WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 3rd Semester Examination, 2020, held in 2021

PHSACOR06T-PHYSICS (CC6)

THERMAL PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10=20

(a) "Internal Energy is a state function and not a path function" — Explain.

(b) 1 kg of ice at 0°C is melted and converted to water at constant temperature. Compute its change in entropy, assuming that melting is done reversibly. The heat of fusion of water is 3.34×10^5 J/kg.

(c) Define zero on absolute scale of temperature.

(d) State the principle of equipartition of energy applicable to ideal gas molecules.

(e) Prove that $\left(\frac{\partial T}{\partial P}\right)_S = \frac{TV\alpha}{C_p}$, where the symbols have their usual meaning.

(f) State the differences between first order and second order phase transitions.

(g) Calculate the molecular diameter of nitrogen molecule if its number density $n = 2.7\times10^{25}/\text{m}^3$ and the mean free path $\lambda = 8\times10^{-8}$ m.

(h) Prove that in a *T*-*S* diagram the slope of isochoric curve is T/C_V.

(i) Using Maxwell's relations prove that $\left(\frac{\partial C_V}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$.

(j) "The Brownian motion of large particles is practically unnoticeable" — Explain.

(k) Define 'Boyle temperature' and 'critical temperature' of a real gas.

(l) State the Kelvin-Planck statement of second law of thermodynamics.

(m) Show that for a gas possessing f degrees of freedom the ratio of two specific heats $\frac{C_P}{C_V} = 1 + 2/f$.

(n) Find the Joule-Thomson coefficient for an ideal gas.

2. (a) For a group of particles (n_i is the number of particles with speed v_i): 2+2+1

n_i	v_i (m/s)
2	1.0
4	2.0
8	3.0
6	4.0
3	5.0

(i) Compute the average speed.

(ii) Compute the rms speed.

(iii) Find out the most probable speed.

(b) Prove that, working between the same two heat reservoirs, no engine can be more efficient than a Carnot engine. 3

(c) Show that for a hydrostatic system 2

$$\frac{dV}{V} = \beta_P \, dT - \frac{1}{B_T} dP$$

where β_P is the coefficient of volume expansion at constant pressure and B_T is the isothermal bulk modulus.

3. (a) How much work is performed by 1 mole of van der Waals gas during an isothermal expansion from volume V_1 to V_2 at temperature T ? Compare it with the work done by a perfect gas. 3+1

(b) Using kinetic theory of gas, show that the coefficient of self-diffusion $D = \frac{1}{3}\lambda \vec{c}$, where λ is the mean free path and $\vec{c}$ is the average thermal velocity. 4

(c) Explain the concept of entropy in terms of disorder. 2

4. (a) Prove the following thermodynamic relations 3+3

(i) $T\,dS = C_V \, dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$

(ii) $C_P - C_V = -T\left(\frac{\partial V}{\partial T}\right)_P^2 \left(\frac{\partial P}{\partial V}\right)_T$.

(b) What is inversion temperature? Show that the expression for inversion temperature for a van der Waals gas is $T_i = \frac{2a}{Rb}$. 1+3

5. (a) The Maxwell's velocity distribution for a two dimensional perfect gas is given by 2+2+2

$$dn = n\left(\frac{m}{2\pi KT}\right)e^{-\frac{(u^2+v^2)}{KT}}\,du\,dv$$

Here n is the number of molecules per unit area and u, v are the components of the velocity (K being the Boltzmann constant).

(i) Obtain the distribution of molecular speed between c to $c+dc$, where $c=\sqrt{u^2+v^2}$.

(ii) Find the mean square speed $\overline{c^2}$ and the most probable speed c_m.

(b) Calculate the rise in temperature of a diatomic ideal gas initially at 27°C if its pressure gets suddenly doubled. 2

(c) Show that the pressure of an ideal gas is equal to $2/3$ of the translational kinetic energy of the molecules per unit volume. 2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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