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PHSA(HN)-02

West Bengal State University

B.A./B.Sc./B.Com (Honours, Major, General) Examinations, 2015

PART - I

PHYSICS — HONOURS

Paper - IIA

Duration : 2 Hours] [Full Marks : 50

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

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

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

a) The best vacuum attained in the laboratory is 10^{-10} mm of Hg. Assuming the gas to be an ideal one, find out the number of molecules present per cc of the gas at 20°C at this vacuum.

b) Which physical quantity is transported in the process of diffusion ? Define the coefficient of diffusion.

c) The fraction of total no. of particles of a gas with velocity lying between c and $c + dc$ is given by $Fdc = 4\pi A^3 c^2 e^{-bc^2}$. Show that the most probable velocity of the particles of gas is $\sqrt{1/b}$.

d) What is meant by a 'quasistatic process' ? Is this process always a reversible one ?

e) Prove that for an ideal gas, the adiabatic curve is steeper than the isothermal curve at the point of their intersection.

f) A mole of an ideal gas undergoes a reversible isothermal expansion from a volume V to volume $2V$. What is the change in entropy of the gas ?

g) Describe briefly how phase transitions are classified according to Ehrenfest.

h) What is meant by diffusivity or thermometric conductivity ?

Group – A

2. a) Deduce Maxwell's velocity distribution law given by the formula $dN_c = 4\pi N A^3 c^2 e^{-bc^2} dc$ where N is the total no. of molecules of the gas while A and b are two constants. Plot the corresponding distribution function against the velocity c.

b) Use the Maxwell's velocity distribution law as given above to obtain an expression for the energy distribution of the gas molecules (in terms of A and b).

c) A system is composed of two-level atoms, the excited state being 1 eV above the ground state. Find the fraction of all atoms which will be in the excited state if the system is in the thermal equilibrium at 300K. It is given that Boltzman constant $k_B = 1 \cdot 38 \times 10^{-23}\ J/K$. (5 + 1) + 2 + 2

3. a) What are meant by critical constants of a gas ? Find out the critical constants for one mole of a van der Waals gas.

b) The expression for the coefficient of viscosity of a gas is given by $\eta = \frac{1}{3} mn\bar{c}\lambda$ where symbols bear usual meaning. State the underlying assumptions to derive this expression. Show that in general the coefficient of viscosity of a gas is independent of its pressure. Explain why this independence of pressure breaks down at very low and very high pressure. (2 + 3) + (2 + 2 + 1)

Group – B

4. a) Briefly describe the operation of a Carnot cycle using P-V (indicator) diagram. Compute work done in each part of the cycle and find an expression for its efficiency.

b) Two identical bodies of constant heat capacity at temperatures T_1 and T_2 are used as the source and sink respectively for heat engine. If the bodies remain at constant pressure and there is no change in phase, show that the maximum possible work done by the heat engine is $C_p(\sqrt{T_1} - \sqrt{T_2})^2$.

(2 + 4) + 4

5\. a) Establish the Clausius-Clapeyron equation for first order phase transition.

b) Find the latent heat of vaporization of water at 100°C. It is given that specific volume of water and vapour in the phase equilibrium are 1 c.c. and 1674 c.c. respectively and the rate of change of corresponding pressure with temperature is 27·1 mm of Hg/°C.

c) Use the Tds equations $Tds = C_v dT + T\left(\frac{\partial P}{\partial T}\right)_v dv$ and $Tds = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dp$ to show that $C_P - C_V = -T\left(\frac{\partial V}{\partial T}\right)^2\left(\frac{\partial P}{\partial V}\right)_T$.

Show that C_P can never be less than C_V. 4 + 2 + (3 + 1)

6\. a) Show that the initial and the final values of the enthalpy are same in a throttling process or Joule-Thomson expansion. Is the process an isenthalpic one ?

b) Define Joule-Thomson coefficient. Show that its expression is given by $\mu = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$, where the symbols have their usual meaning.

Show that an ideal gas cannot be cooled using Joule-Thomson expansion.

(3 + 1) + (1 + 3 + 2)

7\. a) Define 'emissive power' and 'absorptive power' of a body. State Kirchhoff's law for thermal radiation.

b) State Stefan-Boltzman law of radiation. Mentioning underlying assumptions clearly show how Newton's law of cooling can be obtained from Stefan's law.

c) Assuming the sun to be a black body at temperature 5800K, find (i) total radiant energy emitted by sun per sec, (ii) the rate at which energy reaches the top of the earth's atmosphere per unit area assuming no heat is lost and (iii) corresponding radiation pressure. It is given that Stefan's constant $\sigma = 5 \cdot 672 \times 10^{-8}$ SI unit, the radius of the sun $= 7 \times 10^{8}$ m and the distance of the earth from the sun is $1 \cdot 5 \times 10^{11}$ m.

(1 + 1 + 2) + (1 + 2) + (1 + 1 + 1)
