Maximum mark: 15 Duration: 1 hr. Date: 12.02.2025

Answer all questions.

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1. Plot and mathematically explain the Maxwell distribution curves of velocity/speed for ideal gases in (i) 1D, (ii) 2D and (iii) 3D, each for Helium and Nitrogen.

   2÷2÷2

2. (i) Plot and mathematically explain how the mean square speed (assuming Maxwell distribution of speed in 3D for ideal gases) vary with temperature for Oxygen and Carbon dioxide (assuming ideal behaviour). (ii) Plot and explain Maxwell distribution of kinetic energy for Oxygen and Carbon dioxide.

   2÷2

3. (i) Calculate mean free path of molecules of a gas (d = 5 Å) at (a) 1 atm. and 300 K. (b) 10^{-9} atm. and 300 K. Compare the results. (ii) What is the effect of temperature on collision frequency and mean free path (assume volume to be constant)?

   3÷2

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH KOLKATA

SEMESTER 2

CH1201: Elements of Chemistry - II

Class Test -II

Maximum mark: 15 | Duration: 1 hr. | Date: 15.04.2025

Answer both questions.

1. Consider a consecutive reaction: $A \xrightarrow{k_1} B \xrightarrow{k_2} C$

   How does the concentration of starting material (A), intermediate (B) and product (C) will vary with time depending on the relative magnitude of rate constants (k_1 and k_2) in case of the above reaction. Explain (a) mathematically and (b) graphically.

   (5+3)

2. (a) Starting from the concept of 'pre-equilibria' and employing steady state approximation, explain how you will calculate K_M of an enzyme catalyzed reaction mathematically as well as graphically. (b) The enzyme catalyzed conversion of a substrate at 25°C has a Michaelis constant of 0.03 mol dm^{-3}. The rate of the reaction is 3.0×10^{-4} mol dm^{-3} s^{-1} when the substrate concentration is 0.30 mol dm^{-3}. What is the maximum velocity of this enzymolysis?

   (5+2)

All terms have their usual meaning.

IISER KOLKATA

Indian Institute of Science Education and Research Kolkata

Class Test (Spring Semester)

Subject: Elements of Chemistry-II *Subject Code(s): CH1201*

Full Marks: 15 *Time Allotted: 1 hour*

You may choose any **two** questions from Q1, Q2, Q3.

Q1. (i) An ideal gas is expanded adiabatically against a constant pressure P_2 until it doubles its volume. If the initial temperature and pressure be T_1 and P_1, respectively, **derive** the final temperature (say T_2) using generalized mathematical form of 1st law of Thermodynamics.

(ii) An ideal gas undergoes a reversible polytropic expansion according to the relation $PV^n = C$, where C & n are constant, n>1. **Derive and calculate** workdone (W) for such an expansion if one mole of the gas expands from V_1 to V_2 and if T_1=300K, T_2=200K, and n=2 (R=8.314J/mol.K).

(iii) **Compare** the work done by an ideal gas during an adiabatic expansion with the work done during an isothermal expansion between the same initial (V_1) and final volumes (V_2).

(3+2.5+2=7.5)

Q2. (i) Heat of neutralization of HCl with NaOH is -13.7 kcal/mol. When 10 mL 0.1(N) acetic acid is neutralized by 10 mL 0.1 (N) sodium hydroxide, enthalpy change is -12.5 cal. Calculate the heat of dissociation of acetic acid **per mol**.

(ii) Using the following thermochemical equations, calculate the enthalpy change (ΔH) for the combustion of carbon to form carbon dioxide:

$$(1)\ C\,(s) + 1/2\, O_2\,(g) \rightarrow CO\,(g) \quad \Delta H_1 = -110.5\,\text{kJ/mol}$$

$$(2)\ CO\,(g) + 1/2\, O_2\,(g) \rightarrow CO_2\,(g) \quad \Delta H_2 = -283.0\,\text{kJ/mol}$$

State Hess's law and using it determine the enthalpy change for the following reaction:

$$C\,(s) + O_2\,(g) \rightarrow CO_2\,(g)$$

(iii) Combining Clausius inequality and First Law of Thermodynamics show Helmholtz free energy function is equal to the maximum work accompanying a process at constant temperature.

(2+2+3.5=7.5)

Q3. A Carnot engine operates between temperatures of 600 K and 300 K using one mole of O_2 as the working substance. The gas initially has a pressure of 20 atm. Given that Cv=5 cal.K^{-1}.mol^{-1}, answer the following:

(i) Calculate the efficiency of the Carnot engine.

(ii) Assuming the working substance undergoes isothermal expansion at 600 K from volume V_A to V_B such that the pressure drops from 20 atm to 5 atm, **draw the whole cycle pointing each state** and calculate the work done during isothermal expansion (put correct input values; while you may skip calculations which requires calculator).

(iii) Hence, calculate the net work done (by the system) per cycle.

(1+4.5+2=7.5)