U.G. 2nd Semester Examination - 2022

PHYSICS

[PROGRAMME]

Course Code : PHY-G-CC-T-02

(Thermal Physics)

SET–III

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.

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

   a) Explain the terms 'State function' and 'Path function'. Show that the work done by a system is a path function.

   b) Write the Zeroth law of thermodynamics and hence give a concept of temperature.

   c) "The existence of internal energy can be inferred from the first law of thermodynamics" —Discuss.

   d) Prove for a quasistatic adiabatic process of an ideal gas $TV^{\gamma-1}$ = const.

   e) Define Compressibility and Expansion Co-efficient.

   f) What is meant by degrees of freedom of a dynamical system. Write the Law of Equipartition of Energy.

   g) A carnot engine whose low temperature is at 7°C has an efficiency of 40%. It is desired to increase the efficiency to 50%. By how many degrees should the temperature of the source be increased?

   h) Calculate the mean free path and collision rate of hydrogen, given $\eta = 85\times10^{-6}$ *pa.sec*, $\bar{c} = 16\times10^{6}$ cm/sec and $\rho = 0.000089$ g/c.c.

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

   a) Prove that the difference of molar specific heat $C_p - C_v = \left\{P + \left(\frac{\partial U}{\partial V}\right)_T\right\}\left(\frac{\partial V}{\partial T}\right)_P$. Hence calculate the difference of molar specific heat for an ideal gas. 4+1

   b) Write the principle of increase of Entropy. Calculate the change in entropy for an ideal gas which undergoes an isothermal expansion. 2+3

c) Deduce an expression for the most probable velocity of the molecules of a gas. Hence show that if the most probable velocity is taken as unit of speed for gas molecules, the probability that the speed is between c and $c+dc$ is independent of temperature. 2+3

d) Prove that the first law of thermodynamics is a mere statement of conservation of energy. Show from the first law of thermodynamics that the temperature remains constant during an adiabatic and free expansion of a perfect gas. 2+3

Answer any **two** questions: 10×2=20

3. a) Write down the Maxwell's law of velocity distribution of the molecules of a gas mentioning each symbol. Indicate graphically how this distribution changes with the rise of temperature. 2+2

b) Starting from speed distribution law of Maxwell, deduce the momentum distribution law of the molecules of a gas. 2

c) If αt be the probability of a gas molecule making a collision in the time interval dt, where α is a constant, (i) find the probability of a gas molecule experiencing no collision during the interval t, and (ii) calculate the mean time interval between successive collisions. 2+2

4. a) The equation of state of Vander waal gas is given by $\left(P+\frac{a}{v^2}\right)(v-b)=RT$, where a, b and R are constants. Calculate the quantities: $\left(\frac{\partial P}{\partial v}\right)_T$ *and* $\left(\frac{\partial P}{\partial T}\right)_v$. 2+2

b) Show that the work done by an ideal gas during the quasi-static, isothermal expansion from an initial pressure P_i to a final pressure P_f is given by $W = nRTln(P_f/P_i)$. Calculate the work done when the pressure of 1 mol of an ideal gas is decreased quasi—statically from 20 to 1 atm, the temperature remaining constant at 20^o C(R = 8.31 J/mol.deg). 2+1

c) Consider the entropy of a pure substance as a function of T and V, derive the first TdS equation. 3

5. a) What is Joule—Thomson coefficient? 2

b) What is inversion curve? Mention the region of cooling and the region of heating corresponding to this curve. 1+2

c) Show that the initial and final temperatures are the same under all conditions for an ideal gas in the Joule-Thomson expansion. 3

d) Write down the difference between cooling produced by J-T process and adiabatic expansion. 2

6. a) Write down the Maxwell's four thermodynamic relation. Starting from the first relation derive the Clapeyron's equation. 2+2

b) Derive the first energy equation and hence show that temperature remaining constant, the internal energy of an ideal gas is independent of volume. 2+2

c) What are the first and second order phase transitions and what is the phase diagram? 2

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