'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 3rd Semester Examination, 2023

CC6-PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.

GROUP-A

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

   (a) What is the temperature at which all molecular motion ceases? Why does it cease?

   (b) What do you mean by "degrees of freedom" of a dynamical system?

   (c) Why is the reduced equation of state also called the law of corresponding state?

   (d) Draw a Carnot cycle on PV diagram.

   (e) What is internal energy of a system? Is it a state function?

   (f) Write the names of four thermodynamic potentials.

   (g) Give your comments on whether van der-Waals' constants are really constants or not.

   (h) Give the statement of Gibb's phase rule.

GROUP-B

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

2. Deduce an expression for the heat conductivity K from the Kinetic theory of gases. Show that the thermal conductivity $K = \eta C_v$, for an ideal gas, where η is the coefficient of viscosity and C_v is the specific heat at constant volume. 3+2

3. It is given with usual symbols, that 5

   $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$ where U = internal energy of the system. Show that for 1 mole of van-der-Waals' gas

   $$dQ = C_V dT + \frac{RT}{V-b} dV$$

4. Show that for an isotropic transformation 3+2

   $$\left(\frac{\partial V}{\partial T}\right)_S = \frac{-C_V}{C_P - C_V}\left(\frac{\partial V}{\partial T}\right)_P \quad \text{and} \quad \left(\frac{\partial P}{\partial T}\right)_S = \frac{C_P}{C_P - C_V}\left(\frac{\partial P}{\partial T}\right)_V$$

5. (a) State the law of equipartition of energy. 2+3

   (b) The mean free path of molecules of a certain gas at pressure p and temperature T is 2×10^{-5} cm. Determine the mean free path when (i) the pressure is $p\times10^{-6}$ and temperature T, (ii) the pressure is $\frac{p}{2}$ and temperature $2T$.

6. (a) State Carnot theorem. 1+4

(b) A Carnot engine operates between T and T' with a gas as working substance whose equation of state is given by $P(V-b)=RT$. Find expression for the heat absorbed and show that the efficiency of the cycle is $1-\frac{T'}{T}$.

GROUP-C

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

7. (a) Show that $\eta=\frac{1}{3}\rho\bar{c}\lambda$ where η is the coefficient of viscosity of the gas, ρ is the density, $\bar{c}$ is the mean molecular velocity and λ is the mean free path. How does η of a gas vary with temperature? (5+1)+(2+2)

(b) (i) Show that the number of molecules with translational kinetic energy between E and $E+dE$ is given by $dN_E=\frac{2N}{(kT)^{3/2}}\left(\frac{E}{\pi}\right)^{1/2}e^{-E/kT}dE$.

(ii) Show that the most probable energy of a molecule is $\frac{1}{2}kT$.

8. (a) Show that entropy S and pressure P for a system with fixed T and fixed V are $(1\frac{1}{2}+1\frac{1}{2})$ +4+3

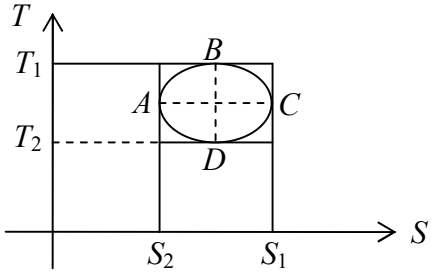
$$S=-\left(\frac{\partial F}{\partial T}\right)_V, \quad P=-\left(\frac{\partial F}{\partial V}\right)_T$$

(b) Establish the Clapeyron equation for a system that can have a first order phase transition.

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

9. (a) Define entropy and state briefly its physical significance. Show that entropy increases in natural processes. (1+2+3)+4

(b) Calculate the efficiency of the cycle *ABCDA* as depicted in the *TS* diagram internal of T_1 and T_2, given $AB=CD$.



10.(a) If $f(x,\,y,\,z)=0$, then show that (2+2)+2+4

(i) $\left(\frac{\partial z}{\partial x}\right)_y=\frac{1}{\left(\frac{\partial x}{\partial z}\right)_y}$ (ii) $\left(\frac{\partial x}{\partial y}\right)_z\left(\frac{\partial y}{\partial z}\right)_x\left(\frac{\partial z}{\partial x}\right)_y=-1$

(b) Write down the four Maxwell's relations.

(c) Calculate the change of melting point of naphthalene per atmospheric change of pressure, given the melting point = 80°C, latent heat = 35.5 cal/g, density of solid = 1.145 g/cc. and density of liquid = 0.981 g/cc.

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