COURSE CODE: CHM 301   **CREDIT: 3 Units**
COURSE TITLE: PHYSICAL CHEMISTRY III   **TIME ALLOWED: 3 Hours**
INSTRUCTION: Answer Question ONE (1) and any other Four (4) Questions

1. a. Mention and explain the classification of systems based on;
    i.   number of phases they have   **(3 marks)**
    ii. exchange of energy and matter with the environment   **(4 ½ marks)**
    b. i. State Zeroth's law of thermodynamics   **(2 marks)**
    ii.   Calculate the heat necessary to raise the temperature of 3.00 mol of butane from 298 to
            573 K at constant pressure. Given that the equation for the molar heat capacity of
            butane is $C_p = (19.41 + 0.233\ T)$ J mol^{-1} K^{-1}.   **(6 marks)**
    c. Define the following terms and provide their mathematical symbols   **(4 ½)**
    i. Enthalpy
    ii. Entropy
    iii. Gibbs Free Energy
    d. What is Joule- Thomson effect?   **(2 marks)**

2. a. Define the following processes
    i. Isothermal process   **(3 marks)**
    ii. An adiabatic process   **(2 marks)**
    b. i. Mention the four steps of Carnot cycle operation: **(2 marks)**
       ii. Define a cyclic process   **(2 marks)**
    c. Derive the formula for the total work done, *W,* as the gas expands isothermally and reversibly
    from V_1 to a volume V_2.   **(3 marks)**

3. a. Define the following processes
    i.   isobaric process   **(2 marks)**
    ii.   isochoric process   **(2 marks)**
    b. i. State the first law of thermodynamics   **(2 marks)**
       ii.   What is meant by pressure-volume work?   **(2 marks)**
     c. Explain reversible and irreversible Processes   **(4 marks)**

4. a. Explain the first two processes of Carnot's cycle   **(4 marks)**
      b. i. Describe the term Heat capacity   **(2 marks)**
         ii. what is meant by Internal Energy, U of a system?   **(2 marks)**

c. An ideal gas initially at 3.00×10^2 K and 3.00×10^5 Pa pressure occupies 0.831 m^3 space. What is the minimum amount of work required to compress the gas isothermally and reversibly so that the final pressure is 6.00×10^6 Pa? (R= 8.314Jmol^{-1}K^{-1}). **(4 marks)**

5. a.i. Derive the equation for change in internal energy and heat change for a process carried out at constant volume. **(3 marks)**

ii. State the Carnot theorem **(2 marks)**

b. For an ideal gas, prove that Cp and Cv can be related according to the formula $Cp - Cv = nR$. **(4 marks)**

c. Given that W = - P_{ext}dV, derive the volume-temperature relationship for an adiabatic irreversible process. **(3 marks)**

6. Prove that the temperature-volume relationship in a reversible adiabatic process can be written as $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$ or TV = Constant. **(12 marks)**