'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 3rd Semester Examination, 2022

CC6-PHYSICS

THERMAL 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 thermodynamic equilibrium? 1

   (b) Explain whether adiabatic process is an isentropic process or not. 1

   (c) What are the assumptions made in deducing the Einstein's equation for Brownian motion? 1

   (d) Mention how can you increase the efficiency of a Carnot engine? 1

   (e) Show that for an one component hydrostatic system, the number of phase that can co-exist at equilibrium is 3. 1

   (f) Define the "Boyle temperature" and "Critical temperature" of a gas. 1

   (g) From Maxwell relation, show that $\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$ 1

   (h) Explain why the internal energy of an ideal gas depends only on its temperature. 1

GROUP-B

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

2. (a) Why is the thermodynamic scale of temperature called absolute scale of temperature? 2

   (b) Two Carnot engines A and B operate in series. 'A' receives heat at 900 K and rejects to a reserver at T K. 'B' receives the heat rejected by 'A' and in turn, rejects to a reservoir at 400 K. Find temp T when $1\frac{1}{2}+1\frac{1}{2}$

   (i) The work output of A and B are equal

   (ii) Efficiency of A and B are equal.

3. (a) Obtain the second TdS equation. 2

   (b) As consequence of 3rd law of thermodymics discuss the unattainability of absolute temperature. 3

4. (a) Write down the van-der Walls equation for 2 gm of O_2 and calculate the pressure at which the volume should be 500 cc at a temperature of 27ºC. The values of the constants for 1 mole of O_2 are : $b = 32$ cc, $a = 13.6\times10^{-5}$ in atom·cm^4, $R = 8.31$ J/degree. 3

   (b) Use the virial theorem to obtain the equation of state for an ideal gas. 2

5. (a) The coefficient of visosity of a gas is $16.6\times10^{-6}\,\mathrm{N\,s^{-1}m^{-1}}$. Calculate the mean free path, frequency of collision and diameter of the gas. Given, $\overline{C}=450\,\mathrm{ms^{-1}}$, $\rho=1.25\,\mathrm{kg\,m^{-3}}$, number density is 2.7×10^{25} molecules/$\mathrm{m^3}$ 3

(b) Describe the principle of Perrin's method of determination of Avogadro's number. 2

6. Show that for an isentropic transformation 4+1

(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) $\left(\frac{\partial P}{\partial T}\right)_S=\frac{C_P}{C_P-C_V}\left(\frac{\partial P}{\partial T}\right)_V$

GROUP-C

Answer any *two* questions from the following 10×2= 20

7. (a) Discuss how concept of entropy follows directly from Clausius theorem. 4

(b) A monoatomic ideal gas of N atoms undergoes an isothermal reversible expansion from volume V_1 to V_2. Find change in entropy of the gas. 3

(c) Prove that no engine can be more efficient than a reversible engine, working between the same two temperatures. 3

8. (a) What do you mean by first order phase transition? Establish Clapeyron's equation for a 1st order phase transition. 1+4

(b) Show that J-T coefficient for an isentropic change is $\mu_H=\frac{1}{C_P}\left(\frac{\partial H}{\partial P}\right)_T$ $3\frac{1}{2}$

(c) Explain the reason of cooling in adiabatic demagnetization process. $1\frac{1}{2}$

9. (a) The energy distribution law for a system of ideal gas molecules at temperature T is given by: 1+2+2+2

$$n(\varepsilon)d\varepsilon = AN\exp(-\varepsilon/kT)\sqrt{\varepsilon}d\varepsilon$$

where A is a constant and N is the total number of molecules. Plot the nature of energy distribution law graphically. Find the value of constant 'A' and hence calculate (i) the average energy, (ii) the most probable energy.

(b) If the density of a gas is 1.78 g/liter at N.T.P and the molecular weight is 40, find the kinetic energy of the gas. 3

10.(a) Assuming Maxwell's distribution law of velocities of gas molecules, find expression for, (i) r.m.s speed, (ii) most probable speed. 2+2

(b) Calculate the workdone by 1 mole of gas during a quasistatic isothermal expansion from volume V_i to V_f, when the equation of state is: 3+3

(i) $P(V-b)=RT$, (ii) $PV=RT\left(1-\frac{B}{V}\right)$

where $B=f(T)$

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