WEST BENGAL STATE UNIVERSITY

B.Sc. Honours PART-I Examinations, 2016

PHYSICS-HONOURS

PAPER-PHSA-II A

Time Allotted: 2 Hours | Full Marks: 50

The figures in the margin indicate full marks. Candidates should answer in their own words and adhere to the word limit as practicable.

Answer Q. No. 1 and any *four* from the rest taking at least one from Group A

1. Answer any *five* questions from the following: $2\times 5 = 10$

(a) The average kinetic energy of a molecule of H_2 at 0°C is 5.6×10^{-11} Joule. Calculate the Avogadro number. Given $R = 8.31$ J/K-mol.

(b) Calculate what fraction of gas molecules has free path lying between λ and 3λ, if λ is the mean free path for the system of gas molecules.

(c) State the law of equipartition of energy applicable for gas molecules.

(d) An ideal gas is expanded isothermally such that its volume is doubled. What is the change in the internal energy?

(e) Define Helmholtz free energy and show that it is a function of temperature and volume only.

(f) Show that for a hydrostatic system $\frac{dV}{V} = \beta\, dT - \frac{dP}{K}$ where β is the co-efficient of volume expansion at constant pressure and K is the isothermal bulk modulus.

(g) Define triple point and state Gibbs' phase rule.

(h) What do you mean by adiabatic lapse rate?

Group-A

2. (a) The probability that a gas particle may have velocity lying between c and $c + dc$ is given by $Fdc = 4\pi a^3 c^2 e^{-bc^2} dc$. Find the ratio between the mean velocity and r.m.s. velocity in terms of a and b. 3+3+(2+2)

(b) An ideal gas expands adiabatically so that its volume is doubled. How many times will the number of collisions per second of the molecules decrease? It is given that $\gamma = 1.4$.

(c) Define degrees of freedom of a gas molecule. Show that for an ideal gas, $\gamma = \frac{C_P}{C_V} = 1 + \frac{2}{f}$, where symbols are of usual meaning.

3. (a) What is reduced equation of state? Obtain an expression for it from Van der Waals' equation of state. It is given that $P_c = \frac{a}{27b^2}$, $V_c = 3b$ and $T_c = \frac{8a}{27Rb}$ where all the symbols have their usual meaning. (1+2)+2+5

(b) Define Boyle's temperature. Obtain a expression for it from Van der Waals, gas equation.

(c) Establish the Einstein's equation of Brownian motion.

Group-B

4. (a) State and prove Carnot's theorem. 3+3+(2+2)

(b) Prove that the combined efficiency of two Carnot engines, one operating between T_1 and T and the other operating between T and T_2 ($T_1 > T > T_2$) will be lower than that of the single engine operating between T_1 and T_2.

(c) State Clausius' theorem for reversible process. Define entropy as a state function from it.

5. (a) Prove that the equation for the adiabatic expansion of Van der Waals' gas is given by 3+(2+3+1+1)

$$\left(P+\frac{a}{V^2}\right)(V-b)^{\gamma}=\text{constant}$$

where all the symbols have their usual meaning.

(b) (i) Establish the *T-dS* equation $TdS = C_V dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$.

(ii) Use another *T-dS* equation $TdS = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$.

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

(iii) Show that $C_P \geq C_V$

(iv) Show that $C_P = C_V$ at 4°C.

6. (a) Calculate the saturated vapour pressure of water as the boiling point changes from 100°C to 103°C. Given: Latent heat of steam = 540 cal/g, specific volume of steam = 1670 c.c./g. 3+3+(1+3)

(b) From thermodynamic considerations deduce the relation $\frac{dL}{dT} = \frac{L}{T} + C_2 - C_1$, where C_2 is the specific heat of saturated matter in the final phase, C_1 is the specific heat of saturated matter in the initial phase and L is the latent heat of the phase transition (first order).

(c) What is inversion temperature (T_i) in the context of Joule-Thomson expansion? Show that, for Van der Waals' gas it is given by $T_i = \frac{2a}{Rb}$, where all the symbols have their usual meaning. { It is given that Joule-Thomson coefficient $\mu = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$ }.

7. (a) Define thermal conductivity and write down its S.I. unit. 2+(4+2)+2

(b) Obtain an expression for the rate of radial flow of heat through a hollow cylinder whose inner and outer surfaces are maintained at different temperatures. Use it to determine the conductivity of rubber in the form of a tube.

(c) A pond is covered with ice 0.04 m thick. The temperature of the air above is 261 k. At what rate will be ice thicken? Given, k of ice = 2.184 W/m/K, density of ice = 920 kg/m^3 and latent heat = 333 kJ/ kg.

$$A\,dx\,\rho L = K A \frac{\theta}{x} dt$$

$$x\,dx = \frac{K\theta}{\rho L} dt$$

$$\frac{dx}{dt} = \frac{K\theta}{\rho L x}$$

$$= \frac{2.184 \times (261)}{920 \times 333 \times .04}$$

$$\frac{dx}{dt} = .0465$$