10. (a) Derive Poisson's equation 3

$$\nabla^2 V = \frac{\rho}{\varepsilon_0}$$

And deduce the Laplace's equation.

(b) Show that the solution of Laplace's equation in spherical coordinate system is

$$\nabla^2 V = 0$$
$$V(r,\theta) = \sum_{l=0}^{\infty} \left(A_l r^l + \frac{B_l}{r^{l+1}} \right) P_l(cos\theta)$$

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★★★

UG (CBCS) EVEN SEMESTER EXAMINATION, 2024

EDUCATION
(B.Sc. B.Ed.)

4th Semester

Course No. : BSPH – 401

(Heat, Thermodynamics and Electrostatics)

Full Marks : 50
Pass Marks : 20

Time : 2 hours

The figures in the margin indicate full marks for the questions

1. (a) Write the Maxwell's velocity distribution function. 1

(b) Derive (i) most probable velocity (ii) average velocity (iii) root-mean square velocity using Maxwell's velocity distribution function. 9

Or

2. (a) Derive the expression for the coefficient of viscosity of gas $\eta = \frac{1}{3}\rho c \lambda$ where the symbols indicate their usual meanings. 6

(b) Derive Maxwell's relation for mean free path

$$\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 n}$$ 4

3. (a) Derive the one dimensional heat conduction

equation $\frac{dT}{dt} - h\frac{d^2T}{dx^2} = 0$ where h is the thermal diffusivity. Also obtain the equation at steady state. 6

(b) Suppose a source of heat is placed at the centre of a spherical shell. If the two surfaces of radii r_1 and r_2 acquire the temperatures T_1 and T_2 at the steady state show that $Q = \frac{4\pi k\,(T_1 - T_2)\,r_1 r_2}{r_2 - r_1}$, where symbols indicate their usual meanings. 4

Or

4. (a) Explain ultra-violet catastrophe of blackbodry radiation. 2

(b) Derive Rayleigh-Jean's law of blackbody radiation from Planck's law. 3

(c) Derive Stefan's law from Planck's law of black body radiation. 5

5. (a) Derive the expression for the work done in an adiabatic process. 5

(b) Show that the adiabatic process curve is more steeper than the isothermal process. 5

Or

6. (a) Show that $C_p = C_v + \left[\left(\frac{\partial U}{\partial V}\right)_T + P\right] V\beta$ where β is the volume expansivity.

6

(b) Derive the relation $C_p - C_v = nR$. What is the physical significance of $C_p > C_v$? 4

7. (a) Derive the Maxwell's thermodynamic relations 6

(i) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$ (ii) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$

(b) Derive the Clapeyron's latent heat equation using Maxwell's thermodynamic relation. 4

Or

8. (a) What is second order phase transition? Given one example. 2

(b) Show that the Gibb's potential per unit mass are equal when the two phases are in equilibrium. 3

(c) Derive the following Tds equations. 5

(i) $Tds = C_V dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$

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

9. Find the (i) electric fields (ii) electric potentials at a point inside and outside a spherical shell of radius R and surface charge density σ. 5+5=10

Or