বিদ্যাসাগর বিশ্ববিদ্যালয়

VIDYASAGAR UNIVERSITY

Question Paper

B.Sc. Honours Examinations 2021

(Under CBCS Pattern)

Semester - III

Subject : PHYSICS

Paper : C 6 - T & P

Full Marks : 60 (Theory - 40 + Practical - 20)

Time : 3 Hours

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

[THERMAL PHYSICS]

(Theory)

Group - A

Answer any ***three*** of the following questions : 12×3=36

1. (a) What is Boyle temperature? How is it related to critical temperature? Calculate the ratio of Boyle temperature to critical temperature.

(b) The velocity distribution of molecules coming out of a vessel is described by the functional $F(v) = Av^3 e \dfrac{-mv^2}{2kT}$. Find the most probable values of the kinetic energy of the molecules in the beam.

(c) The equation of state

$$\left[P+\left(\frac{\alpha N}{V}\right)^2\right](V-\beta N)=NK_\beta T$$

Calculate P_C and V_C. (1+2+2) + 3 + (2+2)

2. (a) Show that mean free path of the molecules of a gas is inversely proportional to the density of the gas. Calculate the mean free path of nitrogen molecule at 27ºC temperature and one atmospheric pressure. The molecular diameter of nitrogen is 3.5×10^{-8} cm.

(b) On the basis of kinetic theory deduce an expression for the viscosity of a gas in terms of mean free path of its molecule. On the basis of kinetic theory of gases deduce an expression for the co-efficient of thermal conductivity and obtain a relation between co-efficient of viscosity and co-efficient of thermal conductivity. (2+2) + (3+3+2)

3. (a) What is Joule-Thomson effect? Discuss mathematically the Joule–Thomson co-efficient for a vander waal gas. What is inversion temperature?

(b) Calculate the co-efficient of volume expansion and isothermal compressibility of a Vander Waal's gas.

(c) Find the ratio between Adiabatic elasticity co-efficient and isothermal elasticity co-efficient. (1+3+1) + (2+2) + 3

4. (a) Calculate $C_P - C_V$ for real gas.

(b) Calculate the work done by 1 mole of gas during a quasistatic isothermal expansion from a volume V_i to a volume V_f, when the equation of state is $PV=RT\left(1-\frac{B}{V}\right)$; B = f (T).

(c) Explain why the temperature of a gas drops in adiabatic expansion?

(d) An ideal gas expands according to the equation PV^n = constant. Show that heat absorbed by the gas $W\frac{(\gamma-n)}{(\gamma-1)}$. Where W is the work donw by the gas during the process. 4+3+2+3

5. (a) Prove that efficiencies of all reversible engines working between the same two temperatures are the same.

(b) A carnot engine is operating between T_1 and T_2 ($T_1 > T_2$). Second carnot engine uses all the heat rejected by 1st engine as input and operating between T_2 & T_3 ($T_2 > T_3$). What is the efficiency of the coupled system?

(c) Show that entropy increases when two gases at the same temperature and pressure diffuse into each other.

(d) Obtain an expression for change in entropy when ice changes into steam.

3+3+3+3

6. (a) Prove that for any substance $\left(\frac{\partial C_P}{\partial P}\right)_T = T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$. Hence show that for a perfect gas C_P does not vary with pressure when the temperature is kept constant.

(b) Find an expression for the change in Helmholtz free energy of a vander waal gas then the gas undergoes an isothermal expansion from volume V to 2V.

(c) Prove that :

(i) $H = -T^2\left[\frac{\partial(G/T)}{\partial T}\right]_P$

(ii) $U = -T^2\left[\frac{\partial(F/T)}{\partial T}\right]_V$

(3+2) + 3 + (2+2)

Group - B

7. Answer any ***two*** of the following questions : 2×2=4

(a) Write down the difference between Adiabatic expansion and Joule Thomson expansion.

(b) How internal energy of a real gas differs from an ideal gas?

(c) Give the limitations of first law of thermodynamics.

(d) Calculate γ of a diatomic molecule at high temperature.

(Practical)

Group - A

Answer any ***one*** of the following questions : 20×1=20

1. **Determination of Thermal Conductivity of a Good Conductor by Searle's Method** (Length (or thickness) and diameter of the good conductor bar are supplied)

   (a) Theory-3

   (b) Time—Temperature data for achieving steady state –7

   (c) Mass of water collected per second –6

   (d) Calculation of thermal conductivity –2

   (e) Discussions –2

2. **Determination of Thermal Conductivity of a Bad Conductor in the form of Disc by Lee's and Chorlton's Method :** (Thickness of the experimental disc and bottom disc are supplied)

   (a) Theory –3

   (b) Radius of the disc –3

   (c) Recording of temperature of steam chamber and bottom disc and achieving steady state –4

   (d) Recording of data for Cooling curve –3

   (e) Plotting of cooling curve –3

   (f) Calculation of thermal conductivity with Bedford correction –2

   (g) Discussions –2

3. **To determine Mechanical Equivalent of Heat by Callender and Berne's Continuous Flow Method**

   (a) Theory and experimental circuit diagram –5

   (b) Achieving steady state temperature at the inlet and outlet, Rate of flow, Voltmeter and Ammeter reading with time in tabular form (for two sets keeping the steady state temperature unaltered) –12

(c) Calculation of Mechanical Equivalent of Heat (J) –3

4. **Calibration of a thermocouple in null method using potentiometer and galvanometer. [one end in ice and another end at water bath which to be heated.]** (Resistance of the potentiometer is supplied)

(a) Theory and circuit diagram –4

(b) Data for null points with temperature (at least six temperature) and corresponding thermo-emf –12

(c) Drawing of Thermo-emf versus temperature graph –2

(d) Calculation of thermoelectric power at specified temperature –2

5. **Calibration of a thermocouple by direct measurement of the thermo-emf using operational amplifier (OPAMP) [One end in ice and another end at water bath which to be heated.]**

(a) Theory and circuit diagram –4

(b) Data for temperature versus output voltage (at least six temperature) –12

(c) Drawing of Thermo-emf versus temperature graph –2

(d) Calculation of thermoelectric power at specified temperature –2

6. **To determine temperature coefficient of resistance of a Platinum Resistance Thermometer (PRT) using. P.O. Box and meter bridge.**

(a) Theory and circuit diagram –3

(b) Data for electrical mid-point –2

(c) Null point reading for determining resistance of PRT at 0ºC for three resistances at third arm of P.O. box –4

(d) Null point reading for determining resistance of PRT at steam temperature for three resistance at third arm of P.O. box –4

(e) Determination of resistance per unit length of meter bridge for ice and steam –4

(f) Calculation of temperature coefficient of resistance of a Platinum Resistance Thermometer (PRT) –3