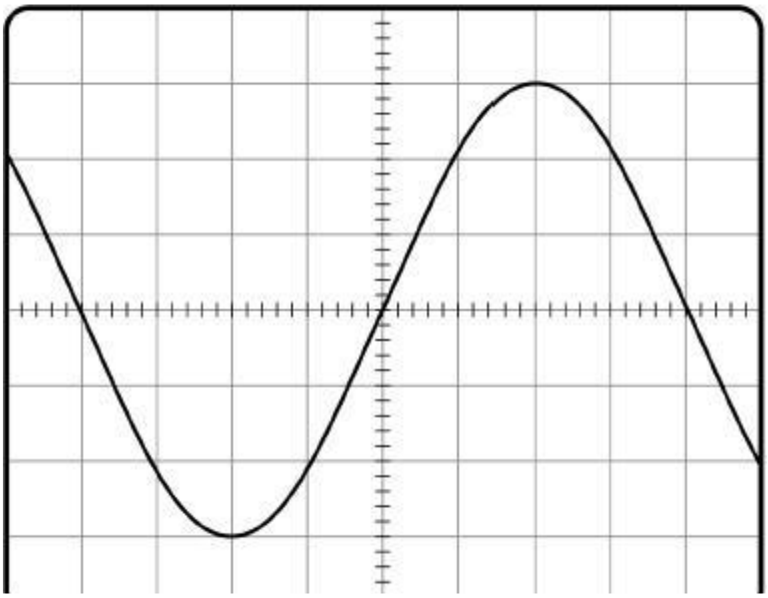
(a) Calculate the rms voltage of the supply.

rms voltage = _______________ V

(1)

Figure 2 shows the trace of the waveform displayed on the oscilloscope.

Figure 2



(b) Determine the y-voltage gain of the oscilloscope used for **Figure 2**.

y-voltage gain = _______________ V div^{-1}

(1)

(c) A dc supply gives the same rate of energy dissipation in R as the ac supply in **Figure 1**.

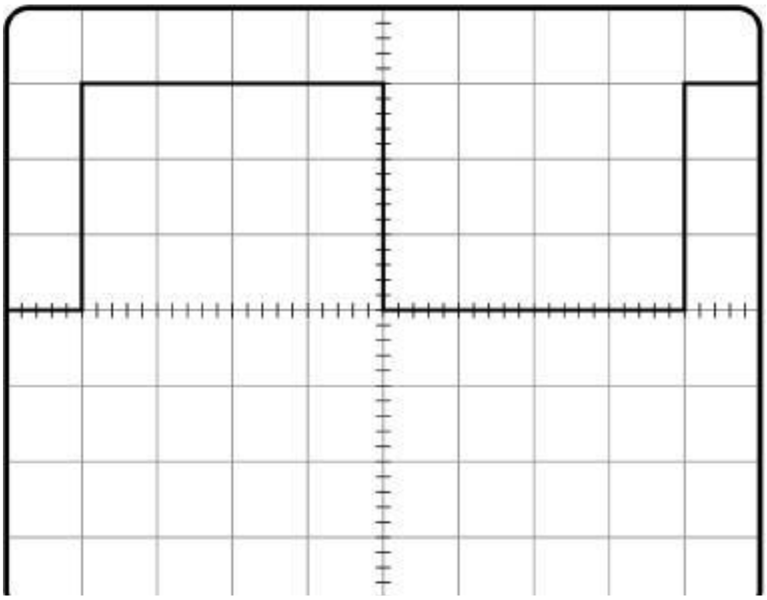
Draw the trace of the output of the dc supply on **Figure 2**.
The oscilloscope settings remain the same.

(1)

(d) The ac supply shown in **Figure 1** is replaced with a square-wave generator operating between 0 and +15 V.

Figure 3 shows the trace of the new waveform displayed on the oscilloscope. The time-base is set to 5.0×10^{-4} s div^{-1}.

Figure 3



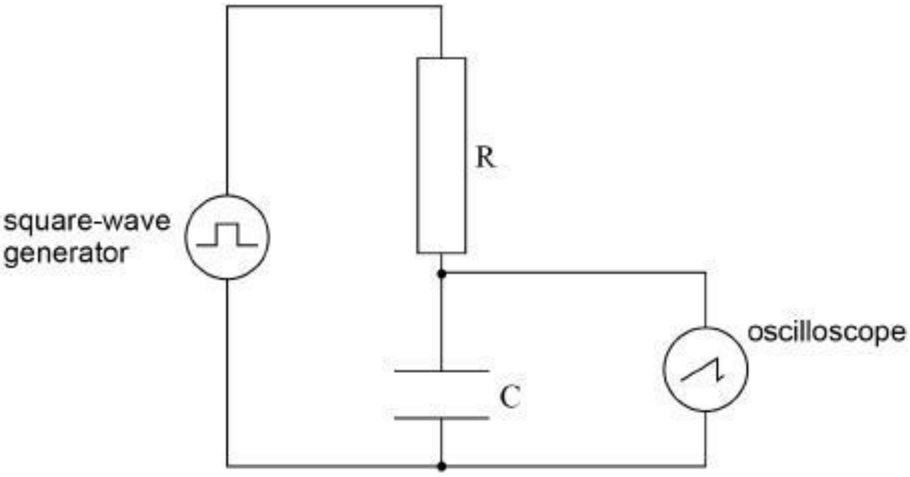
Calculate the frequency of the square waves.

frequency = _______________ Hz

(1)

(e) **Figure 4** shows the arrangement with the square-wave generator connected to an RC circuit.
A capacitor C is placed in series with the resistor R.
The oscilloscope is connected across the capacitor C.

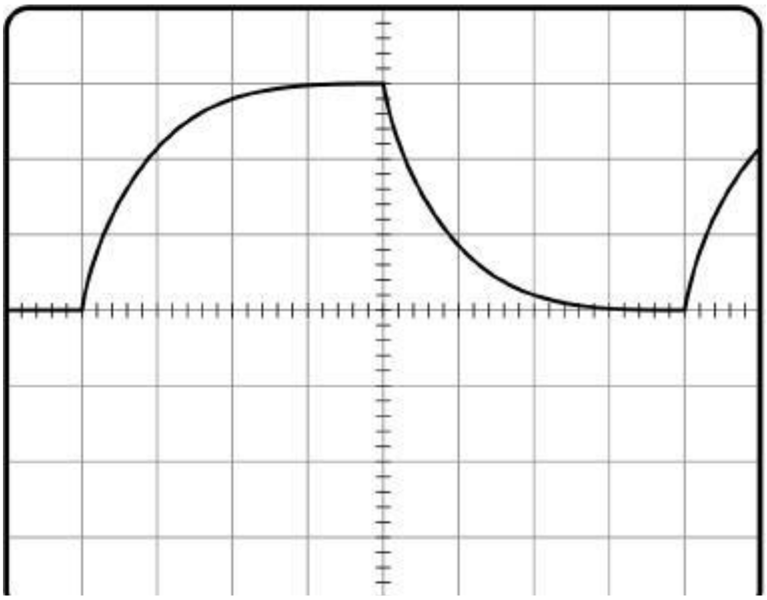
Figure 4



The capacitor charges and discharges.

Figure 5 shows the trace of the waveform displayed on the oscilloscope. The settings of the oscilloscope remain the same as in part (d).

Figure 5



Deduce the time constant for the RC circuit, explaining each step of your method.

time constant = _______________ s

(3)

(f) State and explain a change to **one** control setting on the oscilloscope that would reduce the uncertainty in the value of the time constant.

(2)
(Total 9 marks)