WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 3rd Semester Examination, 2019

PHSACOR06T-PHYSICS (CC6)

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: $2\times10=20$

(a) Explain what is meant by a quasi-static process. Give an example of such a process.

(b) There are 'n' number of molecules of a gas in a vessel. If the number of molecules be increased to $2n$, what will be the effect on (i) the pressure of the gas and (ii) the total energy of the gas.

(c) Why does a rubber band show a heating effect if stretched adiabatically whereas metal wires show a cooling effect in such circumstances? — Discuss with relevant mathematical expression(s).

(d) Differentiate between reversible and irreversible processes. Give necessary condition for the reversibility of a process.

(e) Calculate the collision frequency and molecular diameter of air molecules at N.T.P. given that the viscosity $\eta=1.7\times10^{-5}$ Ns/m^2, mean velocity $\bar{c}=4.5\times10^{2}$ m/s and $\rho=1.29$ kg/m^3.

(f) "The entropy of the universe is increasing." — Explain.

(g) Show that $G=-S^2\left\{\frac{\partial}{\partial S}(H/S)\right\}_P$ where the symbols have their usual meanings.

(h) Show that no engine can be more efficient than a reversible engine operating between the same two reservoirs.

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

(j) The velocities of twenty molecules are 1, 1, 2, 3, 3, 3, 4, 5, 5, 5, 5, 5, 5, 6, 6, 7, 7, 8, 8 and 9 unit. Find the average, R.M.S and most probable velocity of the molecules.

(k) Express the van der Waal's equation of state in virial form,
$PV=RT\left[1+\frac{B}{V}+\frac{C}{V^2}+.....\right]$ to find the coefficients B and C.

(l) Can a room be cooled by leaving the door of an electric refrigerator open? — Explain.

(m) Plot Maxwell speed distribution curve for the temperature T_1, T_2 and T_3 where $T_3>T_2>T_1$.

(n) Calculate the change in the melting point of ice at 0°C when the pressure is increased by 2 atms. Latent heat of fusion of ice is 80 cal/gm and specific volume of water and ice are 1.0001 and 1.0908 c.c. respectively.

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

2. (a) Draw a Carnot cycle diagram on a T-S plane and hence show that for a Carnot cycle, $\frac{T_1}{T_2}=\frac{Q_1}{Q_2}$ where T_1 and T_2 are temperatures of the source and sink respectively and Q_1 is the amount of heat absorbed from the source and Q_2 is the amount of heat rejected to the sink. 2+2

(b) Calculate the increase of entropy of 1 kg of ice when it is converted into steam. Given specific heat of water 1 kcal/kg °C, latent heat of ice 80 kcal/kg and latent heat of steam 540 kcal/kg. 3

(c) Show that $\gamma=1+\frac{2}{f}$, where $\gamma=\frac{C_P}{C_V}$ and f is the degree of freedom. 3

3. (a) Maxwell's energy distribution law is given by the relation $n(\varepsilon)d\varepsilon = A\sqrt{\varepsilon}\ e^{-\varepsilon/kT}$, where $n(\varepsilon)d\varepsilon$ is the number of gas molecules having energy between ε and $\varepsilon+d\varepsilon$. Calculate the normalization constant A, where the total number of molecules is N. Also find the average and the most probable energy of the system. 'k' stands for Boltzmann constant. 3+2+2

(b) Starting from the expression of Helmholtz free energy $F(T,V)$, show that the heat capacity at constant volume is $C_V=-T\left(\frac{\partial^2 F}{\partial T^2}\right)_V$. 3

4. (a) Obtain Clausius-Clapeyron's equation for 1st order phase transition. 3

(b) The equation of state of real gas is $P(V-b)=RT\ \exp(-a/RTV)$ where 'a' and 'b' are constants. Find the inversion temperature of the gas. 3

(c) Derive Einstein's equation for mean square displacement of Brownian particle. 4

5. (a) Explain the principle of cooling of a paramagnetic substance by adiabatic demagnetisation. Give a schematic diagram of the experimental arrangement of adiabatic demagnetisation for the production of low temperature. Find a thermodynamic expression for the amount of cooling. $1+1\frac{1}{2}+2\frac{1}{2}$

(b) (i) Justify that Joule-Thomson's Porous plug experiment can also be called adiabatic throttling process. 2

(ii) Show that the Joule-Thomson coefficient is given by 2

$$\mu=-\frac{1}{C_P}\left(\frac{\partial U}{\partial P}\right)_T-\frac{1}{C_P}\left\{\frac{\partial(PV)}{\partial P}\right\}_T.$$

(iii) Why do He and H_2 show heating effect instead of cooling during the Joule-Thomson porous plug experiment? 1

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