'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 3rd Semester Examination, 2021

CC6-PHYSICS

THERMAL PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
All symbols are of usual significance.

GROUP-A

1. Answer any ***five*** questions from the following: 1×5 = 5

   (a) Give reasons whether an electric capacitor is a thermodynamic system or not. 1

   (b) The density of H_2 gas at N.T.P is 8.96×10^{-5} g/cc. Calculate r.m.s velocity of O_2 molecules at N.T.P. 1

   (c) Can Carnot engine function as a heat pump? 1

   (d) What is quasi-static process? Give example. 1

   (e) What are the units of reduced volume and reduced temperature? 1

   (f) Prove that $\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial P}{\partial T}\right)_V$ 1

   (g) State how viscosity and thermal conductivity are related. 1

   (h) How does viscosity of gas vary with temperature and pressure? 1

GROUP-B

Answer any *three* questions from the following 5×3 = 15

2. (a) From the four thermodynamic potentials, establish the Maxwell's four thermodynamical relations. 2+3

   (b) Calculate change in melting point of ice at 0ºC when the pressure is increased by 2 atmosphere. How much pressure is required to lower the melting point by 1ºC? Given the latent heat of fusion = 80 Cal/g and specific volumes of water and ice are 1.0001cc and 1.0908cc respectively.

3. (a) What is Brownian motion? Give the essential features of the motion. Write down the Einstein's equation for Brownian motion. 2+3

   (b) The coefficient of viscosity of a gas is $16.6\times10^{-6}\,\mathrm{Ns^{-1}m^{-1}}$. Calculate the mean free path, frequency of collisions and the diameter of the gas molecules. Given $\tau = 450\ \mathrm{ms^{-1}}$, $\rho = 1.25\ \mathrm{kg\,m^3}$ and number density is 2.7×10^{25} molecules $\mathrm{m^{-3}}$.

4. What do you mean by collision probability? 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. 1+4

5. (a) Write down the relation between entropy and unavailable energy in an irreversible process. 1+4

   (b) Find the increase in entropy when 1 kg of water at 273 K is mixed with 1 kg of water at 373 K. Given specific heat of water: $4.2\times10^3\,\mathrm{J/kg/^oC}$.

6. (a) Prove that: 2+2+1

   (i) $U = \left\{\dfrac{\partial(F/T)}{\partial(1/T)}\right\}_V$ (ii) $F = \left\{\dfrac{\partial(G/P)}{\partial(1/P)}\right\}_T$

   (b) For a two phase system in equilibriums p is a function of T only so that $\left(\dfrac{\partial p}{\partial T}\right)_V = \left(\dfrac{\partial p}{\partial T}\right)_S$. If E_S be the adiabatic elasticity show that $E_S C_V = TV\left(\dfrac{\partial p}{\partial T}\right)^2$.

   (c) Prove that maximum number of phases that can co-exist in equilibrium is 3 for an one component pVT system.

GROUP-C

Answer any *two* questions from the following $10\times2 = 20$

7. (a) Deduce Maxwell's speed distribution law for 2-dimensional gas. 4

   (b) Explain graphically why Maxwell's distribution curve is broadened with increase in temperature. 3

   (c) Using Maxwell distribution in 3-dimension, find the mean of the reciprocal velocity of a molecule. 3

8. (a) Represent a Carnot cycle on (i) *P-V* diagram, (ii) *S-T* diagram and hence find the efficiency of a Carnot Cycle. $1\frac{1}{2}+2\frac{1}{2}$

   (b) Show for an irreversible process, the net change of entropy will be positive. 3

   (c) A reversible engine converts $\frac{1}{6}$ th of the heat input into work. If the temperature of the sink is reduced by 62ºC, its efficiency is doubled. Find the temperature of the source and the sink. 3

9. (a) Write down the relation among F, G, H and prove that $G = H + T\left(\frac{\partial F}{\partial T}\right)_V$ 2+2

(b) Prove that $\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)$ 2

(c) Why $C_P > C_V$? Explain it physically. 2

(d) Show that $\frac{dL}{dT} = \frac{L}{T} + C_f - C_i$ 2

Where, C_f : Specific heat of liquid

C_i : Specific heat of saturated vapour,

L : Latent heat of liquid

10.(a) State and prove the Virial theorem. (1+3)

(b) Use this theorem to obtain the equation of state of an ideal gas. 3

(c) The Van-der Wall's constants for helium have the following values $a = 3.44 \times 10^{-10}$ dynes $\text{cm}^{-4}\text{mole}^{-2}$ and $b = 23.4$ cc mole^{-1}. Calculate the critical constants for helium. 3

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