WEST BENGAL STATE UNIVERSITY

B.Sc. Honours PART-I Examinations, 2017

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.
All symbols are of usual significance.

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

1. Answer any *five* questions from the following: $2\times5=10$

(a) A beam of particles is passed through a low pressure gas. The mean free path of particles in the gas is 5×10^{-4} m. Find the fractional attenuation in the intensity of the beam in traversing a thickness 10^{-2} m of the gas sample.

(b) What, according to Van-der-Waals, are the reasons for the relation $PV = RT$, not holding good for real gas?

(c) Two mono-atomic gases have atomic weights α_1 and α_2. If k_1 and k_2 are their thermal conductivities, show that $\frac{\alpha_2}{\alpha_1}=\frac{k_1\eta_2}{k_2\eta_1}$, η_1 and η_2 being respective coefficients of viscosity of two gases.

(d) Consider the infinitesimal quantity, $dF=(x^2-y)dx+xdy$. Show that dF is not an exact differential, though dF/x^2 is.

(e) Show that for pure substance, $\left(\frac{\partial P}{\partial T}\right)_V = \frac{\beta}{K_T}$; β being the thermal coefficient of volume expansion and K_T being the isothermal compressibility.

(f) If a rubber band is stretched adiabatically and reversibly, its temperature increases. With this information, find whether the entropy increases, decreases or remains the same, if the rubber band is stretched isothermally and reversibly.

(g) Starting from the expression of Helmholtz free energy $F(T, V)$, show that heat capacity at constant volume, $C_V = -T\left(\frac{\partial^2 F}{\partial T^2}\right)_V$.

(h) Show that for steady state heat conduction, the temperature distribution satisfies Laplace's equation.

Group-A

2. (a) Assuming that the fraction of molecules in an ideal gas, with velocity component along any arbitrary direction lying between v to $v+dv$, is $Ae^{-bv^2}dv$, find the corresponding speed distribution function. 3+3+(1+2+1)

(b) From the above result find the relation between A and b.

(c) State Dulong-Petit's law and obtain it from the principle of equipartition of energy. Is this law universally valid?

3. (a) Define mean free path (λ) of a gas molecule and coefficient of viscosity (η) in a gas. Derive the relation between these two. (1+1+3)+(2+1)+2

(b) Show from the above result that η of a gas is, in general, independent of its pressure. Explain how this independence breaks down.

(c) Express the Van-der-Waals' equation of state in virial form, $PV = RT\left[1+\frac{B}{V}+\frac{C}{V^2}+\cdots\right]$ to find B and C.

Group-B

4. (a) The internal energy of a thermodynamic system is given by $U = AP^2V$, 'A' being a positive constant. Prove that the equation of adiabats in P-V plane is given by $V(AP+1)^2 = B$, B being another constant. 3+(1+2)+(2+2)

   (b) What is meant by free expansion of a gas? If an ideal gas, initially at equilibrium with pressure P, undergoes a free expansion to make its volume double, find its final pressure after its equilibration within a thermally insulated enclosure.

   (c) Show the Carnot cycle in T-S diagram. Derive its efficiency directly from this T-S diagram.

5. (a) Explain what do you understand by absolute or thermodynamic scale of temperature. Show that this scale is essentially identical to the ideal gas temperature scale. (2+2)+2+4

   (b) "A gas has two specific heats, where a liquid has only one." – Explain.

   (c) The equation of state for a system is $V = \frac{RT}{P} - \frac{C}{T^3}$, C being a constant.

   Assuming the validity of Maxwell's relations, show that $\left(\frac{\partial C_p}{\partial P}\right)_T \propto T^{-4}$, C_p being the specific heat at constant pressure and other symbols bearing usual meanings.

6. (a) 'Joule-Thomson process is adiabatic but not reversible.' – Explain. Show that the quantity $H = U + PV$ remains same before and after the process. (2+2)+2+(1+3)

   (b) From the notion of inversion temperature explain why hydrogen gas cannot be liquefied by Joule-Thomson process.

   (c) What is meant by order of phase transition? Obtain Clapeyron's equation for the first order phase transition.

7. (a) Write down Fourier's equation for radial heat flow with spherical symmetry. 1+(3+2)+(2+2)

(b) Two concentric spheres of radii R_1 and R_2 ($R_1 < R_2$) are maintained at constant temperatures θ_1 and θ_2. The space between them is filled up with a material of thermal conductivity K. Find an expression for the rate of radial flow of heat. What will be the temperature at a radial distance R ($R_1 < R < R_2$)?

(c) State Kirchhoff's law for thermal radiation and explain the notion of black body.