4291

2008-2009
B.Sc.(HONS.) (PART-III) EXAMINATION
PHYSICS
THERMAL AND STATISTICAL PHYSICS
(PH-304)

Maximum Marks: 40 Duration : Three Hours.

Answer all questions.
The marks are shown against the questions.
The symbols have their usual meanings.
Use of calculator is permitted.

1.(a) Starting with the expression for the flux of θ v molecules at a surface, derive the equation of state of an ideal gas. 05

(b) Briefly discuss what do you understand by fluctuations and Brownian motion? 02

OR

1'(a) How do you define the microscopic and macroscopic cross-sections? Obtain an expression for the mean free path of gas molecules. 05

(b) A beam of molecules of radius 2×10^{-16} m strikes a gas composed of molecules whose radii are 3×10^{-10} m. There are 10^{24} gas molecules per m^3. Determine

(i) the radius of exclusion and

(ii) the fraction of molecules left in the beam after it travels 10^{-6} m in the gas. 02

2.(a) Define the empirical and thermodynamic temperatures. How are the two temperatures related? 03

(b) Derive the following thermodynamical relations: 03

(i) $C_p - C_v = \left[\left(\frac{\partial u}{\partial v}\right)_T + p\right]\left(\frac{\partial v}{\partial T}\right)_p$

(ii) $\left(\frac{\partial u}{\partial T}\right)_p = C_p - pv\beta$

3.(a) State the Clausuis and the Kelvin- Planck statements of the second Law and show that the two statements are equivalent. 04

(b) Sketch a Carnot cycle for an ideal gas on a (i) T-S diagram and (ii) u – v diagram. 02

4.(a) Discuss the porous plug experiment and draw the isenthalpic curves and inversion curve for a gas. Show that the Joule- Kelvin coefficient for a gas is given by

....2

$$\mu = \frac{1}{C_p}\left[T\left(\frac{\partial v}{\partial T}\right)_p - v\right]$$

What is the importance of this experiment in liquefaction of gases? 2+3+1

OR

4'(a) Define the first order and the second order phase transitions and obtain the Clapeyron equation. 04

(b) Derive the following Maxwell's relations 03

$$\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial S}{\partial v}\right)_T$$

$$\left(\frac{\partial v}{\partial T}\right)_p = -\left(\frac{\partial S}{\partial P}\right)_T$$

5.(a) Define the ensemble, the micro and macro-states and the thermodynamic probability. 02

(b) What is the statistical definition of entropy? Show that the entropy of a system is given by

$$S = K \ell n\, \Omega ,$$

where Ω is the thermodynamic probability of the system. 05

6. What is a quantised linear oscillator? Show that the partition function for an assembly of such oscillators is given by

$$Z = \frac{\exp(-\theta/2T)}{1 - \exp(-\theta/T)}$$

where θ is the characteristic temperature. 07

OR

6'. Starting from first principles, obtain the Rayleigh-Jean formula for the black body radiation. What is the ultra-violet catastrophe? 6+1

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