1. (a) Calculate adiabatic lapse rate if the molecular weight of air is 0.029 Kg mol^{-1} and γ for air is 1.4.

(b) Calculate the critical constants of a gas, given $a=10^{-5}$, the unit of pressure being 1 atm and $b=10^{-3}$, the unit of volume being Ig molecular volume at NTP.

(c) Show diagrammatically how first order phase transition is different from second order phase transition.

(d) 50 g of water at 40° C is converted into ice at -10° C at constant atmospheric pressure. If the specific heat of ice at constant pressure is 0.5 cal $g^{-1}K^{-1}$, calculate the total change in entropy of the system. Latent heat of ice = 80 cal/g.

(e) Give any two differences between reversible and irreversible processes with one example for each process.

(f) At what temperature will the average speed of molecules of H_2 gas be four times the average speed of O_2 molecules. (6x3)

2. (a) Show that for an adiabatic change in a perfect gas $TP^{\left(\frac{1-\gamma}{\gamma}\right)} = constant.$ (7)

(b) Show that for an adiabatic reversible process:

$$\frac{\partial T}{\partial v} = \frac{C_v - C_P}{\alpha v C_v}$$

where C_v, and C_p are the specific heat at constant volume and pressure respectively, v is the specific volume and α is the volume coefficient of expansion. (6)

(c) Prove that adiabatic elasticity of a gas is γ times the isothermal elasticity. (5)

3. (a) Give Kelvin-Planck and Clausius statements for second law of thermodynamics. Show that both the statements are equivalent to each other. (6)

(b) Show that the efficiency of a Carnot engine is dependent only on the temperatures of the source and sink by explaining the various cycles it undergoes. (8)

(c) A reversible engine converts one-fourth of heat into work. When the temperature of the sink is reduced by 50° C, it converts one half of heat input into work. Calculate the temperatures of the source and sink. (4)

4. (a) Starting from the Maxwell's thermodynamical relation prove that $C_P - C_v = \frac{T\alpha^2 v}{\beta_T}$

where C_v, and C_p are the specific heat at constant volume and pressure respectively, T is the absolute temperature, β_T is the isothermal compressibility, α is the coefficient of volume expansion and v is the specific volume. (5)

(b) Derive Clausius-Clapeyron's equation

$$dP/dT = L/T(V_2 - V_1)$$

from Maxwell's the thermodynamical relations & also explain the effect of pressure on

(i) Boiling point of liquids and

(ii) Melting point of solids (6)

(c) Discuss in detail the concept of Clausius inequality and hence show that the difference in entropy for an irreversible process is greater than zero. (7)

5. (a) What do you mean by magneto-caloric effect? Giving a brief description of the experimental procedure, derive the expression for the fall in temperature of the specimen. Under what conditions will the fall in temperature would be more? (9)

(b) Show that when two phases of a one component system are in equilibrium, then specific Gibb's energies have the same value in both the phases. Hence, derive Ehrenfest's equations for the second order phase transitions. (9)

6. (a) Derive an expression for the mean free path and discuss its dependence on temperature and pressure. (6)

(b) Derive an expression for the coefficient of thermal conductivity using kinetic theory of gases. (9)

(c) Calculate the root mean square velocity of neutrons and electrons at 400K, taking the mass of neutron and electron as 1.675×10^{-27} kg and 9.11×10^{-31} kg respectively. (3)

7. (a) Discuss the results of Andrew's experiments on carbon dioxide. Hence, give a comparison of van der Waals' and Andrew's isotherms. (6)

(b) What do you mean by throttling process? Explain by giving a brief discussion of the experiment. Derive an expression for Joule-Thomson coefficient for ideal gases. (8)

(c) Calculate the drop in temperature when carbon dioxide gas suffers Joule-Thomson expansion at 30°C. The pressures on the two sides of the porous plug are given as 40 atm and 1 atm respectively. The van der Waals' constants of the gas are a =

36.5×10^{-2} Nm^4 mol^{-2}, $b=5.28 \times 10^{-5}$ m^3mol^{-1}.

(C_p=36.575 JK^{-1} mol^{-1} and $R = 8.31$ $JK^{-1}mol^{-1}$)

(4)

Values of Constants:

Boltzmann's constant, $k = 1.38 \times 10^{-23}$ JK^{-1} Universal gas constant, $R = 8.31$ $Jmol^{-1}K^{-1}$