U.G. 6th Semester Examination-2025

PHYSICS

[PROGRAMME]

Discipline Specific Elective (DSE)

Course Code : PHY-G-DSE-T-02(A-B)

[New Syllabus]

Full Marks : 40/60 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.

Answers must be precise and to the point to earn credit.

All symbols are of usual significance.

Answer all the questions from Selected Option.

OPTION-A

PHY-G-DSE-T-02A

(Solid State Physics)

[Marks : 40]

1. Answer any **five** questions: 2×5=10

a) What is a Bravais Lattice?

b) Describe how Bragg's Law explains formation of X-ray Diffraction peaks from crystals.

c) Distinguish between acoustical and optical phonons in connection with a diatomic linear chain.

d) What is the main difference between Debye theory and Einstein theory of specific heat? What do you mean by Debye temperature?

e) What is the difference between paramagnetism and diamagnetism?

f) Explain piezoelectric effect.

g) Explain hall coefficient.

h) What do you mean by type I and type II superconductor?

GROUP-B

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

a) Define an unit cell of a crystal lattice. Find the number of atoms per unit ccll for a f.c.c lattice. Define reciprocal lattice. 1+2+2

b) Explain the main features of Einstein's theory of lattice heat capacity. Write down the expression of heat capacity calculated using Einstein's theory and explain the high and low temperature behavior. 1+4

c) State and explain Curie Law. Derive an expression for paramagnetic susceptibility at ordinary temperature and magnetic field according to quantum theory of magnetism. 1+4

d) Show that diamagnetic susceptibility of a material of temperature independent. 5

GROUP-C

3. Answer any **two** questions : 10×2=20

a) What is Bloch theorem? Find the energy bands of electrons for a one dimensional periodic potential of period $(a+b)$ defined as $V = 0$ *for* $0 \le x \le a$ and $V = V_0$ *for* $a \le x \le b$, where $V_0 \to \infty$, $b \to 0$ and $V_0 b$ finite. Show that an energy band of a crystal comprising of N primitive unit cell can accommodate 2N electrons. 2+5+3

b) Explain Hall effect. Consider a metal having electron as only charge carriers. Calculate the Hall-coefficient. Define mobility of a charge carrier. Establish the relation between electrical conductivity and mobility for a metal. 2+3+2+3

c) Define the terms electric displacement **D**, electric field E, and polarization **P**, Establish the relationship between **D**, **E** and **P**. Define atomic polarizability. Deduce the Clausias-Mossotti relation between atomic polarizability and dielectric constant. 3+2+5

d) Distinguish between conductor and semiconductor in terms of Band theory. Explain what is effective mass of electron in a band. Explain how the conductivity of semiconductor varies with temperature. What is ferroelectricity? Explain '*polarization catastrophe*'. 2+2+3+1+2

OPTION-B

PHY-G-DSE-T-02B

(Nuclear & Particle Physics)

[Marks : 60]

GROUP–A

1. Answer any **ten** questions: 2×10=20

a) Write down the quark content of Anti Proton and Neutron.

b) Write down the classification of elementary particles with examples.

c) What is s-process path?

d) What is Cyclotron Accelerator? Name one such Cyclotron facility in India.

e) What are the principal processes by which γ rays interact with matter?

f) Calculate the wavelength and frequencies of γ rays of energies 1.0 and 8.0 MeV.

g) The radius of $^{64}_{29}Cu$ nucleus is measured to be 4.8×10^{-13}cm. Estimate the radius of a $^{49}_{25}Mg$ nucleus?

h) The $^{238}_{92}U$ nucleus decays to stable $^{206}_{82}Pb$ nucleus by emitting how many α and β disintegrations?

i) What do you mean by Q-value of a nuclear reaction?

j) The best possible detector for γ - rays detection is (a) Proportional Counter (b) Gas detector (c) NaI(Tl) scintillation detector (d) High purity Germanium detector.

k) What do you mean by Impact parameter in case of Rutherford Scattering of α -particles?

l) What are the basic β - decay process in a nucleus like ${}^{A}_{Z}X_{N}$?

m) If the half-life of ${}^{90}_{30}Sr$ is 28.8 years, then find out its decay constant?

n) The lepton number is conserved for the following decay process or not. Describe it properly.

$$\mu^{+} \rightarrow e^{+} + \overline{\nu}_{e} + \nu_{\mu}.$$

o) The relativistic mass of an electron is twice that of its rest mass. What should be its velocity and kinetic energy?

GROUP–B

2. Answer any **four** questions : 5×4=20

a) Write down the advantages of Semiconductor detectors over other type of radiation detectors? Calculate the minimum kinetic energy of proton at which Cherenkov radiation will produce in a medium of refractive index 1.5 (for Protons $Mc^2 = 938.3\ MeV$). 2+3

b) Describe briefly the principle of operation of Cyclotron accelerator. Assuming a magnetic field of 1.4 T, compute the maximum energy of protons that can be obtained from a cyclotron of radius 75 cm? 3+2

c) What are the magic numbers of nuclear shell model? Explain. What are the evidences of shell structure in the nuclei? 2+3

d) What do you mean by conservation laws of nuclear reactions? What is compound nucleus model of nuclear reactions? 3+2

e) What do you mean by Baryon number conservation? Give an example where baryon number is conserved? In which interaction strangeness must be conserved? 2+2+1

f) What is neutrino hypothesis in the context of β - decay of a nucleus? Write down the expression of the Q values for the following β - decay processes:

${}^{A}_{Z}X_{N} \rightarrow {}^{A}_{Z+1}X'_{N-1} + \beta^{-}$ and ${}^{A}_{Z}X_{N} \rightarrow {}^{A}_{Z-1}X'_{N+1} + \beta^{+}$

2+3

GROUP–C

3. Answer any **two** questions : 10×2=20

a) Discuss briefly the theory of α -emission? The radioactive ${}^{212}_{84}Po$ nucleus decays to the ground state ${}^{208}_{82}Pb$ by α - emission. Calculate the Q value of the decay process in Mev? Given the mass of ${}^{212}_{84}Po$ is 211.988874 amu, ${}^{208}_{82}Pb$ is 207.976658 amu and ${}^{4}_{2}He$ is 4.002603 amu. Discuss briefly

about the principal processes by which γ-rays interact with matter? 4+3+3

b) Define (i) nuclear binding energy, (ii) mass defect, (iii) packing fraction and (iv) binding fraction of a nucleus? "The nature of binding fraction curve is complementary to the nature of the packing fraction curve"- explain. Discuss about the similarities between the nucleus of an atom and a liquid drop. Let E_s denote the contribution of the surface energy per nucleon in the semiempirical mass formula. Calculate the ratio $E_S\left({}^{27}_{13}Al\right) : E_S\left({}^{64}_{30}Zn\right)$. 4+3+2+1

c) Discuss briefly the basic principle of the action of the scintillation detector. Write down the use of Photo multiplier tube. Write a short note on basic operation of Van de Graaff generator. 4+2+4

d) What do you mean by quark model of particle physics? What are colour quantum numbers? What does the roles play by gluons in strong interactions? What is the basic difference between photons and gluons? 4+2+2+2
