West Bengal State University

B.A./B.Sc./B.Com (Honours, Major, General) Examinations, 2014

PART – I

PHYSICS — HONOURS

Paper – IIA

Duration : 2 Hours] [Full Marks : 50

The figures in the margin indicate full marks.

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

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

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

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

c) Define 'Boyle temperature' and 'Critical temperature' of a gas.

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

e) The critical temperature and pressure of argon are –122°C and 48 atm respectively. Calculate the radius of argon atom.

f) State Gibbs' phase rule.

g) Write down some properties of black body radiation to show that it is very similar to an ideal gas.

h) Write down the first and second $T\,dS$ equations.

Group – A

2. a) What do you mean by collision probability ?

   b) Show that the probability of a gas molecule traversing a distance x, without collision, is $e^{-x/\lambda}$ where λ is the mean free path of the gas molecule.

   c) Use the above expression to show that the mean free path of the gas molecules in thermal equilibrium in an enclosure is approximately given by $1/\pi n\sigma^2$. Symbols carry usual meaning. 2 + 4 + 4

3. a) 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.

   b) Write down van der Waals' equation of state and plot its isotherms. Express the van der Waals' equation in the following virial form :

   $PV = RT\left[1 + \frac{B}{V} + \frac{C}{V^2} + \ldots\right]$, where B, C are virial coefficients.

   From above expansion find out the expression of the second virial coefficient B and the Boyle temperature.

   What is the significance of the Boyle temperature ?

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

Group – B

4. a) State Kelvin-statement and Planck-statement in view of second law of thermodynamics.

   b) Show that the second law of thermodynamics leads to a scale of temperature which is independent of the nature of the working substance. Define zero on the scale and also define the size of a degree on this scale. 2 + (5 + 2 + 1)

5. a) Prove that for an adiabatic expansion of a van der Waals' gas $\left(P+\frac{a}{v^2}\right)(V-b)^{\gamma}$ = constant, where γ is the ratio of two specific heats.

b) Show that for an isentropic transformation

i) $\left(\frac{\partial V}{\partial T}\right)_S = -\frac{C_v}{C_p - C_v}\left(\frac{\partial V}{\partial T}\right)_p$

ii) $\left(\frac{\partial P}{\partial T}\right)_S = \frac{C_p}{C_p - C_v}\left(\frac{\partial P}{\partial T}\right)_v$. 4 + (3 + 3)

6. a) State the physical significance of entropy.

b) Calculate the increase in entropy when n_1 moles of a gas mix up with n_2 moles of another gas, both being at the same temperature and pressure. Discuss Gibbs' paradox in this connection.

c) m gm of water at temperature T_1 is isobarically and adiabatically mixed with an equal mass of water at temperature T_2. Show that entropy change of the universe is $2mC_p \ln\frac{(T_1+T_2)/2}{\sqrt{T_1T_2}}$ and is positive.

2 + (3 + 2) + 3

7. a) What do you mean by thermal conductivity of a substance ? Write down its S.I. unit.

b) Establish the differential equation for the flow of heat through a metal bar of uniform cross-section heated at one end.

Explain how this equation is applied to the cases of (i) a lagged bar and (ii) an unlagged bar, describing the essential difference between them.

2 + (4 + 2 + 2)