U.G. 3rd Semester Examination - 2021

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-06

(Thermal Physics)

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP-A

1. Answer any **five** questions: 2×5=10

a) Why is it necessary to introduce the concept of quasi-static process in thermodynamics?

b) Prove that the adiabatic elasticity of a gas is γ times the isothermal elasticity.

c) At what temperature will root mean square speed of oxygen molecule be double its value at N.T.P., while pressure remaining constant?

d) Prove the relation.

$$\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$$

e) Find the ratio of the coefficient of viscosity of two gas molecules A and B if the diameter of A is twice that of B while the molecular weight is thrice.

f) Define enthalpy and cite an example of an iso-enthalpic process.

g) A certain system has Gibbs free energy given by

$$G(p.T) = RTIn\left[\frac{ap}{(RT)^{5/2}}\right]$$

where a and R are constants. Find out CP, the specific heat at constant pressure.

h) What is the order of the phase transition in ferromagmetic to paramagnetic transition of a metal and why?

GROUP-B

Answer any **three** questions: 10×3=30

2. a) Calculate the probability that the speed of an O_2 molecule will lie between 200 and 201 ms^{-1} at 300K (mass of oxygen molecule is 32 units).

b) Using Maxwell's distribution for speed of molecules in a gas, establish that $vrms > \bar{v} > v_p$ where $\bar{v}$ and v_p are the average and most probable speeds respectively. Why do the velocities increase with temperature? Is the distribution symmetric about v_p? 3+(4+2+1)

3. a) 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.

b) Find the number of degrees of freedom for (i) H_2O and (ii) CO_2 molecule, assuming linear configuration of the molecules.

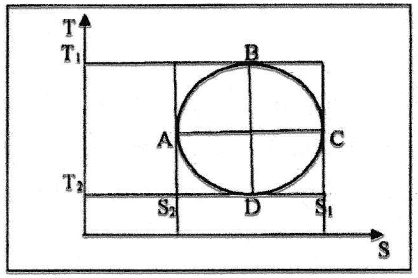
c) State law of equipartition of energy. Hence establish the relation between degrees of freedom and the ratio of two specific heats of a gas. 4+3+(2+1)

4. a) A Carnot engine operates between temperatures T_1 and T_2 with a gas as working substance whose equation of state is given by $P(V-b)=RT$. Work out the expression for the heat absorbed and the work done in each part of the cycle and show that the efficiency of the cycle is $\left(1-\frac{T_2}{T_1}\right)$.

b) Give the Kelvin-Planck statement and Clausius statement of the second law of thermodynamics. Establish the equivalence of the above two statements.

c) Show that the efficiency of the cycle ABCDA is given by $\eta = \frac{2\pi(T_1-T_2)}{\pi(T_1-T_2)+4(T_1+T_2)}$

Given AC=BD



3+3+4

5. a) Establish the relation for the rate of change of temperature with pressure in a Joule-Thomson process:

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H = \frac{V}{C_P}(\alpha T - 1)$$

What is the value of μ_{JT} for an ideal gas? What do you mean by the inversion temperature?

b) Using the fact that dS is an exact differential, derive the following relation:

$$\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$$

(4+1+1)+4

6. a) Using the Clausius theorem, show that for any process $S_f - S_i \geq \int_i^f \frac{dQ}{T}$ where the symbols have their usual meanings.

b) The specific volume of water at 0°C increases by 9.1% on freezing and the latent heat of fusion of ice is 80 cal/gm at atmospheric pressure. Calculate the pressure needed to lower the melting point of ice by 1°C.

c) Show that the $H = \left[\frac{\partial\left(G/T\right)}{\partial\left(1/T\right)}\right]_V$ enthalpy, where G is the Gibbs energy. 3+4+3

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