B.Sc. 3rd Semester (Honours) Examination, 2019 (CBCS)

Subject : Physics

Paper : CC-VI

Time: 2 Hours **Full Marks: 40**

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

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

(a) What do you mean by reversible and quasistatic processes?

(b) A heat engine is operated between the two reservoirs, source at temperature 300°C and sink at temperature 150°C. What is the maximum amount of work the engine can perform for a given heat input Q? Under what condition the maximum amount of work can be achieved?

(c) Show that the magnitude of work of reversible expansion of ideal gas from initial stage P_1 and V_1 to same final volume $V_2(V_2 > V_1)$ under isothermal process is greater than the adiabatic process.

(d) What do you mean by adiabatic work? Explain whether it is a state function or not.

(e) Why does an isochoric curve plotted on T-S diagram have a greater slope than an isobaric curve at the same temperature? Explain with justification.

(f) Nitrogen molecules obey Maxwellian distribution law and their mean energy is $15{\cdot}6\times10^{-21}$ Joules. Calculate their mean speed.

(g) Express Vander Waal's equation of state in the following virial form:

$$PV = RT + \frac{B}{V} + \frac{C}{V^2} + \cdots$$

where B and C are virial coefficients that depend upon temperature T only.

(h) What do you mean by self-diffusion? Define coefficient of self diffusion.

2. Answer *any two* of the following questions: 5×2=10

(a) (i) Find out an expression for the energy distribution of the gas molecules from their Maxwellian velocity distribution. Derive the most probable energy E_m corresponding to the most probable speed C_m.

(ii) A Van der Waal's gas undergoes a reversible isothermal expansion from volume V_1 to volume V_2. Calculate the change in Helmholtz free energy ΔF. 3+2=5

(b) (i) Consider a diatomic ideal gas near room temperature which is expanded at constant pressure by giving heat. What fraction of supplied heat is available for external work?

(ii) The mean free path of the molecules of a gas is 2×10^{-7} m. Calculate the probability that a molecule will travel 6×10^{-7} m without making a collision, if temperature is doubled. 3+2=5

(c) (i) Express the work done by a gas in terms of isothermal compressibility β_T and volume expansivity α.

(ii) Show that the coefficient of volume expansion of a substance vanishes at the absolute zero temperature. 3+2=5

(d) Derive the following thermodynamical relations representing the variation of specific heats:

$$\left(\frac{\delta C_v}{\delta V}\right)_T = T\left(\frac{\delta^2 P}{\delta T^2}\right)_V \text{ and } \left(\frac{\delta C_P}{\delta P}\right)_T = -T\left(\frac{\delta^2 V}{\delta T^2}\right)_P$$

From these relations, show that both the specific heats of ideal gas are a function of temperature only. 3+2=5

3. Answer *any two* of the following questions: 10×2=20

(a) (i) Which physical quantity is transported in case of viscosity of gas? Find an expression for the co-efficient of viscosity of a gas from the kinetic theory of gases and show that it is independent of its density.

(ii) Show that the entropy of the isolated system always increases in an irreversible process. 6+4=10

(b) (i) Derive the Clausius-Clapeyron's equation for a system under the first order phase transition. Explain the phenomenon of regelation of ice with the help of this equation.

(ii) Find out the combined efficiency of two Carnot engines, one operating between the temperature T_1 and T_2 and the other between T_2 and $T_3 (T_1 > T_2 > T_3)$. Consider that whole heat rejected by the first engine is absorbed totally by the second engine at temperature T_2. 3+3+4=10

(c) (i) Write down the Van der Waal's equation of state and graphically represent its isotherm in the P-V indicator diagram. Identify the critical point and critical isotherm with justification.

(ii) Define Joule-Thomson effect. Find out an expression of Joule-Thomson coefficient for a gas. What is the temperature of inversion for a gas in this effect? Obtain the value of inversion temperature for a Van der Waal's gas. 3+7=10

(d) (i) State the law of equipartition of energy. What is the molar specific heat at constant volume C_v for an ideal gas of diatomic rigid molecule in the limit of low temperature and in the limit of high temperature?

(ii) Show that all reversible engines operating between the same temperature limits have the same thermal efficiency.

(iii) Explain unavailable energy and thermal death of the universe. 4+3+3=10

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