This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 03
FEB2023

Do NOT write in this box. Your MARK will be placed here.

Subject :	Physics	
Class :	12E and 12M	
Teacher :	Mr. Ali Moukalled	
Duration :	1 hour	
Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

EXERCISE 1 (10points)

Photoelectric Effect

A metallic plate, covered with a layer of cesium, is illuminated with a monochromatic luminous beam of wavelength $\lambda = 0.45\mu m$ in vacuum. The threshold wavelength is $\lambda_0 = 0.658\mu m$. A convenient apparatus (D) is used to detect the electrons emitted by the illuminated plate.
Given: Planck's constant $h = 6.6 \times 10^{-34} J.s$; speed of light in vacuum $c = 3 \times 10^8 m/s$; $1eV = 1.6 \times 10^{-19} J$; elementary charge $e = 1.6 \times 10^{-19} C$.

1. What aspect of light does the phenomenon of photoelectric effect shows evidence of?
2. Define the terms, Work function and the threshold frequency of a metal.
3. The luminous beam illuminating the metallic plate is formed of photons.
   (a) i. Calculate in **J** and in **eV**, the energy **E** of an incident photon.
   ii. Is this energy of a photon affected by the medium it travels through? Justify.
   (b) (D) detects electrons emitted by the plate. Why do we have emission of electrons by the plate?
   (c) Calculate, in **eV**, the maximum kinetic energy of an emitted electron.
4. The luminous power received by the plate is $10^{-3} W$, and the emitted electrons form a current $I = 5\mu A$.
   (a) Calculate the number of incident photons by the plate in one second.
   (b) Calculate the number of absorbed photons in one second.
   (c) Calculate the quantum efficiency.
   (d) We decrease the wavelength of the irradiated radiations at constant light intensity.
   i. What would happen to the photoelectric current?
   ii. What would happen to the kinetic energy of the emitted electrons?

EXERCISE 2 (10points)

Capacitors

In order to charge a capacitor, we connect up the series circuit that is represented in figure 1. This circuit is formed of:

- a generator of constant **e.m.f** **E** and of negligible internal resistance.
- a resistor of resistance **R**;
- a capacitor of capacitance $C = 1\mu F$;
- a switch **K**.

The capacitor is initially neutral. At the instant $t_0 = 0$, we close **K**. At an instant **t**, the armature **A** carries a charge **q** and the circuit is traversed by a current **i** whose direction is shown on the circuit.

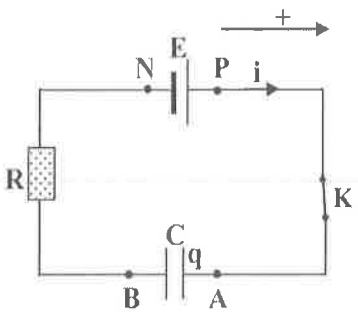


Fig.1

Turn the page

A- Analytical Study

1. Write the expression of $\mathbf{q}$ in terms of $\mathbf{u_{AB}}$ and C.
2. Derive the differential equation that governs the variation of $\mathbf{q}$ as a function of time.
3. Using the differential equation, deduce:
   (a) that the expression of the current at the instant $\mathbf{t_0 = 0}$ is $\mathbf{I_0 = \frac{E}{R}}$;
   (b) the expression, of the maximum value $\mathbf{Q_m}$ of $\mathbf{q}$ in terms of C and E.

B- Exploitation of the curve

The variation of the charge $\mathbf{q}$, as a function of time, is represented by the curve of figure (2). The straight line (OM) represents the tangent to the curve at the instant $\mathbf{t_0 = 0}$.
Using figure 2:

1. (a) indicate the maximum value $\mathbf{Q_m}$ of $\mathbf{q}$;
   (b) deduce the value of E.
2. (a) Show that the value of $\mathbf{I_0}$ is $\mathbf{1mA}$;
   (b) deduce the value of R.
3. Determine the values of $\mathbf{u_{AB}}$ and of i at the instant $\mathbf{t_1 = 10^{-2}s}$.

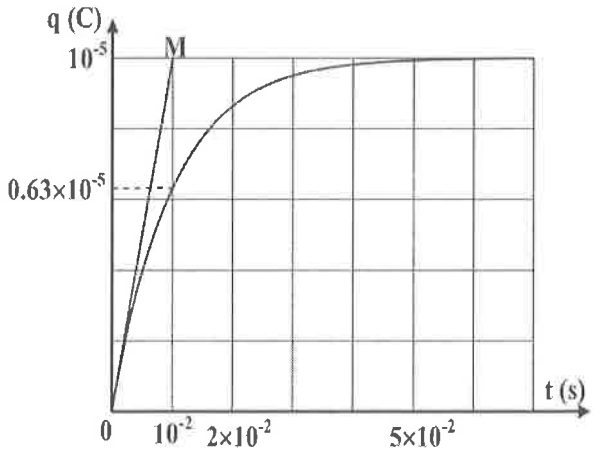


Fig.2

C- Energy stored in the capacitor

Knowing that the energy stored in the capacitor at an instant t is given by $\mathbf{W = \frac{1}{2}\frac{q^2}{C}}$, determine:

1. the values of W at $\mathbf{t_0 = 0}$ and at $\mathbf{t_1 = 10^{-2}s}$;
2. the average electric power received by the capacitor between $\mathbf{t_0}$ and $\mathbf{t_1}$.

GOOD LUCK

SE03: 12ME "Solution"

Exercise 2

$C = 1\mu F = 1 \times 10^{-6} F$

A- Analytical study

1) $q_A = C \times U_{AB}$ (1)

2) Due to the law of addition of voltages

$U_G = U_c + U_R$

$E = U_c + Ri$

but $i = \frac{dq}{dt}$ and $U_c = \frac{q}{C}$ (1)

$\Rightarrow E = \frac{q}{C} + R\frac{dq}{dt}$

$$\boxed{\frac{dq}{dt} + \frac{1}{RC}q = \frac{E}{R}}$$ (1)

3) a) At $t_0 = 0$, $q_A = 0C$ (the capacitor is initially neutral)

and $i = \frac{dq}{dt} = I_0$ (maximum value since at $t_0 = 0$, $U_c = 0V$ & $U_R = E$ $\Rightarrow i = I_0$) (1)

$\frac{dq}{dt} + \frac{1}{RC}q = \frac{E}{R}$

$I_0 + \frac{1}{RC}(0) = \frac{E}{R}$

$$\boxed{I_0 = \frac{E}{R}}$$ (1)

b) $Q_m = U_{c_{max}} \times C$

$$\boxed{Q_m = E \times C}$$ (0.5)

B. Exploitation of the curve

1) a) $Q_m = 10^{-5}\,C$ (0.5)

b) $Q_m = C \times E \Rightarrow E = \frac{Q_m}{C} = \frac{10^{-5}}{10^{-6}}$

$$\boxed{E = 10V}$$ (0.5)

2) a) $I_0 = 1mA$??

$I_0 = \left.\frac{dq}{dt}\right|_{t=0} = \left.\frac{\Delta q}{\Delta t}\right|_{t=0}$ (slope of the tangent at $t_0 = 0$)

$= \frac{q_2 - q_1}{t_2 - t_1} = \frac{10^{-5} - 0}{10^{-2} - 0} = 10^{-3} = 1mA$

$$\boxed{I_0 = 1mA}$$ (1)

b) Due to ohm's law

$U = R \times i$

$E = R \times I_0$

$\Rightarrow R = \frac{E}{I_0} = \frac{10}{10^{-3}} = 10^4\,\Omega$

$$\boxed{R = 10^4\,\Omega}$$ (0.5)

3) $t_1 = 10^{-2}\,s \longrightarrow q = 0.63 \times 10^{-5}\,C$

$u_c = \frac{q}{C} = \frac{0.63 \times 10^{-5}}{10^{-6}} = 6.3V$ (1)

$u_c = 6.3V$

$E = u_c + u_R$

$\Rightarrow u_R = E - u_c$

$= 10 - 6.3 = 3.7V$

$$\boxed{u_R = 3.7V}$$

$$i = \frac{U_R}{R} = \frac{3.7}{10^4}$$

$$\boxed{i = 3.7 \times 10^{-4}\ A}$$

C. Energy stored in the capacitor

$$W = \frac{1}{2}\frac{q^2}{C}$$

1) $$W_{t=0} = \frac{1}{2}\frac{0^2}{C} = 0\ J$$

$$W_{t_1} = \frac{1}{2}\frac{(0.63 \times 10^{-5})^2}{10^{-6}} = 0.198 \times 10^{-4}\ J$$ (0.5)

2) $$P_{av} = \frac{\Delta W}{\Delta t} = \frac{(0.198 \times 10^{-4}) - 0}{10^{-2} - 0}$$ (0.5)

$$\boxed{P_{av} = 0.198 \times 10^{-2}\ W}$$

Exercise 1

$\lambda = 0.45\,\mu m = 0.45 \times 10^{-6}\,m$

$\lambda_0 = 0.658\,\mu m = 0.658 \times 10^{-6}\,m$

1) Corpuscular Aspect of light / Particle Aspect of light (1)

2) Work function: Is the minimum energy required to extract an electron without kinetic energy. (0.5)

Threshold frequency: Is the minimum frequency under which electrons are emitted without kinetic energy. (0.5)

3) a) i) $E_{photon} = h\nu = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{0.45 \times 10^{-6}}$

$= 4.4 \times 10^{-19}\,J$

$\boxed{E_{photon} = 4.4 \times 10^{-19}\,J}$ (1)

$E_{photon} = \frac{4.4 \times 10^{-19}}{1.6 \times 10^{-19}} = 2.75\,eV$ $\boxed{E_{photon} = 2.75\,eV}$ (1)

ii) N_0.

$v = \frac{c}{n}$ & $\lambda = \frac{\lambda_{vac}}{n}$

$E_{photon\ medium} = \frac{hv}{\lambda} = \frac{h\frac{c}{n}}{\frac{\lambda_{vac}}{n}} = \frac{hc}{\lambda_{vacu}}$ (1)

$E_{photon\ medium} = E_{photon\ vacuum}$

b) $\lambda < \lambda_0$ (0.5)

c) $E_{photon} = W_0 + K.E$

$K.E = E_{photon} - W_0$

$= 2.75 - 1.8806$

$= 0.869\ eV$ (1)

$K.E = 0.869\ eV$

$W_0 = \frac{hc}{\lambda_0} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{0.658 \times 10^{-6}}$

$W_0 = 3.009 \times 10^{-19}\ J$

$W_0 = 1.8806\ eV$

4) $P = 10^{-3}\ W$

$I = 5\mu A = 5 \times 10^{-6}\ A$

a) $P = N_{\substack{incident \\ photons/s}} \times E_{photon}$ (1)

$N_{\substack{incident \\ photons/s}} = \frac{P}{E_{photon}} = \frac{10^{-3}}{4.4 \times 10^{-19}} = 2.2727 \times 10^{15}\ photons/s$

b) $I = N_{\substack{absorbed \\ photons/s}} \times e$ (1)

$N_{\substack{absorbed \\ photons/s}} = \frac{I}{e} = \frac{5 \times 10^{-6}}{1.6 \times 10^{-19}} = 3.125 \times 10^{13}\ \substack{absorbed \\ photons/s}$

c) $r = \frac{N_{absorbed\ photons/s}}{N_{incident\ photons/s}} = \frac{3.125 \times 10^{13}}{2.2727 \times 10^{15}}$ (0.5)

$r = 0.013.$

d) i) Would remain the same. (0.5)

ii) It would increase (0.5)