1 (Sem–5/FYUGP) PHY01MJ

2025

PHYSICS

(Major)

Paper : PHY0500104

(Atomic and Molecular Physics)

Full Marks : 60

Time : 2½ hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×8=8

   (a) Write *one* limitation of Bohr's atomic model.

   (b) The radius of 1st orbit of hydrogen atom according to Bohr's model is 0·52Å. What is the radius of the 2nd orbit ?

   (c) The spectral lines of which series of hydrogen spectrum are in the visible region ?

   (d) In spectroscopic term $^2S_{\frac{1}{2}}$, what does $\frac{1}{2}$ represent ?

(e) Draw the figure of transition of sodium D_1 line indicating the energy states.

(f) Why X-ray beam cannot be deflected by electric or magnetic field?

(g) For *Ne* atom the atomic number is 10. Write the electronic configuration according to AUFBAU principle.

(h) Write *one* difference between Infrared spectroscopy and Raman spectroscopy.

2. Answer ***any six*** of the following : 2×6=12

(a) What are the *two* assumptions of Sommerfeld's atomic model?

(b) The orbital quantum number (l) of an electron is 2. Find the possible magnetic orbital quantum number (m_l).

(c) The spectroscopic notation of the ground state of *Na* atom is $^2S_{\frac{1}{2}}$. Find the value of S, L and J.

(d) State Moseley's law and write it mathematically.

(e) Calculate the minimum voltage that must be applied to an X-ray tube to produce X-ray photon of wavelength 0·1Å.

(f) Explain Hund's rule.

(g) Define Gyromagnetic ratio.

(h) What is Stark effect?

(i) The total energy of a molecule depends on three factors. Write the name of *any two* factors.

(j) Under what condition, the Bragg's equation will have no solution?

3. Answer ***any four*** of the following : 5×4=20

(a) Explain fine structure of H_α line using Sommerfeld atom model.

(b) Write the postulates of vector atom model. State different quantum number associated with this model.

(c) Explain *L-S* coupling and *J-J* coupling.

(d) State Pauli's exclusion principle. Using this principle, calculate the maximum number of electron that *M* shell may have. 2+3=5

(e) Explain the spectra of alkali metal atom *Na*.

(f) Calculate Lande '*g*' factor for $^2S_{\frac{1}{2}}$ and $^2P_{\frac{3}{2}}$ energy states. 2+3=5

(g) In Compton effect, derive an expression for the change in wavelength of a photon when it is scattered by an electron.

(h) The moment of inertia of the *CO* molecule is $1{\cdot}4 \times 10^{-46} kgm^2$. Calculate the energy and the angular velocity in the lowest rotational energy level of *CO* molecule.

4. Answer ***any two*** of the following : 10×2=20

(a) Draw a neat diagram of the experimental arrangement of Stern and Gerlach. Show how *two* traces are produced by the atomic beam. 4+6=10

(b) What is Zeeman effect? Explain the quantum theory of anomalous Zeeman effect. 2+8=10

(c) What are X-rays? Write *any two* properties of X-rays? What is X-ray spectra? Explain the mechanism of continuous X-ray spectrum. 2+2+3+3=10

(d) What is molecular spectra? Discuss vibrational-rotational spectra of diatomic molecules. 2+8=10

(e) What is Raman effect? Explain the quantum theory of Raman effect. Why are the stokes lines brighter than the anti-stokes lines? Compare Raman spectra with infrared spectra. 2+3+2+3=10

1 (Sem–5/FYUGP) PHY02MJ

2025

PHYSICS

(Major)

Paper : PHY0500204

(Condensed Matter Physics)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×5=5

   (a) Number of atoms per unit cell in an f.c.c. lattice is

   (i) 1

   (ii) 2

   (iii) 3

   (iv) 4

(b) If temperature increases, the electrical conductivity of semiconductor

(i) increases

(ii) decreases

(iii) remains constant

(iv) reduces to zero

(c) Above Curie temperature a ferromagnetic material becomes

(i) antiferromagnetic

(ii) diamagnetic

(iii) paramagnetic

(iv) ferrimagnetic

(d) What is a phonon ?

(e) The magnetic susceptibility of superconductor is

(i) zero

(ii) positive

(iii) negative

(iv) infinite

2. Give very short answers of the following questions : ***(any five)*** 2×5=10

(a) Draw unit cells of simple cubic lattice showing (111) and (210) planes.

(b) State Curie-Weiss law and Curie law.

(c) A crystalline solid diffracts X-ray. Can the solid also diffract γ-rays and visible light ? Justify.

(d) Write the names of bondings which are available in *NaCl*, diamond, ice and *Cu* molecules.

(e) Define polarisation.

(f) What are primitive and non-primitive unit cells ?

(g) Define Fermi energy and density of states.

(h) An insulator has an optical absorption which occurs for all wavelengths lesser than 1400*Å*. Find the width of the forbidden energy band for insulator.

(i) Write *two* differences between nano-materials and bulk materials.

(j) Find out the relation $\mu_r = 1 + \chi_m$ for magnetic substance, where μ_r and χ_m are the relative permeability and magnetic susceptibility of the substance respectively.

3. Give answers of the following questions : ***(any four)*** 5×4=20

(a) What do you mean by Miller indices? How are Miller indices determined? Write its *four* important features. 1+2+2=5

(b) Write Wiedmann-Franz law and its limitations.

(c) Discuss the properties of nano-materials.

(d) (i) Calculate the cohesive energy of ionic crystal. 3

(ii) Define electron affinity and ionisation energy. 2

(e) Write the assumptions of linear monoatomic vibration and find out its dispersion relation. 2+3=5

(f) (i) Find out relation between electric field, displacement vector and polarisation vector of dielectric. 3

(ii) The electric susceptibility of a material is $25{\cdot}4 \times 10^{-12} \frac{c^2}{nt \cdot m^2}$. What are the values of dielectric constant and permittivity of the material? 2

(g) (i) What is Meissner effect? Write the difference between type-I and type-II superconductors using Meissner effect. 1+2=3

(ii) A superconductor has a critical temperature of $2{\cdot}5K$ at zero magnetic field and a critical field of $0{\cdot}04T$ at $0K$. Determine the critical field at $3K$. 2

(h) (i) Write the differences between diamagnetic and paramagnetic substances. 3

(ii) Calculate the glancing angle on the plane (110) of a crystal ($a = 2{\cdot}5\text{Å}$) corresponding to second order diffraction maxima of wavelength $0{\cdot}7\text{Å}$. 2

4. Answer ***any one*** of the following questions : $10 \times 1 = 10$

(a) Write short notes on ***any two*** of the following :

(i) Free electron theory

(ii) Covalent bond

(iii) Bravais lattice

(iv) B-H curve and Hysteresis loss

(b) (i) Derive classical Langevin theory of diamagnetism. 8

(ii) How magnetic behaviour of magnetic substance changes with temperature ? 2

(c) (i) Discuss Kronig-Penny model. 7

(ii) Calculate the conductivity of germanium. Given mobilities of electron and holes in a sample of germanium at room temperature are $0{\cdot}54 m^2 v^{-1} s^{-1}$ and $0{\cdot}18 m^2 v^{-1} s^{-1}$ respectively. Assuming that electron and hole densities are each equal to $3{\cdot}6 \times 10^{19}$ per m^3. If a potential difference of 2 volts is applied across the germanium plate of thickness $0{\cdot}2mm$ and area $1 cm^2$, calculate the current produced in the plate. 3

(d) (i) Derive Einstein's theory of specific heat. 7

(ii) What are the limitations of Dulong and Petit's law ? 3

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1 (Sem–5/FYUGP) PHY03MJ

2025

PHYSICS

(Major)

Paper : PHY0500304

(Heat and Thermodynamics)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×5=5

   (a) Define the state variables of a thermodynamic system.

   (b) Define Thermodynamic equilibrium of a thermodynamic system.

   (c) Why the real gas equation deviates from ideal gas equation ?

   (d) State the third law of thermodynamics.

   (e) What is Brownian motion ?

2. Answer ***any five*** of the following : 2×5=10

(a) Define Mean, RMS and most probable speed of a gas.

(b) Calculate the root mean square velocity of air molecules at N.T.P. (Given, density of air = $1.293\,kg/m^3$).

(c) What are degrees of freedom? State the law of equipartition of energy in a gas.

(d) Distinguish between reversible and irreversible process.

(e) State the second law of thermodynamics in terms of entropy.

(f) Draw the temperature-Entropy diagram of a Carnot Cycle.

(g) A certain amount of gas at temperature $27°C$ is compressed adiabatically to half of its volume. Calculate the new temperature of the gas. Given, $\gamma = 1.4$ and $2^{0.4} \approx 1.32$.

(h) Is internal energy of a thermodynamic system a state function? Explain.

(i) Explain why a heat engine can't be more than 100% efficient.

(j) State the Clausius inequality in thermodynamics.

(k) Mention *two* main limitations of Van der Waal's Equation of State for real gas.

3. Answer the following : ***(any four)*** 5×4=20

(a) Obtain an expression for work done during an adiabatic process.

(b) What is the physical significance of entropy? Show that the entropy of system remains unchanged during a reversible process.

(c) A Carnot engine is working between steam and ice temperate of water. If the temperature of the source is increased by 10%, calculate the change in its efficiency.

(d) Obtain the relation between C_p, and C_v using first law of Thermodynamics.

(e) Obtain the expression for reduced equation of state for a real gas. Also write down the law of corresponding state.

(f) Explain Joule-Thomson porous plug experiment.

(g) Write down the physical significance of *four* thermodynamic potentials.

(h) Deduce Maxwell's *three* TdS equations of Thermodynamics.

4. Answer the following : ***(any one)*** 10×1=10

(a) Deduce the expression for Van der Waal's Equation of State for a real gas. Obtain Van der Waal's constants in terms of critical constants. 6+4=10

(b) Define Kelvin's absolute thermodynamic scale of temperature. Show that the Kelvin's absolute thermodynamic scale of temperature is identical with the perfect gas scale of temperature. 5+5=10

(c) Obtain Clausius-Clapirron equation using Maxwell's first thermodynamic relation. Water boils at 99.5°*C* and 100.5°*C* when the atmospheric pressures are 74.650 and 77.371*cm* of mercury respectively. Calculate the volume of 1*gm* of steam at 100°C the latent heat being 540*cal./gm.* 5+5=10

(d) Write short notes on : 5+5=10

(i) Brawnian Motion and

(ii) Andrew's experiment on CO_2

2025

PHYSICS

(Major)

Paper : PHY0500404

(Electromagnetic Theory)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×5=5

   (a) What is displacement current?

   (b) Define skin depth.

   (c) What is a waveguide?

Contd.

(d) Give examples of uniaxial and biaxial crystals.

(e) What is the role of cladding in optical fibre ?

2. Answer ***any five*** of the following questions : 2×5=10

(a) Write Lorentz gauge condition. What is its advantage ?

(b) What do you mean by a pointing vector and what does it represents ?

(c) Write the electromagnetic wave equation in free space governing the time varying electromagnetic field vectors $\vec{E}$ and $\vec{H}$.

(d) What are the boundary condition for electric field $\vec{E}$ and magnetic field $\vec{H}$ at the interface between two media ?

(e) An electromagnetic wave is incident on the surface of water normally. Find the percentage of incident intensity transmitted into water. Given the refractive index of water is 1·33.

(f) How will you distinguish between quarter wave plate and half-wave plate ?

(g) Determine the numerical aperture of an optical fibre when the core and cladding refractive indices are 1·51 and 1·47 respectively.

(h) Explain the term optical rotation.

(i) Find the thickness of a quarter wave plate of quartz for light of wavelength 6000Å. Given the refractive indices of quartz for *E*-ray and *O*-ray are 1·5533 and 1·5442 respectively.

(j) Write the parameters on which the reflection and refraction of electromagnetic waves depends.

3. Answer ***any four*** of the following questions : 5×4=20

(a) What is gauge transformation ? Show that electric and magnetic field vector $\vec{E}$ and $\vec{B}$ are invariant under gauge transformation. 1+2+2=5

(b) Obtain Pointing theorem for the conservation of energy in an electromagnetic field and discuss the physical meaning of each term in the resulting equation. 3+2=5

(c) Assuming that the electric vector of an electromagnetic wave given by $E = E_0 e^{i(\vec{k}.\vec{r}-wt)}$ and in crossing a boundary the tangential component of electric intensity is continuous, prove the various laws of reflection and refraction.

(d) Explain the Brewster's law with the help of Fresnel's formula.

(e) Find the reflection co-efficient if angle of incidence is 60° of e.m. wave travelling from free space (medium 1) to a dielectric (medium 2) with $\varepsilon_2 = 4\varepsilon_0$ and $\mu = \mu_0$ in case of perpendicular polarisation.

(f) What is Nicol prism ? Explain its action as polariser and analyser. 1+4=5

(g) Define specific rotation. Write its unit. A tube of sugar solution 20*cm* long is placed between crossed Nicols and illuminated with light of wavelength 6000Å. If the optical rotation produced is 13° and the specific rotation is 65°, determine the strength of solution. 1+1+3=5

(h) What is an optical fibre? On which principle it works? Distinguish between step index fibre and graded index fibre. 1+1+3=5

4. Answer ***any one*** of the following questions : 10

(a) Write down the Maxwell's four electromagnetic field equations. Define magnetic vector and scalar potential. Deduce Maxwell's field equations in terms of magnetic vector and scalar potential. 2+3+5=10

(b) Discuss the propagation of plane electromagnetic wave in a conducting media. Hence find the expression for phase velocity and depth of penetration. 6+2+2=10

(c) Describe the construction and principle of a Laurent's half-shade polarimeter. How will you use it to find (i) Specific rotation (ii) Strength of Sugar solution. 7+2+1=10

(d) Write short notes on the following : ***(any two)*** 5×2=10

(i) Double refraction

(ii) Babinet compensator

(iii) Rectangular waveguide

(iv) Phase retardation plates

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