Mid Semester Examination 2024

Physics for Engineers: PHL101 (Optics)

Time: 30 minutes **Total Marks: 15**

Answer any 5 questions. Each question carries 3 marks.

Q1. Explain techniques of the Division of wavefront and the Division of amplitude to get a fixed phase relationship to observe light interference. (3 marks)

Q2. (a) Write the conditions to observe stationary interference pattern of light. (2 mark)
(b) In Young's double hole experiment, two wavelengths λ_1 = 780 nm and λ_2 = 520 nm are used to obtain interference fringes. If the n^{th} bright fringe due to λ_1 coincides with $(n+1)^{th}$ bright fringe due to λ_2, then find the value of n. (1 mark).

Q3. Describe the properties of Maxwell's Electromagnetic waves. Explain how Maxwell predicted the existence of electromagnetic waves and the speed of electromagnetic waves. (3 marks).

Q4. Circular fringes are observed in a Michelson interferometer illuminated with light of wavelength 5896 $\dot{A}$. When the path difference between the mirrors M1 and M2 is 0.3 cm, the central fringe is bright. Calculate the angular diameter of the 7th bright fringe. (3 marks)

Q5. A thin film of 4×10^{-5} cm thickness is illuminated by white light normal to its surface (r = 0°). Its refractive index is 1.5. Of what colour will the thin film appear in reflected light? (3 marks)

Q6. (a) Derive the expression of fringe position in Young's (double hole) interference experiment. (1.5 marks)
(b) A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 cm away. It is observed that the first minimum is at a distance of 2.5 mm from the center of the screen. Find the width of the slit. (1.5 marks)

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IIT Bhilai

PHL 101, Physics for Engineers

Mid Semester 2024 Examination, Max Marks: 40, Time: 1hr30min

Instructor: Dr. Anjali Chaudhary

Formula sheet (symbols have their usual meanings)

1. $\Delta x \Delta p \geq \frac{h}{4\pi}$
2. $\Delta x \Delta v \geq \frac{h}{4\pi m}$
3. $\Delta E \Delta t \geq \frac{h}{4\pi}$
4. $\lambda = \frac{h}{p}$; $p = \sqrt{2mE_{kinetic}}$; $v \ll c$
5. $E = h\upsilon = \frac{hc}{\lambda}$; $P = \frac{E}{t}$
6. $[A, B] = AB - BA$
7. $\lambda_2 - \lambda_1 = \frac{h}{m_o c}(1-\cos\theta)$; $m_o c = 0.0242\ angstrom$
8. $h\nu = \phi + KE_{max}$; $\phi = h\upsilon_o$
9. $h\nu = h\upsilon_o + KE_{max}$
10. $\lambda_{peak} = \frac{2.9X10^{-3}\ m}{T\ (Kelvin)}$
11. No. of modes = $\frac{8\pi\nu^2\, d\nu}{c^3}$
12. Planck's blackbody radiation $\frac{8\pi\nu^2\, d\nu}{c^3}\left[\frac{h\nu}{e^{\frac{h\nu}{kT}}-1}\right]$

Alpha decay	${}^{A}_{Z}X \rightarrow {}^{4}_{2}He + {}^{A-4}_{Z-2}Y$
Beta decay	${}^{A}_{Z}X \rightarrow {}^{0}_{-1}e + {}^{A}_{Z+1}Y$
Gamma decay	${}^{A}_{Z}X \rightarrow {}^{0}_{0}\gamma + {}^{A}_{Z}Y$
Positron emission	${}^{A}_{Z}X \rightarrow {}^{0}_{+1}e + {}^{A}_{Z-1}Y$
Electron capture	${}^{A}_{Z}X + {}^{0}_{-1}e \rightarrow {}^{A}_{Z-1}Y$

13.

Table 11.1 ▶ Some Masses in Various Units

Particle	Mass (kg)	Mass (u)	Mass (MeV/c^2)
Proton	1.6726×10^{-27}	1.007276	938.28
Neutron	1.6750×10^{-27}	1.008665	939.57
Electron	9.1095×10^{-31}	5.486×10^{-4}	0.511
^{1}H atom	1.6736×10^{-27}	1.007825	938.79

14. Binding energy $= \left[Zm(^1H) + Nm(n) - m\left({}^{A}_{Z}X\right)\right] \times 931.5\ MeV/u$
15. $N = N_o e^{-\lambda t}$
16. $\lambda = \frac{0.693}{T_{1/2}}$; $T = \frac{1}{\lambda}$
17. $\sigma = ne\mu$, $e = 1.602176634 \times 10^{-19}$ C
18. $\alpha = \frac{\Delta l}{l_o \Delta T} = \frac{l_f - l_i}{l_o (T_f - T_i)}$
19. $\frac{Q}{A} = -k\frac{\Delta T}{\Delta x}$
20. $t' = \gamma t$, $\gamma = \frac{1}{\sqrt{1-(v/c)^2}}$ $\quad l' = \frac{l}{\gamma}$

$E = \gamma m_0 c^2$, $\quad K.E. = (\gamma - 1) m_0 c^2$

Questions

(1-10: 1 mark each)

1. What is the binding energy per nucleon of $^{2}_{1}H$.
   (a) 1.1 MeV/nucleon (b) 0.7 MeV/nucleon (c) 0.2 MeV/nucleon (d) none

2. How many total angular momentum states does $3d_{5/2}$ have?
   (a) 5 (b) 3 (c) 6 (d) 2

3. What kind of decay do you expect from $^{6}_{2}He$?
   (a) Positive beta (b) negative beta (c) electron capture (d) Gamma

4. A neutron has almost 2000 times the rest mass of an electron. Suppose they both have 1eV of energy. How do their wavelengths compare?
   (a) Both same
   (b) Neutron wavelength<electron wavelength
   (c) Neutron wavelength>electron wavelength
   (d) None

5. Which is the correct statement for Figure1?
   (a) 1-semiconductor 2-conductor
   (b) 1-conductor 2-semiconductor
   (c) 1-metal 2-semiconductor
   (d) 1-insulator 2- semiconductor

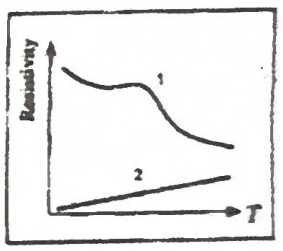

Figure 1

6. Calculate conductivity of metal with carrier concentration of $10^{22}/cm^3$ and mobility of 40 $cm^2V^{-1}s^{-1}$.

7. Which is the correct statement for Figure 2?

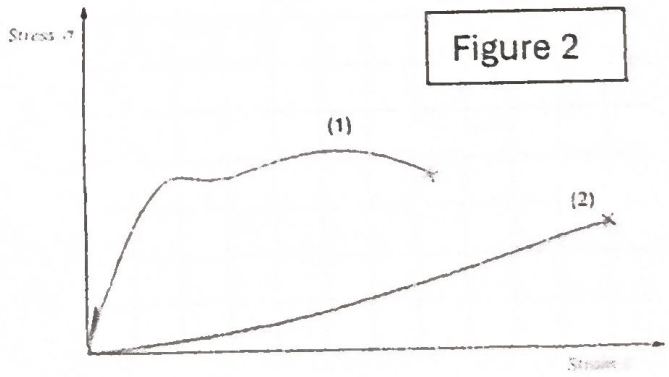

Figure 2

   (a) 1-steel,2-rubber (b) 1-rubber,2-steel (c) 1-rubber,2-rubber (d)none

8. Write Schrodinger's time dependent equation?

9. Write Hamiltonian operator of a free particle?

10. Calculate number of modes in a chamber of volume 100 cm^3 in frequency range $4X10^{14}$ Hz to 4.01 $X10^{14}$ Hz.

(11-15: 2 marks each)

11. A green photon collides with a stationary electron. After the collision the photon color is

(a) Unchanged

(b) Shifts towards red

(c) Shifts towards blue

(d) None

12. The 14C:12C ratio in a fossil bone is found to be 1/8 that of the ratio in the bone of a living animal. The half-life of 14C is 5,730 years. What is the approximate age of the fossil?

(a) 7640 years (b)17200 years (c)22900 years (d)45800 years

13. Write definition of electrical and thermal conductivity. Also write units of both.

14. At what speed does the kinetic energy of a particle equal to its rest mass energy?

15. A particle has a kinetic energy 10 times its rest energy. Find the speed of particle in terms of c.

(16-19: 3 marks each)

16. A woman leaves the earth in a spacecraft that makes a round trip to the nearest star, 4 light years distant, at a speed of 0.9c. How much younger is she upon her return than her twin sister who remained behind?

(a) 5 b) 2.2 c) 1 d) 7

17. An electron is bound inside copper by a binding energy of 5 eV. Which wavelength will eject electrons from copper?

(a) 300 nm

(b) 500 nm

(c) 700 nm

(d) 200 nm

18. How fast must a spacecraft travel relative to the earth for each day on the spacecraft to correspond to 2 days on the earth?

19. An incident 71-pm X-ray is incident on a calcite target. Find the wavelength of the X-ray scattered at a 30°angle. What is the largest shift that can be expected in this experiment?

(20-21: 4 marks each)

20. A semiconductor chip is used to store information. The information can be erased by exposing the chip to ultraviolet light for a period of time. Following data is provided.

Frequency of ultraviolet light used	= $9X10^{14}$ Hz
Minimum intensity of ultraviolet light required at the chip	= $25Wm^{-2}$
Area of chip exposed to radiation	= $1.8 X 10^{-9} m^2$
Time taken to erase the information	= 15 minutes
Energy of radiation needed to erase the information	= 40.5 μJ

(a) Calculate the energy of a photon of the ultraviolet light.

(b) Calculate the number of photons of the ultraviolet light required to erase the information.

21. In a famous fiction movie, Cooper landed on Miller's planet and experienced that with 1 year passing on their planet is equivalent to 7 years on planet earth.

(a) What is the name of concept behind Cooper's observation?

(b) What is the speed (in terms of c) of Miller's planet as observed in earth' frame?