U.G. 3rd Semester Examination - 2019

PHYSICS

[HONOURS]

Course Code : PHYS(H)CC-06-T

Thermal Physics

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Kandi Raj College (Govt. Spons.) Estd - 1950
Kandi, Murshidabad

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: $2\times5=10$

   a) Define the principle of increase of entropy.

   b) Write down the third law of thermodynamics.

   c) What is Brownian motion?

   d) Briefly explain the Doppler Broadening of spectral lines.

   e) Write the law of corresponding states.

   f) What do you mean by transport phenomena of gases.

   g) Explain the term "degrees of freedom" of a dynamical system.

   h) Define coefficient of performance of a refrigerator.

2. Answer any **two** questions: $5\times2=10$

   a) i) Calculate the increase in entropy when the temperature of 2 kg of ice is raised from $-5^{\circ}C$ to $15^{\circ}C$ water at normal pressure. Given that:

Specific heat of ice=2.09×10^{3} $Jkg^{-1}K^{-1}$

Specific heat of water=$4.18\times10^{3}Jkg^{-1}K^{-1}$

Latent heat of melting=3.35×10^{5} J/kg

ii) Prove $TdS = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$. 3+2

b) i) For a mole of ideal gas at t=0°C, calculate the work done W (in Joules) in an isothermal expansion from V_0 to $10V_0$ in volume.

ii) Derive Maxwell's relations using thermodynamic potentials. 1+4

c) i) Using the Maxwell's law of distribution of molecular speed, derive expression for root mean square speed.

ii) Obtain the relation: $F = U + \left(\frac{\partial F}{\partial T}\right)_V$ 3+2

d) i) A gas obeys the equation $P(V-b)=RT$, where b is constant and C_V is constant. Show that:

A relation that holds during an adiabatic process is $P(V-b)^{\gamma}=\text{constant}$, where $\gamma=\frac{C_P}{C_V}$.

ii) Show that the probability of a gas molecule traversing a distance x, without collision, is $e^{-\frac{x}{\lambda}}$ where λ is the mean free path of the gas molecule. 3+2

3. Answer any two questions: 10×2=20

a) i) Show that for a van der Waal's gas $C_P - C_V = R\left(1+\frac{2a}{RTV}\right)$.

ii) Which is more effective way of increasing the efficiency of Carnot engine– to increase the source temperature T_1, keeping T_2 fixed, or to decrease the sink temperature T_2, keeping T_1 fixed? Explain.

iii) Show that mean free path of gas molecules in thermal equilibrium is approximately given by $\frac{1}{\pi\sigma^2 n}$, where the symbols have their usual meanings. 4+3+3

b) i) Derive the Clausius-Clapeyron's equation from third Maxwell's relation, namely $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$.

ii) Find the change in melting point of ice at 0°C for an increase of pressure by

1 atm. Given specific volume of ice at $0^\circ C = 1.09$ cc, latent heat at $0^\circ C = 80$ cal/gm.

iii) Obtain the expression for critical constants P_c, V_c and T_C for van der Waal's equation of state. 2+4+4

c) i) Draw the temperature versus entropy diagram for Carnot cycle. Hence derive the expression for efficiency of Carnot engine.

ii) For helium gas, covolume b=23.4 cc/gm.mol. Given, $N_A = 6.22 \times 10^{23}$, calculate the diameter of the helium atom.

iii) Define first and second order phase transition with examples.

$(2+2)+3+(1\frac{1}{2}+1\frac{1}{2})$

d) i) Deduce that the Joule-Thomson coefficient μ is given by

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right].$$

ii) Discuss the results on the experimental study of isothermals of CO_2 by Andrews.

iii) The average kinetic energy of a molecule of hydrogen at $0^\circ C$ is 5.645×10^{-14} erg and the molar gas constant $R = 8.31 \times 10^7$ erg. Calculate the Avogadro number N_A. 4+3+3

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