2025

1st Semester Examination (CCFUP : NEP)

PHYSICS

Paper : MJ 1-T (Single Core Major)

(Foundation of Physics - 1)

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group - A

Answer any ***ten*** questions : $2\times10=20$

1. If the magnitude of a vector $\vec{A}$ is constant with respect to time, show that $\frac{d\vec{A}}{dt}$ is perpendicular to $\vec{A}$.

2. Find the order and degree of the following differential equation : $\frac{d^2y}{dx^2}+\left(\frac{dy}{dx}\right)^{1/2}+xy=0$.

3. Write the difference between axial vector and polar vector.

P.T.O.

4. Calculate the efficiency of Carnot engine using T-S diagram.

5. What do you mean by thermodynamic equilibrium? Represent on a P-V diagram an isobaric and an isochoric process.

6. 20 g of hydrogen gas at 27°C are compressed isothermally to one-fourth of the original volume. Find the amount of work done.

7. Which thermodynamic potential remains constant when ice melts into water? Explain why.

8. What is the wavelength of maximum intensity radiation radiated from a source at temperature 3000°C? Wien's constant = 2.898×10^{-3}mK.

9. Determine whether the force field given by $\vec{F} = x^2yz\hat{i} - xyz^2\hat{k}$ is conservative or not.

10. If $\vec{r}$ be the position vector of a point on a closed contour C, prove that $\oint_C \vec{r}.d\vec{r} = 0$.

11. Prove that $\vec{\nabla}\times\left(\vec{\nabla}\phi\right) = 0$, where ϕ is a scalar field.

12. Calculate the components of velocity in cylindrical coordinates.

13. Find the particular integral of $\left(D^2-4\right)y = e^{2x}$.

14. Expand $e^x\ln(1+y)$ in powers of x and y in Taylor series in the neighbourhood of $(0, 0)$ as far as the first four terms.

15. If $f(r)$ is differentiable then calculate curl$\left(\vec{r}f(r)\right)$.

Group - B

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

16. Solve the equation $\frac{d^2y}{dx^2}+3\frac{dy}{dx}+2y = x\sin 2x$.

17. Deduce expression for the work done in a quasistatic isothermal and adiabatic expansion or compression of an ideal gas.

18. (a) Find the areal velocity of a particle which moves along the path $\vec{r} = a\cos\omega t\hat{i} + b\sin\omega t\hat{j}$, where a, b, ω are constants and t is time.

    (b) Find the volume element dV in spherical polar coordinate, using curvilinear coordinate system. 3+2

19. Verify Green's Theorem in the plane for $\int_C (x+y)dx + (x-y)dy$, where C is the closed curve of the region bounded by $y = x^2$ and $y^2 = 8x$.

P.T.O.

20. Derive Clausius-Clapeyron's latent heat equation

$$\frac{dP}{dT} = \frac{L}{T(V_2 - V_1)}$$

from Maxwell's thermodynamic relations.

21. Show how would you determine :

(a) Enthalpy H from a knowledge of Gibbs free energy G and

(b) Gibbs free energy G from a knowledge of Helmholtz free energy F. 2½+2½

Group - C

Answer any *two* questions : 10×2=20

22. Show that the average energy of a Planck's oscillator is given by $\bar{E} = \frac{h\nu}{e^{h\nu/kT} - 1}$.

23. (a) If $\vec{F} = 4xz\hat{i} - y^2\hat{j} + yz\hat{k}$, evaluate $\iint \vec{F}.\hat{n}\, dS$, where S is the surface of the cube bounded by $x = 0,\ x = 1,\ y = 0,\ y = 1,\ z = 0,\ z = 1$.

(b) Verify Stokes theorem for $\vec{A} = (2x - y)\hat{i} - yz^2\hat{j} - y^2z\hat{k}$, where S is the half surface of the sphere $x^2 + y^2 + z^2 = 1$ and C is its boundary. 5+5

24. (a) Find the unit normal vector at the point

$\left(\frac{a}{\sqrt{3}}, \frac{b}{\sqrt{3}}, \frac{c}{\sqrt{3}}\right)$ on the surface of the ellipsoid $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$.

(b) Solve : $x^2\frac{d^2y}{dx^2} - x\frac{dy}{dx} + y = 2\log x$.

(c) Evaluate $\left|\int_C \vec{r} \times \vec{d\theta}\right|$ for a circule C of radius r with centre at the origin. 3+4+3

25. (a) Calculate the RMS velocity of Argon gas molecule at 200 K (molecular weight of Argon 40gm/mol).

(b) Find out the critical temperature of van der Waals' gas.

(c) When two gases at the same temperature and pressure diffuse into each other, show that there is an increase in entropy in the process. Show that entropy of the universe is always increasing. 3+2+(3+2)
