Mount Kenya University

UNIVERSITY EXAMINATION 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL AND MATHEMATICAL SCIENCES

BEDS/BSNE
REGULAR

UNIT CODE: BCH2202 UNIT TITLE: CHEMICAL THERMODYNAMCS

DATE: THUR 16TH DEC, 2021 8.00AM MAIN EXAM TIME: 2 HOURS

R = 8.314 J/mol/K or 0.08206 litre atm/mol K, 1 atm Pressure = 101325N/M^2, Density of water = 1g/cm^3, 1M^3 = 1000 Litres.

INSTRUCTIONS: ANSWER ALL THE QUESTIONS IN SECTION A AND ANY OTHER TWO QUESTIONS IN SECTION B

SECTION A – 30 MARKS
QUESTION ONE

a) Explain the following terms as applied in thermodynamics
   i) Isothermal process
   ii) Molar heat capacity
   iii) Internal energy
   iv) iv. Entropy (8 Marks)

b) The heat capacity at constant pressure C_p is always greater than the heat capacity at constant volume C_v. Explain (3 Marks)

c) Two moles of an ideal gas at 273K and 1 atm. pressure expanded from 560 cm^3 to 1 litre at the same temperature. Determine the work done. (3 Marks)

d) Giving relevant examples where necessary, differentiate between the following terms
   i) Intensive and extensive properties (3 Marks)

ii) Isochoric and Isobaric process (3 Marks)
iii) Spontaneous and non-spontaneous (3 Marks)

e) Molar heat capacity, C in differential form is given by $C = \delta q/dT$. Show that the molar heat capacity at constant pressure is given by the following relationship $C_p = C_v + R$. (4 Marks)

f) An ideal gas initially at 200K and 4.0×10^4Pa pressure occupies $0.42M^3$space Calculate the minimum amount of work required to compress the gas Isothermally and reversibly so that the final pressure is 8.0×10^5Pa? (3 Marks

SECTION B – 40 MARKS: ANSWER ANY TWO QUESTIONS IN THIS SECTION EACH QUESTION CARRIES 20 MARKS.

QUESTION TWO

a) Iron metal can be produced by reducing Iron III oxide with hydrogen as shown below.

$$Fe_2O_{3(s)} + 3H_{2(g)} \rightarrow 2Fe_{(s)} + 3H_2O_{(g)} \quad \Delta H^\circ = +98.8kJ, \Delta S^\circ = +141.5J/K.$$

i) Is this reaction spontaneous at 25°C? (3 Marks)

ii) At what temperature will the reaction become spontaneous? (2 Marks)

b) State the first law of thermodynamics (2 Marks)

c) Calculate the free energy change for ammonia synthesis at 25°C given the following sets of partial pressures:

i) 1.0 atm N_2, 3.0 atm H_2 and 0.020 atm NH_3 (4 Marks)

ii) 0.010 atm N_2, 0.030 atm H_2 and 2.0 atm NH_3 (4 Marks)

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)} \qquad \Delta G^\circ = -33.0kJ$$

d) 0.1 mole of an ideal gas is expanded isothermally at 273 K from 3 dm^3 to 5 dm^3. Determine the energy (q) absorbed from the surroundings. (3 Marks)

e) Differentiate between closed and open systems (2 Marks)

QUESTION THREE

a) Classify the following variables as either intensive or extensive. (6 Marks)

i) Viscosity
ii) Heat capacity
iii) Density
iv) Weight
v) Refractive index

vi) Volume

b) I) State the Hess's law of constant heat summation. (2 Marks)

II) Calculate the enthalpy of the following reaction at 298K from the data given (4 Marks)

$C_2H_{4(g)} + H_{2(g)} \rightarrow C_2H_{6(g)}$

$C_2H_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(g)}$ $\Delta H = -1395kJ$

$C_2H_{6(g)} + 7/2O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$ $\Delta H = -1550kJ$

$H_{2(g)} + 1/2O_{2(g)} \rightarrow H_2O_{(g)}$ $\Delta H = -243kJ$

c) Show that for an adiabatic change carried out reversibly $P_1T_2^{C_P/R} = P_2T_1^{C_P/R}$ Given that from the first law of thermodynamics: $dE = -dw$ (5 Marks)

d) Calculate the standard entropy change for the following reaction (3 Marks)

$N_2O_{4(g)} \rightarrow 2NO_{2(g)}$

Given that:

Substance(Formula)	Molar entropies(S° in J/Kmol)
N_2O_4	304.2
NO_2	240.0

QUESTION FOUR

a) To what pressure must a given volume of neon originally at 57 °C and 1 atm. pressure be adiabatically compressed in order to raise its temperature to 273°C? (4 Marks)

b) I) Show that for an isothermal expansion of an ideal gas the change in entropy of a system is given by the following equation $\Delta S_T = -RLn(P_2/P_1)$. (5 Marks)

II) One mole of an ideal monatomic gas at STP is heated at constant volume to a temperature of 323K. Determine the change in entropy for the process. (3 Marks)

) State the law of Lavoisier and Laplace and explain how it's based on the first law of thermodynamics (3 Marks)

) A cylindor fitted with a piston contains 2 moles of helium at 100K and 2.00 atm. pressure. The pressure is increased reversibly to 6 atm. Pressure. Determine w, q and ΔE. (5 Marks)