Diamond Harbor Women's University
Department of Physics
M.Sc. 4th Semester Examination 2022
Subject: Physics
Paper- PHY/DCA/TH/401A

FM=40 **Time= 2 hrs**

Group A (Answer any two)

1. (a) What is de Hass-van Alphen effect? Mention one application of it. Briefly discuss the origin of this effect.

(b) What is Landau level? Calculate the total energy in the presence of a magnetic field applied along the z-direction. **(1+1+2) + (1+5) = 10**

2. (a) What is cyclotron frequency? Calculate the cyclotron frequency when an electron moves in a magnetic field.

(b) Write down linearized Boltzmann transport equation and hence show that electrical conductivity is a tensor. **(1+3) + (2+4) = 10**

3. (a). What is the transconductance of an FET? Show its dependence with built-in potential.

(b). The transconductance and AC drain resistance of a FET are 0.2 mA/V and 150 kΩ, respectively. This device is used in CS configuration with load resistance 150 kΩ. Determine the small signal voltage gain.

(c). Show that in Gummel-Poon model of a BJT, β is proportional to $I_C^{(1-1/n)}$ for low V_{EB}. Where symbols have their usual meaning. **(1+3) + 3 + 4 = 10**

Group B (Answer any two)

4. (a) Two photodiodes, each with an effective area of 10 cm^2, are exposed to bichromatic radiation having power densities of 500W/m2, in narrow bands one around 430 THz and the other, around 600 THz. One diode has a bandgap energy of 1 eV, the other has 2 eV. When diode is reverse biased (in the dark), the saturation current is 10 nA. The diodes operate at 300 K.

i) What are the short-circuit photo currents?

ii) What is the open-circuit voltage of each diode?

iii) What is the maximum theoretical efficiency of each diode?

iv) What is the maximum power each diode can deliver to a load (assume no series resistance in the diodes)?

(b). What is a IMPTT diode? Calculate the AC impedance part of an IMPATT diode. What are the major differences between BARITT diode and IMPATT diode?

(1.5+1.5+1.5+1.5)+(1+2+1)=10

5. (a) What do you mean by a tunnel diode? Draw an ideal IV characteristics of tunnel diode and explain its characteristics.

(b). State and explain Ramo's theorem.

(c). For a given value of Gunn parameter calculate the current density and negative electron mobility.

Threshold field E_{th} = 2800 V/cm

Applied field E = 3200 V/cm

Device length (L) = 10 μm

Doping concentration = 2×10^{14} cm^{-3}

Operating frequency (f) = 10 GHz

Drift Velocity (V_d)= 10^7 cm/s.

(1+3)+2+(2+2)=10

6. (a). Show that the values of numerical aperture (N.A) and Dispersion of an optical fiber have dependence of the refractive index of core and cladding.

(b) Show that output efficiency(η) of a photodetector relates with

$\eta=(1-R)\times(1-e^{-\alpha d})\times\xi$

where R=Reflectivity

d= material thickness

α=Abs. coefficient

ξ= Fraction of photons generates excitons.

(c) Calculate the thickness of the material where 90% of the incident light can be absorbed, let's say absorption coefficient = 20000.

(d). Explain the origin of negative resistance of a Gunn Diode. **2+3+2+3=10**

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Group A
(Answer any two)

1. (a) Find the normal mode frequencies of a diatomic linear chain.
   (b) Write down the scattering amplitude of a neutron scattering phenomena and hence calculate the Debye Weller factor. **5+(1+4) =10**

2. (a) What do you understand by the effective mass of an electron? Explain its significance.
   (b) Discuss Kronig-Penny model for the energy band structure of solids. Show that each band can accommodate 2N electrons where N is the total number of atoms in the crystals. **(2+2) + (4+2) = 10**

3. Electrical resistivity of copper and nickel at room temperature are 1.65×10^{-8} and 14×10^{-8} Ωm respectively. If quantum treatment is applied to these materials, find the electronic contribution to thermal conductivities of these materials.

   (b). Calculate the Hall co-efficient of sodium on free electron model, given that sodium has a $b\ c\ c$ structure of cell side 4.28 Å. Hence determine the electron mobility for conductivity of $1 \times 10^{-1}\ (\Omega\ cm)^{-1}$.

   (c). Describe the phenomenon of cyclotron resonance in metals and semiconductors and explain its applications.

   3 + (2+2) + (2+1) = 10

Group B
(Answer any two)

4. (a) Explain AC Josephson effect. Show that the supercurrent of superconducting pairs across the junction oscillates with frequency $\omega = \left(\frac{2eV}{\hbar}\right)$.

   (b) Show that because of field penetration, the critical field of a superconducting slab of thickness t is of the order of $B_c\ (1+\frac{\lambda}{t})$, where B_c is the critical field for the bulk sample.

   (Assume that the free energy difference between the normal and the superconducting states is independent of the specimen size.)

(c) On heating crystals of KCl in potassium vapours, the crystal start exhibiting a violet colour, why? **5+3+2=10**

5. (a) What kind of defect is present in $Fe_{0.93}O$ compound? Find the percentage of Fe^{2+} and Fe^{3+} ions in this compound.

(b) Consider a gas containing N similar atoms/m^3 of polarizability α placed in an ac field. Show that the dielectric constant of the gas is given by

$$\varepsilon = 1 + \frac{Ne^2}{m\varepsilon_0(\omega_0^2 - \omega^2 - i\gamma\omega) - \frac{1}{3}Ne^2}$$, terms have their usual meanings

(c) Discuss Fick's first law. Hence derive Fick's second law in connection with diffusion inside solid.

2+4+(1+3) =10

6. (a) Show that the Photoconductivity of a pure crystal is given by $\sigma = n_0 e\sqrt{L}$ where L is the number of photons incident on the crystal per unit volume and n_0 is the number of charge carriers at equilibrium.

(b) What is trap center? How the above expression for photoconductivity is modified due to the introduction of N number of trap center into the crystal?

(c) Explain the terms dielectric loss and dielectric breakdown.

4+(1+3)+2=10

DHWU

M.Sc. (2nd Year) 4th Semester Examination, 2022

Subject: Physics

Paper: Astrophysics

PHY/DCE/TH/402A

Time: 2 Hours **Full Marks: 40**

Answer any four questions taking two from each group.

Answers to the questions should be written in the candidates own words as far as practicable.

Group – A

1. (a) At Diamond Harbour (latitude $22^0 22' N$), a star is observed to cross the meridian at $44^0 2' H$ of Zenith. Find its declination.

   (b) What do you mean by '*Pogson*' scale? What are the disadvantages of this scale? Compare (the order of magnitude) the luminosities of the Sun and a star whose magnitudes of the brightness are -26.75 and -1.75 respectively.

   (c) Write a short note on multi-wave astronomy.

   [2+(1+1+2)+4=10]

2. (a) Find the optical depth (τ) in a media for which a passing radiation's intensity falls to $1/e^9$ of its initial one. If the said media has a constant mass absorption factor ($k_\nu = 1$) then find the elementary distance (s) traveled by the radiation in this problem. It has been given that the density of the media is proportional to s^2 with a proportionality constant 1.

   (b) Derive the *Embden* equation for a system with polytropic index n. What can you infer about the system characteristics for a fractional n?

   [(2+2)+(4+2)=10]

3. (a) Write a short note (point wise) on "Star formation".

   (b) Lets say a star has a mass around $2.44 M_\odot$ and a radius, twice that of the radius of the Earth. The star has burnt all the fuels inside and now shrinking due to its enormous gravitational contraction. What is the possibility of the star to end up becoming a white dwarf. Discuss with physical reasons.

(c) Why do we need Fermi gas model to describe the formation of White Dwarfs?

[5+3+2=10]

Group – B

4. (a) What is the change in understanding the age of the universe with and without gravity?

   (b) Show that the rate of change of the redshift of a galaxy with respect to earlier time is given by

$$\frac{dz}{dt_e} = (1+z)^2 \left[H_0 - \frac{H}{(1+z)} \right].$$

   Thereafter, show that there is no change in the redshift for a curvature dominant model of the universe. The symbols carry their usual meanings.

   (c) Let us assume that there are two containers of plasma with equal electron number densities. The equilibrium temperatures for the electrons in those two containers are respectively as $900K$ and $1024K$. Compare the screening lengths for those plasma systems.

   (d) Write down the *Schwarzschild* metric and discuss about its singularities.

[2+(3+1)+2+2=10]

5. (a) Define the deceleration parameter $q(t)$ and discuss about the physical understanding regarding the acceleration of the universe.

   (b) Two events occur at redshifts 8 and 3 respectively. Find the physical distance between them for a positively curved universe model. Also find the respective times taken by a radiation to reach us from those two event points.

   (c) What are magnetic viscosity and magnetic Reynolds number?

[2+(4+2)+2=10]

6. (a) How can you relate the Saha ionisation to the formation of plasma at earth? Can every ionised gas be labelled with the term 'plasma'? Explain.

   (b) Derive the dispersion relation for the electron plasma wave (1-D) with the assumption that the electromagnetic field is electrostatic. Also, assume that the equilibrium velocity of the electron fluid is zero. Now, what would be the change in the dispersion if the equilibrium velocity is finite and constant?

[(1+2)+(5+2)=10]

DHWU

M.Sc. (2nd Year) 4th Semester Examination, 2022

Subject: Physics

Paper: PHY/DCE/TH/403A (Nuclear Physics)

Time: 2 Hours | Full Marks: 40

Answer any 4 questions taking two from each group.

Answers to the questions should be written in the candidates own words as far as practicable.

Group – A

1. (a) State the form of the magnetic moment operator for a nucleus ${}_zX^A$. Show that in case of an odd-even nucleus with odd number of protons the nuclear magnetic moment, when $j = \ell - 1/2$, is given by an expression of the form $\mu = \mu_N \left[Aj + \frac{Bj}{j+C} \right]$. Determine the values of A, B and C in the above expression. Calculate the value of the magnetic moment of ${}_1H^3$ for $j = \frac{1}{2}$; the gyromagnetic ratios of a proton are $g_\ell(p) = 1$ and $g_s(p) = 5.6$ respectively.

   (b) Define the nuclear mean square charge radius and calculate its value for the spherically symmetric charge distribution, $\rho(r) = \rho_0 \left(1 + \frac{r}{a}\right) e^{-r/a}$, where ρ_0 and a are constants.

[7+3=10]

2. (a) Define the nuclear form factor and explain its significance. Show that to a first approximation $F(q^2) \approx 1 - \frac{q^2}{6\hbar^2}\langle r^2 \rangle$, when $\frac{q\langle r \rangle}{\hbar} << 1$. Assuming $\int_{R^3} \rho(\vec{r}) d^3\vec{r} = 1$, calculate the nuclear form factor for the spherically symmetric charge distribution $\rho(r) = \rho_0 \frac{e^{-r/a}}{r}$.

   (b) Show that in the extreme single particle shell model the quadrupole moment of a single odd proton nucleus is given by, $Q = -\sqrt{\frac{5}{16\pi}} \frac{(2j-1)}{2(j+1)} \langle r^2 \rangle$. Note that the Clebsch-Gordon coefficient and the formula for the reduced matrix element are given by

$$\begin{bmatrix} j & 2 & J \\ m & 0 & M \end{bmatrix} = \frac{3M^2 - J(J+1)}{\sqrt{J(J+1)(2J-1)(2J+3)}},$$

and

$$\langle \ell \tfrac{1}{2} j || Y_k || \ell' \tfrac{1}{2} j' \rangle = \frac{1}{2} \sqrt{\frac{2k+1}{4\pi}} (1 + (-1)^{\ell+\ell'+k})(-1)^k \begin{bmatrix} j & k & j' \\ \frac{1}{2} & 0 & \frac{1}{2} \end{bmatrix}.$$

[(3+4)+3=10]

$$O_{GT} = G_A \sum_{j=1}^{A} \sigma(j)\tau^{\pm}(j).$$

Show that the transition probability between an initial state ($|i\rangle$) and final state ($|f\rangle$) of a nucleus is

$$S_{\pm} = G_A^{-2} \sum \langle i| \, |O_{GT}^{*} O_{GT} \, |i\rangle,$$

where notations have their usual meanings. Hence show that $S_- - S_+ = 3(N - Z)$ where N and Z are the number of neutrons and protons present in the given nucleus.

(c) Defining the isospin raising (τ_+) and lowering (τ_-) operators as $\tau_{\pm} = \frac{1}{2}(\tau_1 + i\tau_2)$ evaluate $\langle p| \, (\tau_+\tau_-)^q \, |p\rangle$, where q is any nonzero positive integer. The other symbols carry their usual meanings.

[2+(4+2)+2=10]