This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School

for Boys and Girls Loueizeh - Baabda

Stage Exam 04

27MAR2023

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.

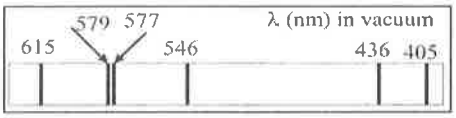
EXERCISE 1 (10points)

The Mercury Atom

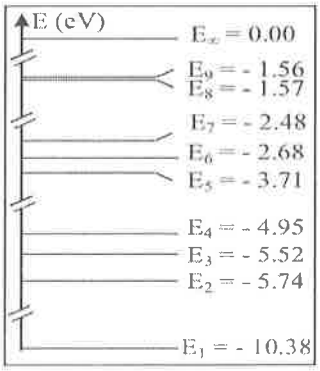
Given: $h = 6.626 \times 10^{-34}$J.s, $c = 3 \times 10^{8}$m/s, $e = 1.6 \times 10^{-19}$C, and $1eV = 1.6 \times 10^{-19}$J.

A-Transition

The adjacent figure shows a part of the emission spectrum of a mercury vapor lamp (M) and the energetic diagram of some energy levels of the mercury atom.



1. The energy levels of the mercury atom are quantized. Justify.
2. Calculate the ionization energy of the atom when it is in each of the energy levels: E_1 and E_5.
3. A mercury atom in the energy level E_9. It undergoes a downward transition to the ground state thus passing successively by the levels E_5 and E_2.
   (a) Determine the transition to which a radiation of wavelength **577nm** is associated.
   (b) Justify then the presence of the yellow doublet **(577, 579)**.
4. Explain what is likely to happen if a:
   (a) moving electron of energy **6.00eV** collides with the mercury atom that is in the ground state:
   (b) photon, of energy **6.00eV**, were to be incident to the atom that is in the ground state.



B-Planck's Constant

The yellow doublet will be considered as one radiation of wavelength **578nm**. The lamp (M), equipped with several filters, illuminates the cesium cathode of a photoelectric cell of work function $W_0 = 2.15eV$. For each of the wavelengths, we measure the maximum kinetic energy **K.E** of the emitted electrons (adjacent table).

λ(nm)	615	578	546	436	405
KE(eV)	0	0	0.18	0.75	0.97

1. Determine the expression of **K.E** in terms of $\frac{1}{\lambda}$.
2. Determine the value of the Planck's constant.
3. (a) Determine the wavelength threshold λ_0 associated to the cesium.
   (b) Interpret the presence of the zeros in the table.
4. (a) The photoelectric effect shows evidence of an aspect of light. Which one?
   (b) Another phenomenon shows evidence of the other aspect of light. Which one?

Turn the page

EXERCISE 2 (10points)

Diffraction of White light

A point source (S) emits a white light of wavelengths $400\text{nm} \leq \lambda \leq 800\text{nm}$. (S) illuminates under normal incidence a thin vertical slit of width a.
We observe a diffraction pattern on a screen (E) placed parallel and at a distance D from the slit.

1. Describe the aspect of diffraction pattern observed on the screen.
2. Specify the color at the center O of the central fringe.
3. The width of the central bright fringe of the red light of $\lambda = 800\text{nm}$ is $L_{red} = 6.4\text{mm}$.
   (a) Calculate the width of the 2^{nd} bright fringe of the red color.
   (b) Determine the width of the central bright fringe of a violet light of $\lambda = 400\text{nm}$
   (c) Write down the expression of the width of the central bright fringe in terms λ, D and a.
   (d) Determine D and a if the angular width of the C.B.F of the red light is $\alpha_{red} = 1.6 \times 10^{-3}\text{rad}$.
4. N is a point on the screen which has an abscissa x ($x = ON$). N is the center of a dark fringe of order n of the red color ($\lambda = 800\text{nm}$). Also, N is the center of a dark fringe of order $(n+1)$ of a color of wavelength $\lambda' = 640\text{nm}$.
   Determine n and x.
5. Determine the wavelengths of the missing radiations (dark fringes) and their orders at a point M, in the diffraction pattern on the screen, whose abscissa is $x_M = OM = 10\text{mm}$.

GOOD LUCK

Ex 1

A- Transition

1) The energy levels of the Mercury atom are quantized because the energy of this atom been worth discrete (0.5)

2) For E_1: $E_i = E_\infty - E_1$
$= 10.38\ eV$ (0.5)

For E_5: $E_i = E_\infty - E_5$
$= 3.71\ eV$. (0.5)

3) a) $\Delta E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 2.998 \times 10^{8}}{577 \times 10^{-9} \times 1.602 \times 10^{-19}} = 2.15\ eV$ (1)

This corresponds For a transition From E_4 to E_2.

b) The yellow doublet (577): from E_4 to E_2

& 579 nm From E_3 to E_2: (1)

$$\frac{6.626 \times 10^{-34} \times 2.998 \times 10^{8}}{(-1.57 + 3.71) \times 1.602 \times 10^{-19}}$$

$= 579\ nm$

4) a) $E + E_1 = -4.38\ eV$ (1)

∴ the atom can pass one of the levels E_2, E_3 or E_4 & the rest energy will be taken by the electron.

b) In the case of the photon, the atom remains in the ground state because $E + E_1 = -4.38\ eV$ which doesn't correspond to any energy level. (0.5)

B.

1) $K.E = h\nu - W_o$

$= \frac{hc}{\lambda} - W_o$ (0.5)

2) K.E is a linear function of $\frac{1}{\lambda}$ ⇒

$$hc = \frac{\Delta K.E}{\Delta\left(\frac{1}{\lambda}\right)}$$ (0.5)

$$hc = \frac{(0.97 - 0.18) \times 1.602 \times 10^{-19}}{\left(\frac{10^9}{405} - \frac{10^9}{546}\right)}$$

$$h = 6.62 \times 10^{-34}\ J.s$$ (1)

3) a) $W_o = \frac{hc}{\lambda_o} \Rightarrow \lambda_o = \frac{hc}{W_o} = \frac{6.626 \times 10^{-34} \times 2.998 \times 10^8}{2.15 \times 1.602 \times 10^{-19}}$ (0.5)

$\lambda_0 = 576\,nm$ (0.5)

b) $615\,nm$ & $578\,nm > \lambda_0 \Rightarrow$ P.E = 0 J. (1)

4) a) Particle aspect (0.5)

b) Interference - Diffraction. (0.5)

Exercise 2

1) We observe: - alternating bright and dark fringes.
- the width of the central fringe is double that of any other bright fringes.
- The direction of the pattern of fringes is perpendicular to that of the slit. (2)

2) Diffraction takes place for each monochromatic radiation $\Rightarrow$ all the central bright fringes superpose at O $\Rightarrow$ the color at O is white. (1)

3) $\lambda = 800nm = 800\times10^{-9}m$ $\quad L_{red} = 6.4mm = 6.4\times10^{-3}m$

a) ~~$L = \alpha D$~~ width of 2nd B.F $= \frac{L_{red}}{2} = \frac{6.4}{2} = 3.2mm$ (1)

b) $L = \alpha D = \frac{2\lambda D}{a} \Rightarrow \frac{D}{a} = \frac{L}{2\lambda} \Rightarrow$

$$\frac{L_{red}}{2\lambda_{red}} = \frac{L_{violet}}{2\lambda_{violet}}$$

$$\Rightarrow L_{violet} = \frac{L_{red}\times\lambda_v}{\lambda_{red}} = 3.2mm$$ (1)

c) $L = \frac{2\lambda D}{a}$ (1)

d) $L = \alpha D$

$D = \frac{6.4\times10^{-3}}{1.6\times10^{-3}} = 4m$ (1)

$$\alpha = \frac{2\lambda}{a} \Rightarrow a = 10^{-3}\,m$$

4) $$\theta_n = \frac{n\lambda}{a} \Rightarrow x_n = D\theta_n = \frac{n\lambda D}{a}$$

$$x_{n(red)} = n\frac{(800\times10^{-9})(4)}{10^{-3}} \quad (1)$$

$$x_{n(red)} = 3.2\times10^{-3}\,n \quad (1)$$

$$x_{n+1}(\lambda') = \frac{(n+1)(640\times10^{-9})(4)}{10^{-3}} = 2.56\times10^{-3}(n+1) \quad (2)$$

$$x_{n(red)} = x_{(n+1)} \Rightarrow 3.2\times10^{-3}\,n = 2.56$$

$$n = 4$$

Replace n in (1) (1)

$$x = 0.0128\,m$$

5) $$x_m = \frac{n\lambda D}{a} \quad \text{but } x_m > a$$

$$n = \frac{a x_m}{\lambda D} = \frac{10^{-3}\times4\times10^{-3}}{\lambda\times4} = \frac{2.5\times10^{-6}}{\lambda}$$

$$400\times10^{-9} \leq \lambda \leq 800\times10^{-9}$$

$$3.125 \leq n \leq 6.25 \quad (0.5)$$

$n = 4, 5, 6$

$$\lambda = \frac{2.5 \times 10^{-6}}{n}$$

$n = 4 \Rightarrow \lambda = 6.25 \times 10^{-7}\,m = 625\,nm$ (4th D. Fr.)
$n = 5 \Rightarrow \lambda = 5 \times 10^{-7}\,m = 500\,nm$ (5th D. Gr.)
$n = 6 \Rightarrow \lambda = 4.166 \times 10^{-7}\,m = 416.6\,nm$ (6th D. Gr.)

0.5

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