ANSWER KEY OF

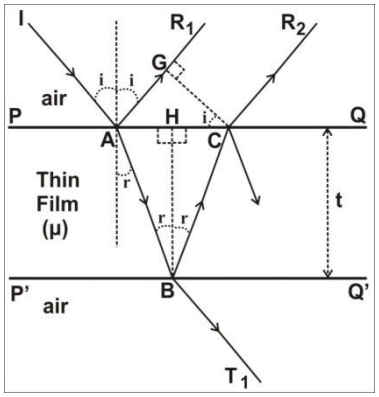
F.E. Semester – I (RC 2019-20) Examination, Nov/Dec 2019

PHYSICS

Part – A

Answer **any two** questions:

1. a) <u>Interference in parallel thin film due to reflected light</u>



Ray Diagram **…. 1 mark**

The optical path difference between the rays R1 and R2 is:

Δ = (AB + BC) in film – AG in air

= μ (AB + BC) – (AG + λ/2) **…….1mark**

Solving and obtaining:

$\Delta = 2\,\mu\,t\cos r - \frac{\lambda}{2}$ **…….2marks**

Conditions for maxima & minima:

$2\,\mu\,t\cos r = (2n+1)\frac{\lambda}{2}$

$2\,\mu\,t\cos r = n\,\lambda$ } ….**1mark**

b) <u>Paramagnetism</u>

Brief explanation of paramagnetism **…… 1 mark**

Any 4 properties of paramagnetic materials **…….4marks**

c) <u>Band theory of solids</u>

Diagram showing band structure of Conductors, Insulators & semiconductors **……. 2 marks**

Explanation of each with one example **…..3marks**

d) <u>Magnetostriction</u>

Definition of magnetostriction **…….1 mark**

<u>Numerical problem</u>

$f_n = \frac{1}{2L}\sqrt{\frac{Y}{\rho}}$ **….. 1mark**

$= \frac{1}{2\times8\times10^{-2}}\sqrt{\frac{11.5\times10^{10}}{7.8\times10^{3}}}$ **…….. 1 mark**

$= 23998\ Hz$ **……. 1 mark**

Since the natural frequency is greater than 20,000Hz, the rod can be used to generate USW…..**1mark**

2. a) <u>Piezoelectric oscillator</u>

Circuit diagram of piezoelectric oscillator **…….2 marks**

Explanation of working of circuit and generation of USW **……3 marks**

b) <u>Hysteresis Loop</u>

Diagram of hysteresis loop **……1 mark**

Explanation of hysteresis loop **…..2marks**

Definition of retentivity and coercivity **……1 mark each**

c) <u>Interference in Wedge shaped film</u>

Ray diagram **…..1mark**

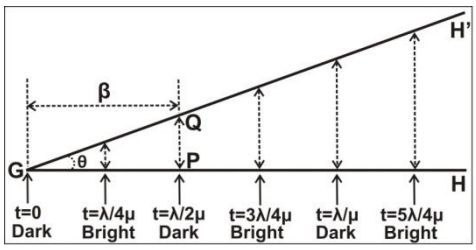
Applying the theory of thin film interference for reflected light, using conditions for minima & maxima:

$2\,\mu\,t\cos r = n\,\lambda$

$2\,\mu\,t\cos r = (2n+1)\frac{\lambda}{2}$ } **1 mark**

Using normal incidence assumption and then putting n = 0,1,2,3…. and obtaining different values of 't' **….. 1mark**

From the figure, obtaining expression for fringe width:



$\beta = \frac{\lambda}{2\,\mu\,\theta}$ **….2marks**

d) <u>Numerical problem</u>

For intrinsic semiconductor,

$\sigma_i = e\, n_i(\mu_e + \mu_h)$ **……1mark**

$= 1.6\times10^{-19} \times 2.5 \times 10^{9} \times (0.36 + 0.17)$ **….1mark**

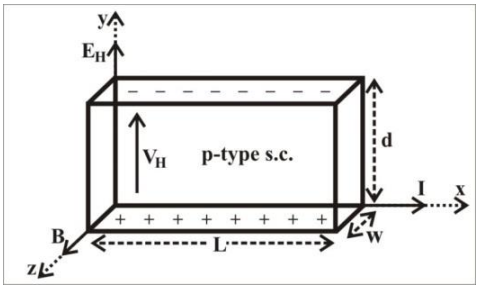
$= 2.12 \times 10^{-10}$ ohm^{-1}m^{-1} **…….1mark**

Current density, $J = \sigma_i E = 2.12 \times 10^{-10} \times 1000 = 2.12 \times 10^{-7}$ A / m^2 **…..2marks**

3. a) <u>Hall Effect and expression Hall Voltage</u>

Hall Effect definition **…… 1mark**

Diagram **……1 mark**



Explanation about magnetic and electric forces in opposite direction and obtaining $V_H = dv_d B$ **……. 2 marks**

Replacing v_d using expressions for current density and obtaining the final expression $V_H = \frac{IB}{pew}$ **……. 1mark**

b) <u>Applications of US waves</u>

(i) Detection of flaws in metals (brief expln.) **……2½ marks**

(ii) SONAR (brief expln.) **……2½ marks**

c) <u>Cathode ray oscilloscope (CRO)</u>

Block diagram of CRO **……4marks**

Purpose of time base circuit: to generate sawtooth signal **…….1mark**

d) <u>Numerical Problem</u>

In a parallel thin film, due to reflected light, condition for minima is:

$2\,\mu\,t\cos r = n\,\lambda$ **……1mark**

$\Rightarrow t = \frac{n\,\lambda}{2\,\mu\cos r}$ } **1mark**

For smallest thickness, n = 1

$t_{min} = \frac{\lambda}{2\,\mu\cos r} = \frac{6000\times10^{-10}}{2\times1.5\times\cos 45}$ **…….1mark**

$= 2.82 \times 10^{-7}$ m **……2 marks**

Part – B

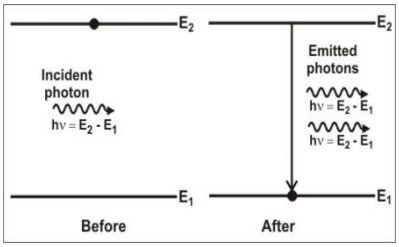
Answer **any two** questions:

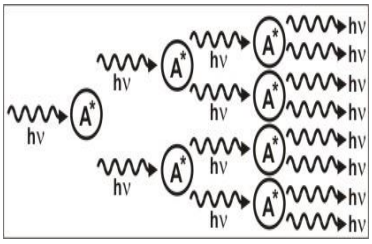
4. a) <u>Stimulated emission</u>

Energy level diagram **…… 1 mark**

Explanation of process of stimulated emission**….. 2mark**

Light amplification using stimulated emission (with diagram) **…. 2marks**





b) Bragg's Law of X-ray diffraction

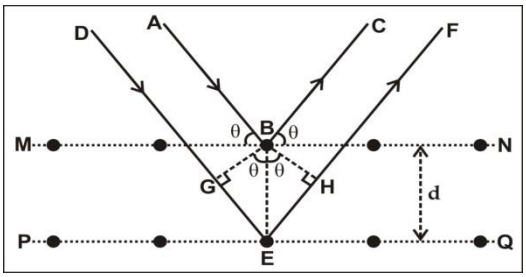


Diagram ……**1 mark**

Path difference between the rays ABC & DEF is:

$\Delta = GE + EH$ ……**1 mark**

Obtaining expression for Δ and then using condition for constructive interference and finally obtaining:

$2dsin\theta = m\lambda$ ……**3 mark**

c) Compton effect & Compton Effect experiment

Definition of Compton Effect **…… 1mark**

Diagram of experimental setup **…… 1mark**

Explanation of setup and observations **…….3 marks**

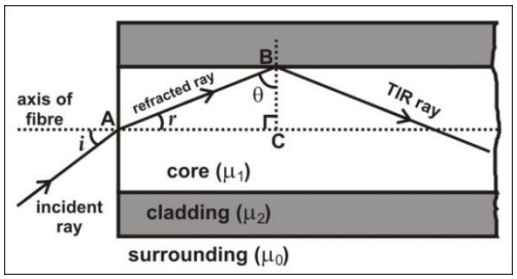
d) Numerical problem

Critical Angle, $i_c = \sin^{-1}\left(\frac{\mu_2}{\mu_1}\right) = \sin^{-1}\left(\frac{1.48}{1.5}\right) = 80.6°$ **…..2 mark**

Acceptance angle, $i_{max} = \sin^{-1}\left(\frac{\sqrt{(\mu_1^2-\mu_2^2)}}{\mu_0}\right) = \sin^{-1}\left(\frac{\sqrt{(1.5^2-1.48^2)}}{1}\right) = 14.13°$ **…2mark**

Numerical Aperture, $N.A. = \sin i_{max} = \sin 14.13 = 0.2441$ **……1mark**

5. a) Expression for Acceptance Angle & Acceptance cone



Ray diagram …… **1 mark**

Limiting condition: when $i = i_{max}, \theta = i_c$ …… **1 mark**

Using Snell's Law and critical angle formula and finally obtaining the expression:

$i_{max} = \sin^{-1}\left(\frac{\sqrt{(\mu_1^2-\mu_2^2)}}{\mu_0}\right)$ …… **3 mark**

b) Characteristic and continuous X-ray spectra

Explanation of origin of Characteristic X-ray spectra with diagram **…..2½ marks**

Explanation of origin of Continuous X-ray spectra with diagram **…..2½ marks**

c) de Broglie's hypothesis & matter waves

de Broglie's hypothesis: every particle has a wave associated with it. **…….1 mark**

de Broglie's wavelength: $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$ **……..1 mark**

Any 3 properties of matter waves **……3marks**

d) Population inversion is a state in which there are more atoms in the upper lever than in the lower level **…….. 1mark**

Numerical Problem

$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT}$ **….. 1mark**

$E_2 - E_1 = h\nu = \frac{hc}{\lambda}$
$= \frac{6.63\times10^{-34}\times 3\times10^8}{6328\times10^{-10}}$
$= 3.14 \times 10^{-19}$
} **….. 1mark**

$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT}$
$= e^{-(3.14\times10^{-19})/(1.38\times10^{-23}\times330)}$ **….. 1mark**
$= 1.13 \times 10^{-30}$ **….. 1mark**

6. a) Ruby laser

Diagram of setup **….. 1 mark**

Energy level diagram **…..1mark**

Brief explanation of setup and working **….. 2marks**

Drawbacks (any two) **……..1mark**

b) Types of optical fibres

i) Single-mode Step-index fibre (ii) Multimode step-index fibre (iii) GRIN fibre

RI profile diagrams **….1 mark**

Cross-sectional view diagrams **….2 marks**

Brief explanation of each type of fibre **…..2 marks**

c) Moseley's Law and its significance

Statement of Moseley's Law **….1mark**

Formula of Moseley's Law: $\frac{1}{\lambda} = \mathrm{R}(\mathrm{z}-\mathrm{a})^2\left[\frac{1}{\mathrm{n_f}^2} - \frac{1}{\mathrm{n_i}^2}\right]$ **……..1matk**

Significance: Correction of Mendelev's periodic table, identification of new elements, determination of atomic number **…….. 3 marks**

d) Numerical problem

Compton shift, $\lambda' - \lambda = \frac{\mathrm{h}}{\mathrm{m_0 c}}(1-\cos\theta)$ **…….1mark**

$$\Rightarrow \lambda' = \lambda + \frac{\mathrm{h}}{\mathrm{m_0 c}}(1-\cos\theta)$$

$$= 2\times10^{-10} + \frac{6.63\times10^{-34}}{9.1\times10^{-31}\times3\times10^{8}}(1-\cos 90) \quad \textbf{…..1mark}$$

$$= 2.0242\times10^{-10}\mathrm{m} \quad \textbf{……2marks}$$

Compton shift = $\lambda' - \lambda$ = 0.0242 x10^{-10}m **…..1mark**

Part – C

Answer **any one** question:

7. a) Diameter of dark rings in Newton's Rings for reflected

General expression for diameter: $\mathrm{D_n^2} = 8\,\mathrm{R\,t}$ **….1mark**

Using the theory of interference in thin films for reflected light, condition for mimimas is:
$2\,\mu\,t\cos r = n\,\lambda$ **…..1mark**

Using, normal incidence assumption we get $2\,\mu\,t = n\lambda$

$$\Rightarrow t = \frac{n\lambda}{2\,\mu} \quad \textbf{…..1mark}$$

Substituting in general expression and solving we get,

$D_n = 2\sqrt{\frac{\lambda R}{\mu}}\cdot\sqrt{n}$

$= C\cdot\sqrt{n}$ where $C = 2\sqrt{\frac{\lambda R}{\mu}}$ is a constant **2marks**

Thus, $D_n \propto \sqrt{n}$

b) Optical Resonator

Diagram of optical resonator **…..1mark**

Brief explanation **….2 marks**

Requirement of optical resonator in laser: feedback of photons & selection of direction. Brief explanation. **……..2marks**

c) Optical fibre communication system

Block diagram **…….2marks**

Explanation of block diagram **…. 2marks**

Any two advantages of optical fibres over copper wires **….1mark**

d) Numerical Problem

$\frac{1}{\lambda_{K_\alpha}} = \frac{3}{4}R(z-1)^2$ **….1mark**

$(z-1)^2 = \frac{4}{3\,\lambda_{K_\alpha} R} = \frac{4}{3 \times 1.55 \times 10^{-10} \times 1.097 \times 10^7} = 784.1$

$z - 1 = \sqrt{784.1} = 28$

$z = 28 + 1 = 29$

3 marks

The target element is Copper (atomic number 29) **…….1mark**

8. a) Expression for conductivity of a semiconductor

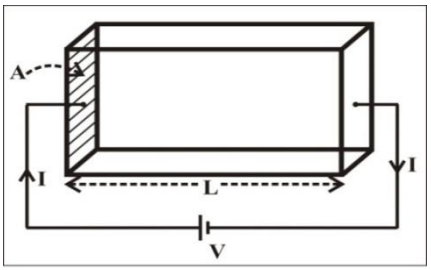


Diagram **…….. 1mark**

Using definition of current (I =Q/t) obtaining expression for J:

$J = n\,e\,v_d$ **…… 1½marks**

Using Ohm's law obtaining another expression for J:

$J = \sigma\,E$ **….. 1½marks**

Combining the above two and obtaining final expression

$\sigma = n\,e\,\mu$ **…… 1mark**

b) Soft and hard magnetic materials

Difference between soft and hard magnetic materials based on hysteresis loop **……1marks**

Any two properties each of soft and hard magnetic materials **…….2marks**

Any two applications each of soft and hard magnetic materials **…….2marks**

c) Compton effect explanation

Explanation for modified component (collision of photon & electron of scatterer) **……2½marks**

Explanation for modified component (collision of photon & nucleus of scatterer) **……2½marks**

d) Numerical Problem

Wavelength of ultrasonic waves, $\lambda_u = \frac{2n\lambda}{\sin\theta} = \frac{2\times2\times6000\times10^{-10}}{\sin5°36'} = 2.46 \times 10^{-5} m$ **……..3marks**

Velocity of USW, $v = f.\lambda_u == 1 \times 10^6 \times 2.46 \times 10^{-5} = 24.6$ m/s **……2marks**

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