ANSWER KEY OF
F.E. Semester – I (RC 2019-20) Examination, Jan/Feb 2022
PHYSICS

Part – A

Answer **any two** questions:

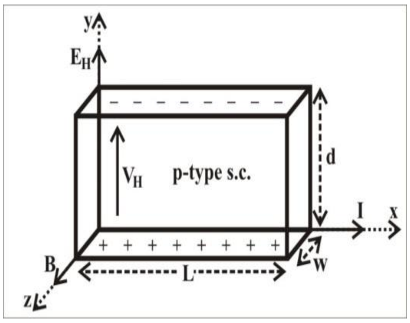
1. a) <u>Hall Effect and expression Hall Voltage</u>

Hall Effect explanation (for n-type or p-type) **…… 2mark**

Diagram **……1 mark**

Explanation about magnetic and electric forces in opposite direction and obtaining $V_H = dv_dB$ **……. 1 marks**

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



b) <u>Properties of paramagnetic substances</u>

Five properties **……..1 mark each**

c) <u>Numerical Problem</u>

$R = \frac{D_{n+p}^2 - D_n^2}{4\,p\,\lambda}$ **….. 1mark**

$= \frac{0.6^2 - 0.3^2}{4 \times 15 \times 6000 \times 10^{-8}}$ **…….. 1 mark**

$= 75$ cm **……. 1 mark**

$D_5^2 = 4 \times 5 \times \lambda R/\mu$
$= 4 \times 5 \times 6000 \times 10^{-8} \times 75/1.33$
$= 0.068$
$D_5 = \sqrt{0.068} = 0.26$cm

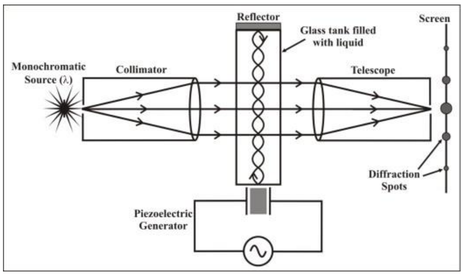
……. 2 marks

d) <u>Acoustic Diffraction Grating</u>

Diagram of setup **……. 1 mark**

Explanation of setup **……. 2 marks**

Analysis using equation of diffraction and obtaining expression for wavelength and velocity of USW. **……. 2 marks**



2. a) <u>Band theory of solids</u>

Explanation of Energy Gap **……. 1 mark**

Diagram showing band structure of conductors, insulators & semiconductors **……. 1 marks**

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

b) <u>Numerical problem</u>

To find mobility:

$\mu_h = \sigma . R_H = \frac{1}{\rho} \cdot R_H$ **……. 1 mark**

$= \frac{1}{8.93 \times 10^{-3}} \cdot 3.66 \times 10^{-4}$ **……. 1 mark**

$= 0.041$ m^2/V.s **……. 1 mark**

To find density of charge carriers:

$R_H = \frac{1}{pe}$

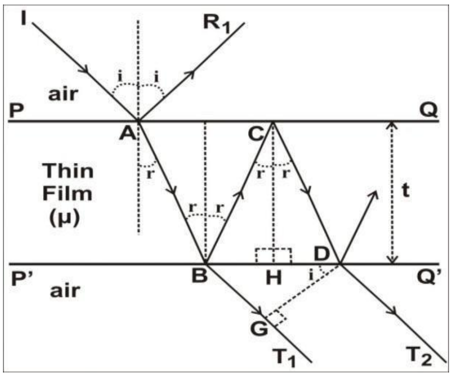
$\therefore p = \frac{1}{R_{He}} = \frac{1}{3.66\times10^{-4}\times1.6\times10^{-19}} = 1.7 \times 10^{22}$ /m^3 **……. 2 marks**

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

Block diagram of CRO **……3marks**

Vertical & horizontal signals **…….2marks**

d) <u>Interference in parallel thin film due to transmitted light</u>



Ray diagram **……. 1mark**

Equation for path difference between rays T_1 and T_2:

$\Delta = \mu\,(BC + CD) - BG$ **……. 1mark**

Simplifying and obtaining the expression:

$\Delta = 2\mu t \cos r$ **…….2marks**

Writing final conditions for maxima and minima:

$2\,\mu\, t \cos r = n\,\lambda$ (maxima)
$2\,\mu\, t \cos r = (2n+1)\,\lambda/2$ (minima) } **…1mark**

3. a) <u>Applications of USW</u>

i) Detection of flaws in metals (with diagram) **….2½marks**

ii) SONAR (with diagram) **….2½marks**

b) <u>Numerical Problem</u>

$\lambda_u = \frac{2n\lambda}{\sin\theta}$ **……..1 mark**

$= \frac{2\times2\times5893\times10^{-10}}{\sin 4°30'} = 3.004 \times 10^{-5} m$ **……. 2 marks**

$v = f.\lambda_u = 100 \times 10^6 \times 3.004 \times 10^{-5}$ = 3004 m/s **……. 2 marks**

c) <u>Diameter of dark rings in Newton's Rings for reflected light</u>

Obtaining general expression for diameter of Newton's rings using theorem of intersecting chords. $D_n^2 = 8\,R\,t$ **….2marks**

Using the theory of interference in thin films for reflected light,
condition for <u>mimimas</u> is: $2\,\mu\, t \cos r = n\,\lambda$
Using, normal incidence assumption we get $2\,\mu\, t = n\lambda$
$\Rightarrow t = \frac{n\lambda}{2\,\mu}$ } **…..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, $D_n \propto \sqrt{n}$

d) <u>Diamagnetism</u>

Explanation about diamagnetism and its origin **…..2marks**

Properties of diamagnetic substances (any three) **…..3marks**

Part – B

Answer **any two** questions:

4. a) <u>He-Ne Laser</u>

Diagram of setup ……**1 mark**
Diagram of energy level **diagram** ……**1 mark**
Explanation of construction ……**1 mark**
Explanation of working **…..2marks**

b) <u>Numerical problem</u>

Acceptance angle, $i_{max} = \sin^{-1}\left(\frac{\sqrt{(\mu_1^2-\mu_2^2)}}{\mu_0}\right) = \sin^{-1}\left(\frac{\sqrt{(1.44^2-1.41^2)}}{1}\right) = 17°$ **…2marks**

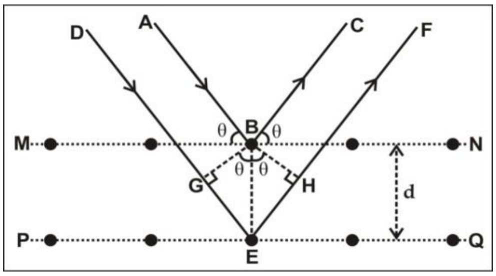
Numerical Aperture, $N.A. = \sin i_{max} = \sin 17° = 0.2924$ **……1mark**

Fractional Refractive Index Change, $\Delta = \frac{\mu_1-\mu_2}{\mu_1} = \frac{1.44-1.41}{1.44} = 0.0208$ **…. 2marks**

c) <u>Davisson-Germer Experiment</u>

Diagram of experimental setup **…… 1mark**
Brief explanation of setup **…… 1½mark**
Oservations, analysis and inference from experiment showing that electrons behave like waves **…….2½ marks**

d) <u>Bragg's Law of X-ray diffraction</u>



Brief explanation about x-ray diffraction ……**1 mark**
Bragg's law ray 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:
$2d\sin\theta = m\lambda$ ……**2marks**

5. 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) <u>Numerical Problem</u>

i) For ball

$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{10\times10^{-3}\times10} = 6.63\times10^{-33}$m **…….2½ marks**

ii) For electron

$\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times100\times1.6\times10^{-19}}} = 1.22\times10^{-10}$m **…….2½ marks**

c) <u>Compton effect & Compton Effect experiment</u>

Diagram of setup of Compton Effect experiment **…… 1mark**
Explanation of experiment and observations**…… 3marks**
Explanation for un-modified component (collision of photon & nucleus of scatterer) **……1mark**

d) <u>Moseley's Law</u>

Statement of Moseley's Law **….. 1 mark**
Equation of Moseley Law **…..2marks**
Significance of Moseley's Law: Correction of periodic table & determination of atomic number of new elements **…..2 marks**

6. a) <u>Numerical Problem</u>

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

$$E_2 - E_1 = h\nu = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times 3\times10^{8}}{6328\times10^{-10}} = 3.14 \times 10^{-19}$$ **….. 2marks**

$\frac{N_2}{N_1} = e^{-(E_2 - E_1)/KT}$

$= e^{-(3.14\times10^{-19})/(1.38\times10^{-23}\times330)}$ **….. 1mark**

$= 1.13 \times 10^{-30}$ **….. 1mark**

b) <u>Numerical Aperture and fractional refractive index difference</u>

$\mathrm{N.A.} = \sin \mathrm{i}_{\mathrm{max}}$ **….. 1mark**

Using the expression for $\mathrm{i}_{\mathrm{max}}$ we get,

$\mathrm{N.A.} = \left(\frac{\sqrt{(\mu_1^2 - \mu_2^2)}}{\mu_0}\right)$ **….. 2mark**

Fractional Refractive Index Difference,

$\Delta = \frac{\mu_1 - \mu_2}{\mu_1}$ **…..1mark**

Expression for Numerical Aperture in terms of Fractional Refractive Index Difference

$N.A. = \mu_1\sqrt{2\Delta}$ **…..1mark**

c) <u>Characteristic X-ray spectra</u>

Diagram showing incoming electron and target atom **….1 mark**

Explanation of production of Characteristic X-ray spectra **…..4 marks**

d) <u>Types of optical fibres</u>

Step-index fibre & GRIN fibre

RI profile diagrams **….1 mark**

Cross-sectional view diagrams **….1 marks**

Brief explanation of each type of fibre **…..3 marks**

Part – C

Answer **any one** question:

7. a) <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:

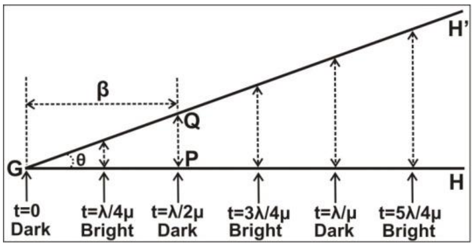
$2\,\mu\,t\cos r = n\,\lambda$

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



b) <u>Magnetostriction mrthod of producing USW</u>

Brief explanation about magnetostriction **…..1mark**

Circuit diagram of magnetostriction oscillator **…..1mark**

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

c) <u>Numerical problem</u>

Intrinsic concentration (of electrons & holes) = 2.5 x $10^{19}/m^3$

Since donor impurities are added to pure Ge, concentration of holes will remain same as intrinsic concentration, whereas concentration of electrons will increase to: intrinsic concentration + concentration of donors.

Hence, conc. of holes, $p =$ 2.5 x $10^{19}/m^3$, and

Conc. of electrons, $n =$ 2.5 x 10^{19} + (4.2 x 10^{28} / 10^6) = 4.2025 x $10^{22}/m^3$

Conductivity, $\sigma = n\, e\, \mu_e + p\, e\, \mu_h$

$= e(n\ \mu_e + p\, \mu_h)$

= 1.6 x 10^{-19} x (4.2025 x 10^{22} x 0.36 + 2.5 x 10^{19} x 0.18)

= 2421.36 $\Omega^{-1}m^{-1}$

Resistivity, ρ = 1/ σ = = 4.13 x 10^{-4} Ω-m

d) <u>Hard and Soft magnetic materials</u>

Five differences **….. 1 mark each**

8. a) <u>Four-level pumping scheme</u>

Energy level diagram (before/after) **….. 1 mark**

Explanation of process of pumping and obtaining population inversion **…..3marks**

Advantages: requires less pumping power **….. 1 mark**

b) <u>Optical fibre communication system</u>

Block diagram of one-way communication system using optical fibre link **….1 mark**

Explanation of the block diagram **….3 marks**

Two advantages of using optical fibres over copper wires for communication **…..½ mark each**

c) C<u>ontinuous X-ray spectra</u>

Explanation of origin of Continuous X-ray spectra with diagram **…..3 marks**

Equating loss of K.E. of electron to photon energy and then obtaining expression for cut-off wavelength, $\lambda_{min} = \frac{hc}{eV}$ **…… 2 marks**

d) <u>Numerical Problem</u>

We have, KE, $E = \frac{1}{2}mv^2 = eV$ **….. 1 mark**

Also we have from de Broglie's wavelength formula,

$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2meV}}$ (Substituting for E from above equation) **….. 1 mark**

Squaring both sides and rearranging we get,

$V = \frac{h^2}{2me\lambda^2} = \frac{(6.63\times10^{-34})^2}{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times(0.4\times10^{-10})^2} = 943.44$ volts **….. 2 marks**

Kinetic Energy of this electron will be, $E = eV = 1.6\times10^{-19}\times943.44$

$= 1.51\times10^{-16}$ J **….. 1 mark**

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