U.G. 3rd Semester Examination - 2023
PHYSICS
[PROGRAMME]
Course Code : PHY-G-CC-T-03-(A&B)

Full Marks : 40   Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer all the questions from selected option.

OPTION-A

PHY-G-CC-T-03

(Elements of Modern Physics)

GROUP–A

1. Answer any **five** questions: $2 \times 5 = 10$

    a) How does the frequency of incident light affect the photoelectric effect ?

    b) What are the magic and semi-magic numbers?

    c) What is the hypothesis of De Broglie ?

    d) What is population inversion ?

    e) What is the group velocity of a wave packet ?

[Turn over]

f) Show that $[\hat{x}, \hat{p}_x] = ih/2\pi$.

g) What is neutrino? What are the basic differences between a neutrino and an antineutrino ?

h) What is the physical significance of normalizing a wave function?

GROUP–B

2. Answer any **two** questions: 5×2=10

a) Calculate the normalization constant for a wave function (at t = 0) given by $\psi(x) = Ae^{-\alpha x^2/2}e^{ikx}$. Determine the probability density and probability current density of the wave packet.   2+1+2

b) What do you mean by inverse beta decay ? How can the continuous nature of the beta-ray spectrum be explained theoretically? Does parity remain conserved in case of beta decay?   1+3+1

c) Define the binding energy of a nucleus. How does the binding energy per nucleon vary with the mass number ? Give examples of isotope and isotone.   2+2+1

d) What is the Compton wavelength ? Explain the presence of the unmodified line in Compton scattering. Will there be any Compton shift for light in the visible range ? 1+2+2

GROUP–C

3. Answer any **two** questions: $10 \times 2 = 20$

a) Give a short description of construction and working principle of RUBY laser. Derive relations between Einstein's A and B coefficients. What is optical pumping in laser action?

$4+4+2$

b) i) State and explain Heisenberg's uncertainty principle.

ii) Explain why free electrons can not exist in atomic nuclei.

iii) The ground state and the first excited state wave functions of an atom are ψ_0 and ψ_1 respectively, the corresponding energies being E_0 and E_1. If the system has a 40% probability of being found in the first excited state, find the wave function and the average energy of the atom?

$2+3+5$

440/Phs. (3) [Turn over]

c)   i)   What is the photoelectric effect ?

     ii)   The maximum kinetic energy of photoelectron is 1.3 eV when ultraviolet light of wavelength 350 nm is directed at a potassium surface. Find the work function of potassium.

     iii)   A particle of mass m is free to move in a force-free region in one dimension between two rigid walls situated at $x = -L/2$ and $x = +L/2$. Find the eigenfunctions and eigenvalues of the Hamiltonian. Sketch the ground state wave function.   1+3+6

d)   i)   The nuclei are approximately spherical and have an average radius r given by $r = R_0 A^{1/3}$ where A is the mass number and R_0 is a constant equal to 1.2×10^{15} m. If the mass of proton and neutron be approximately equal to 1.6×10^{-27} kg then show that the nuclear density is greater than the density of water by a factor 10^{14}.

     ii)   Show from the semi-empirical mass formula, that $A \simeq 2Z$ for light nuclei .

iii) A nucleus with A = 235 splits into two nuclei whose mass no. are in the ratio 2:1. Find the radii of the new nuclei. (R_0 = 1.4 *fm*)   4+4+2

OPTION-B

PHY-G-CC-T-03

(Analog Systems and Applications)

GROUP-A

1. Answer any **five** questions: $2 \times 5 = 10$

   a) What do you mean by drift velocity of charge carriers? Write down its SI unit.

   b) In the light of band theory distinguish metal, conductor and semiconductor.

   c) Explain Zener breakdown and avalanche breakdown.

   d) Define static and dynamic resistances of a p-n junction diode.

   e) With the help of a schematic diagram explain the use of a filter in a rectifier circuit.

   f) Derive relation between α and β of a transistor.

   g) With the help of a neat diagram show the frequency response of an R-C coupled amplifier. What do you mean by bandwidth?

   h) Explain the necessary condition for working a feedback amplifier as oscillator.

GROUP–B

2. Answer any **two** questions: $5 \times 2 = 10$

a) Write down the full form of LDR. Draw the V-l curve of a forward biased LED. Write down two advantages of LED. Write two applications of a photodiode. $1+1+1\frac{1}{2}+1\frac{1}{2}=5$

b) With the help of a neat diagram explain the working principle of a full wave bridge rectifier. Write down its two disadvantages. $3+2=5$

c) Define load line. Explain class A and Class B and class AB amplifiers. $2+3=5$

d) What do you mean by the hybrid parameters of a transistor? Why are they called so? Explain the terms h_{oe} and h_{fe} in a transistor. Define decibel gain. $1+1+2+1=5$

GROUP–C

3. Answer any **two** questions: $10 \times 2 = 20$

a) What do you mean by inverting and non-inverting OP-AMP? Derive the expression for current gain in a non-inverting OP-AMP. Explain briefly the working principle of an OP-AMP as a subtractor. For the circuit given below determine the value of V_0. $2+3+2+3=10$

330 kΩ

33 kΩ

V_1

+9 V

10 kΩ

V_2

−

+

V_0

−9 V
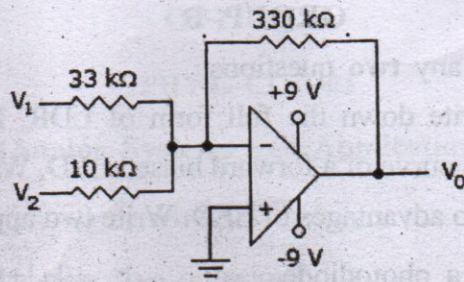
b) With the help of necessary circuit diagram explain the working principle of a RC coupled amplifier. Write a short note on the D/A converter. 5+5=10

c) What do you mean by intrinsic and extrinsic semiconductors? Draw energy band diagrams of a p-type and n-type semiconductor. Using the schematic diagram explain the effect in potential barrier height due to forward and reverse biasing in a p-n junction diode. Explain the working principle of a zener diode as voltage regulator. 2+2+3+3=10

d) Explain the terms CMRR and virtual ground. Establish the relation $\dfrac{D_p}{\mu_p} = \dfrac{kT}{e}$; The symbols have their usual meanings. Write down the principle of multi-stage amplifiers. Write down two origins of noises in an amplifier. 2+4+2+2=10

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PHY-G-CC-T-03 **(Thermal Physics and Statistical Mechanics) - 2023**
(GENERAL)
Full Marks: 40
GROUP- A
(Symbols have their usual meaning.)
1. Answer any five questions 2x5=10

a) Write down the first law of thermodynamics explaining each term.
b) Name one boson and one fermion.
c) What are the basic assumptions for the kinetic model of gaseous system?
d) One mole of an ideal gas at 0^0C is isothermally expanded from 1 litre to 2 litre. Find the work done?
e) What is black body radiation?
f) Represent a Carnot cycle on i) $p-v$ diagram, ii) $S-T$ diagram.
g) What is an isenthalpic process, discuss with an example.
h) Write down the Maxwell Boltzmann molecular velocity distribution law explaining all the symbols used.

GROUP- B   2x5=10
2. Answer any two questions.

a) Define mean free path of gas molecules. Show that the probability of gas molecule traveling a distance x without collision, is $e^{x/\lambda}$, where λ is the mean free path of the gas molecule. 1+4

b) Discuss the concept of quasistatic process in thermodynamics. During a quasistatic adiabatic expansion of an ideal gas, the pressure at any moment is given by the equation $PV\gamma=K$, where γ and K are constants. Show that the work done in expanding from a state (Pi,Vi) to a state (Pf,Vf) is $W = -\frac{P_iV_i-P_fV_f}{\gamma-1}$.
2+3

c) A Carnot engine operates between T_1 and T_2 with gas as working substance whose equation of state is given by $P(V-b)=RT$. Work out expression for heat absorbed and the work done in each part of the cycle and show that the efficiency $\eta=1-T_2/T_1$.   2+2+1

d) What do you mean by phase space? Write Bose- Einstein distribution law and Fermi- Dirac distribution law explaining each term.   2 + 1.5+1.5

GROUP- C

3. Answer any two questions. 2x10=20

a) Write down four Maxwell's relations. Write down the first and second TdS equations. Hence prove the

$$C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P.$$

relation   4+3+3

b) Derive Planck's radiation law in case of black body radiation. In what conditions that Planck's law reduces to Wein's law and Rayleigh- Jeans law? Calculate the total rate of radiation of energy of a thin circular disc of radius 10 cm, heated at 500^0C. 5+2+3

c) What is Joule- Thomson effect? Show that the Joule- Thomson coefficient μ can be derived as

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$$

. Hence show that ideal gas does not show any Joule- Thomson effect. What do you mean by inversion temperature? Write short note on Clausius- Clapeyron equation. 2+3+1+1.5+2.5

d) What is the principle of increase of entropy? Calculate the change of entropy for an ideal gas which undergoes an isothermal expansion. What do you mean by Gibb's free energy? Show that for an infinitesimal reversible process $dG=-SdT+VdP$ (symbols have their usual meaning). Also show that in case of a reversible isothermal and isobaric process Gibb's free energy remains constant. 2+3+1+3+1