2020
PHYSICS
[HONOURS]
Paper : IV

Full Marks : 75 Time : 4 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.

Specify all symbols in your answer.

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

a) Define coefficient of viscosity of gas.

b) State Wiedemann-Franz's law.

c) State Maxwell's distribution law of velocities in a gas.

d) State the Zeroth law of thermodynamics.

e) What is a second order phase transition?

f) Sketch the pressure versus volume graphs at constant temperatures of a vander Waals gas.

g) State the Kirchhoff's law of thermal radiation.

2. Answer any **six** questions: 2×6=12

a) Explain dependence of Maxwell's velocity distribution on temperature.

b) Find the diameter of a molecule of benzene if its mean free path is 2.2×10^{-8}m and the number of benzene molecules per unit vol^{m} is 2.79×10^{25} molecules/m^{3}.

c) Using vander Waals equation of state, obtain the reduced equation of state.

d) What is Boyle temperature? How is it related to critical temperature?

e) How does the viscosity of a gas vary with pressure?

f) Calculate the work done in isothermal expansion of an ideal gas.

g) What is the physical significance of entropy?

h) Explain :

i) Degrees of freedom

ii) Equipartition energy

i) What is Joul-Thomson effect?

j) State Planck's law of blackbody radiation. What is radiation pressure?

3. Answer any **three** questions: 6×3=18

a) Calculate the most probable velocity from Maxwell's velocity distribution. What is the ratio of mean velocity, root mean square velocity and most probable velocity? What is mean free path? 3+2+1

b) What are the critical constants of a gas? Deduce law of corresponding state. What is diffusion in gaseous system? 2+3+1

c) Draw the P-V diagram of a Carnot's cycle and explain its different steps. Calculate the efficiency of a Carnot's engine. 3+3

d) Show that $$\frac{Tds = C_v dT + T\left(\frac{\partial P}{\partial T}\right)_v dV}{Tds = C_p dT - T\left(\frac{\partial P}{\partial T}\right)_v dP}$$

Explain Nernst heat theorem. 2+2+2

e) State and derive Stefan-Boltzman law of radiation. Draw the curve showing the energy distribution in the spectrum of blackbody radiation. 1+4+1

4. Answer any **four** questions: 10×4=40

a) Show using kinetic theory of gases, that the pressure exerted by an ideal gas on the walls of its container is $P = \frac{1}{3}mn\overline{c}^2$ where m is the mass, n is the number density and $\overline{c}^2$ is the mean squared velocity of the gas molecules. What is Brownian motion? How do you distinguish between reversible and irreversible process. 6+2+2

b) Set up Fourier's equation for thermal conduction of a solid rod neglecting radiation loss. Solve this equation when one end is periodically heated and cooled in a simple harmonic manner in time. Distinguish between thermal conductivity and thermometric conductivity.

A refrigerator is working between the temperatures 7°C and 27°C. Calculate the maximum amount of heat that can be removed per hour if energy is supplied to the refrigerator at the rate of 250 Watts. 2+3+2+3

c) Two identical bodies of constant heat capacity at temperature T_1 and T_2 are used as reservoir for a heat engine. If the bodies remain at constant pressure and undergo no change of phase, show that the amount of work obtainable is $W = C_v(T_1 + T_2 - 2T_f)$ where T_f is the final temperature. Show that for maximum W, $T_f = \sqrt{T_1T_2}$.

Show how the second law of Thermodynamics enables us to define a scale of temperature independent of the properties of any working substance.

Explain Clausius inequality. 3+4+3

d) Show that $C_p - C_v = T\left(\frac{\partial p}{\partial T}\right)_v\left(\frac{\partial V}{\partial T}\right)_p$. Show that for an isentropic transformation $\left(\frac{\partial V}{\partial T}\right)_s = \frac{C_v}{C_p - C_v}\left(\frac{\partial V}{\partial T}\right)_p$.

Write down the Kelvin-Planck and Clausius statements in context of the second law of thermodynamics. Calculate the temperature of the Sun from the following data: Radius of the Sun=7×10^8m, Distance of the Sun from the Earth=1.5×10^{11}m, Solar constant=1.36×10^3J/m/s, Stefan's constant=5.67×10^3w/m^{2}k^4.

2+3+2+3

e) Discuss thermodynamically the equilibrium between a liquid and its vapour and hence deduce Clapeyron's equation $\left(\frac{\partial P}{\partial T}\right)_V = \frac{L}{T(V_2 - V_1)}$ (where the symbols have usual significance)

Show that in case of a throttling expansion Joule-Thomson coefficient can be expressed as $\mu = \frac{1}{C_p}\left[T\left(\frac{\partial V}{\partial T}\right)_p - V\right]$ State Wien's Distribution law. 5+3+2

f) Derive Cribbs-Helmholtz equation from Cribbs free energy equation. What is virial coefficient? Mention their significance in explaining the nature of the gas. Explain the principle of cooling of a system by adiabatic demagnetisation.

4+1+1+4

———————