5. a) The thermal conductivity of brass is 0.26. What is meant by that statement?

b) Explain steady state in case of thermal conduction.

c) Two slabs both of area A and thickness x_1 and x_2 having thermal conductivities K_1 and K_2 respectively are put in contact face to face. Show that the equivalent thermal conductivity of the composite system is

$$\frac{x_1 + x_2}{\left(\frac{x_1}{K_1} + \frac{x_2}{K_2}\right)}$$

d) What is diffusion coefficient? How does it relate to the viscosity coefficient according to transport phenomena? 1+2+4+(1+2)

6. a) Plot and compare Fermi-Dirac, Bose-Einstein, and Maxwell-Boltzmann distribution function as a function of energy.

b) What are the basic postulates used in Bose-Einstein statistics? What is Fermi energy?

c) Write short notes on Photon gas and Electron gas. 3+4+3

U.G. 3rd Semester Examination - 2024

PHYSICS

[HONOURS]

Generic Elective Course (GE)

Course Code : PHY-H-GE-T-03(A-C)

[CBCS]

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-H-GE-T-03

(Electricity and Magnetism)

GROUP–A

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

a) Define polarization vector of a dielectric. What is its physical significance?

b) State and explain Stokes theorem.

c) Write the differences between paramagnetic and ferromagnetic material.

d) Write the Faraday's laws of electromagnetic induction.

e) Define Poynting vector? Mention its physical significance.

f) Check whether the vector $\vec{E} = y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}$ represents an electrostatics field or not.

g) Find the angle between the vectors $\vec{A} = -\hat{i} + \hat{j} - \hat{k}$ and $\vec{B} = -\hat{i} - \hat{j} + \hat{k}$

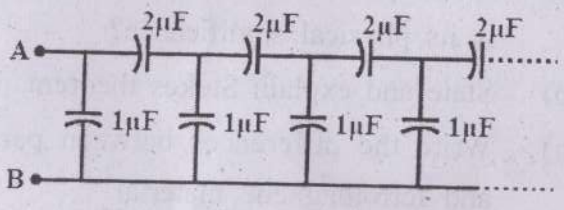
h) Define magnetic susceptibility and permeability. Write the relationship between them.

GROUP–B

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

a) Write the Biot-Savart's law. Apply this law to find the magnetic field at any axial point of a circular coil carrying a current I. 2+3

b) What do you mean by source field and sink field? Find out the equivalent capacitance value between points A and B in the figure below:



2+3

c) Write down Gauss's theorem of electrostatics. Apply this theorem to calculate the electric field due to a charged infinite plane with a surface charge density σ. 2+3

d) Derive the expression of potential and electric field due to an electric dipole. Define displacement vector. 4+1

GROUP–C

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

a) What do you mean by hysteresis and hysteresis loss? What kind of materials will you suggest for the electromagnet and permanent magnet? State and explain Ampere's circuital law. Using this law derive the expression for the magnetic field due to a long current carrying conductor. 1+1+1+1+2+4

b) Define magnetic susceptibility and permeability. Find the relationship between B and H. Define Bohr magneton and find out its value. State and prove Lenz's law. Show that $\vec{\nabla} r^n = n r^{n-2} \vec{r}$. 2+2+2+2+2

c) Write down the relation between B, H and M. What is ferromagnetism? Explain the term 'hysteresis of a magnetic material'. Calculate the mutual force between two straight parallel conductors. each of length 1 metre in air 2.5 cm apart, when the current in each conductor is 250 Amp. Show that the energy expended in establishing a current 'I' in a coil of self inductance L is $\frac{1}{2}LI^2$. (1+1+2)+3+3

d) Using Gauss's theorem of electrostatics find the electric field at a distance r from the centre of a uniformly charged spherical shell for i) $r > r_2$ and ii) $r \leq r_1$, Where 'r_1' and 'r_2' are the inner and outer radius respectively. Write the Gauss's theorem in dielectrics. Derive an expression of capacitance of a cylindrical capacitor whose inner and outer radii are 'a' and 'b' respectively. 4+2+4

OPTION–B

PHY-H-GE-T-03

(Mechanics)

GROUP-A

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

a) Show that the total linear momentum is zero in the centre of mass frame.

b) State and prove the work energy theorem.

c) Determine the dimension of the coefficient of viscosity of a liquid.

d) Give the basic idea of global positioning system (GPS).

e) Define inertia and non-inertia frame of reference.

f) Define radius of gyration for a rigid body rotating about a specified axis.

g) Show that under Galilean transformation, acceleration of a particle remains invariant.

h) What is Poisson's ratio of a rigid body.

GROUP–B

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

a) A string of length L is stretched horizontally with a tension T between two rigid supports. A mass m is attached at a distance a from one end. Show that the Frequency of small vertical oscillation of the mass is

$$f = \frac{1}{2\pi}\sqrt{\frac{TL}{am(L-a)}}$$

Assume that the tension in the string remain constant. 5

b) What are the postulates of Special Theory of Relativity? A thin rod has proper length 10. If the rod is moving at 0.6c in a direction of 300 to its own length, calculate its new length and inclination with respect to the rest frame. 2+3

c) i) Find the general solution of the differential equation $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 5y = 0$

ii) Solve: $ydx - xdy - 3x^2y^2e^{x^3}dx = 0$ 3+2

d) A body of mass m falling from a hight h on a flywheel with radius R. Show that the linear acceleration a of the mass is $, a = \frac{g}{\left(1+\frac{1}{mr^2}\right)}$

(where g is gravitational acceleration) 5

GROUP–C

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

a) i) Prove that $\vec{A}\times\left(\vec{B}\times\vec{C}\right) = \vec{B}\left(\vec{A}.\vec{C}\right) - \vec{C}\left(\vec{A}.\vec{B}\right)$

ii) Prove that central force is conservative.

iii) Show that areal velocity is constant for planetary motion. 4+4+2

b) i) A particle moves in a plane. Find expression for radial and transverse velocity and acceleration of the particle in spherical polar coordinate system.

ii) A particle of mass m_1 moving with a velocity u_1 suffers a perfectly inelastic collision with a particle of mass m_2 at rest. Calculate the K.E of the system before and after collision in the Lab system and C.M system. Show that decrease in K.E is the same in two case.

iii) Show that the square of the period of a planet is proportional to the cube of semi major axis of the elliptic orbit. 4+4+2

c) i) Find a distance which an object moves in time t if it starts from rest and has acceleration $\frac{d^2x}{dt^2} = ge^{-kt}$ where k is a constant. Show that for small t the result

is $x=\frac{1}{2}gt^2$ and for very large t the velocity is approximately constant.

ii) What is time dilation?

iii) Show that the equation of motion of a free particle does not change its form under Galilean transformation. 4+4+2

d) The differential equation for a one dimensional damped harmonic oscillator is given by

$$m\frac{d^2x}{dt^2}+K\frac{dx}{dt}+Sx=0$$

Explain the significance of each term in the equation. Solve the equation for overdamped condition. 2+8

OPTION–C

PHY-H-GE-T-03

(Thermal Physics and Statistical Mechanics)

GROUP–A

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

a) Calculate the change in entropy when 10 gram of ice at 0°C is convened into the vapour at l00°C.

b) What is Wien's Displacement Law in Black body radiation?

c) Why are the Helmholtz function F and Gibbs function G called thermodynamic potentials?

d) Discuss the changes of entropy in reversible as well as in irreversible processes.

e) Calculate what traction of gas molecules dies out in moving a distance of mean free path.

f) Deduce the expression for the work done in the adiabatic expansion of a perfect gas in terms of temperature.

g) Find the temperature at which the RMS velocity of a gas will be l/4th of that at zero degree Celsius.

h) Show that an isothermal curve for an ideal gas drawn on a P-V diagram is enthalpic.

GROUP–B

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

a) Write down the four Maxwell's equation. Derive the following *TdS* equation. Terms have their conventional meaning. 2+3

$$TdS = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$$

b) What do you mean by quasi static process? An ideal gas undergoes quasistatic adiabatic process, then show that $PV^\gamma = \text{constant}$. 2+3

c) State and explain Maxwell's Law of distributions of molecular velocity. Draw the Maxwell's velocity distribution curve at different temperature. Discuss the shifting of the peak of the curve and also the broadening of the curve with temperature variation. 2+2+1

d) Write down the postulates of Planck's Radiation Law in case of Black body radiation. Derive Wein's displacement Law from Planck's Law. 1+4

GROUP–C

Answer any **two** questions: 10×2=20

3. a) For a thermodynamic system U=3/2 *PV* and $P=A\ T^4V$, find the Gibbs' potential *G* and Helmholtz function *F*.

b) Calculate the change of the entropy of free expansion of an ideal gas system.

c) What is isenthalpic process?

d) For an isentropie transformation show that,

$$\left(\frac{\partial V}{\partial T}\right)_S = \frac{C_r}{C_P - C_V}\left(\frac{\partial V}{\partial T}\right)_P$$

(2+2)+2+2+2

4. a) From Maxwell's relations derive the expression

$$C_P - C_V = -T\left(\frac{\partial V}{\partial T}\right)_P^2\left(\frac{\partial P}{\partial V}\right)_T.$$

b) What is inversion curve? Write down the expression for Clausius Clapeyron equation.

c) Find the change in freezing point of water at 0°C for an increase of pressure by 1 atm. At 0°C specific volume of ice is 1.091 cc/g, latent heat of water is 76.9 cal/g and specific volume of water is 1 cc/g. 3+(2+2)+3