U.G. 3rd Semester Examination - 2020

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-06

(Thermal Physics)

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.

GROUP-A

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

   a) Write down Maxwell's law of distribution in terms of momentum of the particle.

   b) Calculate the mean free path for oxygen at 298 K and 10^{-3} mmHg. Given: σ (molecular diameter) = 3.61×10^{-8}cm.

   c) Briefly explain the distinctions between Joule's expansion, Joule-Thomson's expansion and adiabatic expansion.

   d) Calculate molecular diameter d of helium from its van der Waals constant b (b=24 cm^3mol^{-1}).

   e) Draw the cycle of operation of a Carnot engine indicating each step.

   f) 'In natural processes entropy increases'. Discuss the statement.

   g) Write down the four Maxwell's thermodynamic relations indicating each term.

   h) State and explain briefly the basic concept of the 'third law of thermodynamics'.

   i) Calculate the temperature of inversion for H_2 if the critical temperature be 22^oK.

GROUP-B

Answer any **three** questions: 10×3=30

2. a) State the fundamental postulates of the kinetic theory of matter. Discuss the basic concept of temperature.

   b) Write down Maxwell's law of distribution of molecular velocities and explain the symbols you use. Indicate graphically how the distribution changes with the rise of temperature and pressure. Calculate the

fraction of N_2 molecules at 101.325 kPa and 300 K whose kinetic energies are in the range of $\in$ - 0.005 $\in$- and $\in$+ 0.005 $\in$. [$\in$ denotes the average kinetic energy].

c) What is Boyle point of a gas?

(2+1)+(1+2+3)+1

3. a) What is Brownian motion? Based on Einstein's theory of Brownian motion, deduce an expression for Avogadro's number.

b) What is meant by critical constants of a gas? Berthelot's equation of state can be represented as $\left(P+\frac{a}{V^2T}\right)(V-b)=RT$ (where a, b are constants). Obtain the expression for critical volume.

c) Two van der Waals gases have the same value of 'b' but different 'a' values. Which of these would occupy greater volume under identical conditions? If the gases have the same 'a' value but different values of 'b' which would be more compressible? (1+3)+(1+3)+2

4. a) What do you mean by a 'quasistatic process'? Discuss the statement: 'Work is not a perfect differential: It depends on the path'.

b) The equation of state of an ideal elastic substance is given by $T=K\theta\left(\frac{L}{L_0}-\frac{{L_0}^2}{L^2}\right)$, where K is a constant and L_0 (the value of L at zero tension) is a function of temperature only. Calculate the work necessary to compress the substance from L_0 to $L_0/2$ quasistatically and isothermally.

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

d) An ideal gas with an adiabatic exponent γ, undergoes a process in which its internal energy relates to the volume as $U=aV^{\alpha}$ where a and α are constants. Find the work performed by the gas and the amount of heat to be transferred to increase internal energy ΔU?

1+2+3+2+2

5. a) Prove that no engine working between two given reservoirs can be more efficient than a reversible Carnot's engine.

b) Draw T-S diagram for 'rectangle' in P-V diagram and a 'right angle triangle' in a P-V diagram in which the base refers to an isobaric state, the altitude an isochoric state, and the hypotenuse an adiabatic state.

c) Calculate the increase in entropy which occurs when 1 litre of H_2 at a pressure of 1 atmosphere mixes with 1 litre of H_2 at 3-atmosphere pressure, the final volume being 2 litres. The temperature is taken to be constant at 0°C. 4+3+3

6. a) Derive the following equations where the symbols have the usual significance

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

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

b) Calculate the change in melting point of Naphthalene per atmosphere change of pressure, given melting point = 80°C and latent heat = 35.5 cal./gm. Density of solid = 1.145 gm./c.c. and the density of liquid is 0.981 gm./ c.c.

c) Observation of the Brownian movement in water showed that the horizontal displacement of a given particle in 11 successive intervals of 30 seconds were 0, 5.6, –4.7, –10.8, 6.6, –9.8, –11.2, –4.0, 15.0, 19.1, 16.0×10^{-4}cms. The temperature was 20°C at which viscosity of water = 0.0100 cgs unit, radius of the particle is 1.15×10^{-5} cm. If R = 8.32×10^{7}, obtain the value of *N*. 4+3+3