UG (CBCS) Even Semester Examination, May 2025

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) Derive the expression for the duffusion coefficient (D) of a gas given by $D = \frac{1}{3}\lambda c$, where the symbols indicate their usual meanings. 5

   (b) Derive (i) most probable velocity (ii) average velocity using Maxwell's velocity distribution function. 5

Or

2. (a) Derive the Vander Waal's equation of state 6
   $\left(P + \frac{a}{V^2}\right)(V - b) = RT$ where the symbols indicate their usual meanings.

   (b) Derive the relation for mean free path
   $\lambda = \frac{kT}{\sqrt{2}\pi d^2 p}$ 4

3. (a) Derive the one dimensional heat conduction

(Turn Over)

equation $\frac{dT}{dt} = \frac{k}{\rho C}\frac{d^2T}{dx^2}$ where the symbols indicate the usual meanings. 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) Derive Rayleigh-Jean's law of blackbody radiation from Planck's law. 3

(b) Define emmissive and absorptive power of a blck body. 2

(c) State and prove Kirchhoff's law of black body radiation. 5

5. (a) Derive the expression for the work done in an isothermal process. 3

(b) Show that the efficiency of a Carnot's engine is $\eta = 1 - \frac{T_2}{T_1}$. Find the efficiency of a Carnot's engine working between 127^{0}C and 27^{0}C. It absorbs 90 calories of heat. How much heat is rejected. 5+2=7

Or

6. (a) Derive the relation C_p - C_v = nR. What is the physical significance of $C_p > C_v$? 6

(b) Find the entropy of a perfect gas in terms of pressure and temperature. 4

7. (a) Derive the Maxwell's thermodynamic relations from the thermodynamic potentials 6
U (S, V) , A (T, V) , H (S, P) and G (P, T)

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

Or

8. (a) What is first 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) $Tds = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$

(ii) $Tds = C_V\left(\frac{\partial T}{\partial P}\right)_V dP + C_P\left(\frac{\partial T}{\partial V}\right)_P dV$

9. (a) Find the electric field inside a sphere which carries a charge density proportional to the distance from the origin, $\rho = kr$, for some constant k. 3

(b) A hollow spherical shell carries charge density $\rho = \frac{k}{r^2}$ in the region $a \le r \le b$. Find the electrif field in the three regions : (i) $r < a$, (ii) $a < r < b$, (iii) $r > b$. Plot E as a function of r. 7

Or

10. (a) Obtain Laplace's equation $\nabla^2 V = 0$ 2

(b) Find the potential inside a hollow sphere of radius R if a potential $V_0(\theta) = k\,sin^2(\theta/2)$, where k is a constant, is specified on the surface of the sphere. 8

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