

# 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 THERMODYNAMICS

DATE: THUR 16<sup>TH</sup> DEC, 2021 8.00AM MAIN EXAM TIME: 2 HOURS

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

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

- Isothermal process
- Molar heat capacity
- Internal energy
- 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 <sup>at p</sup>  $560 \text{ cm}^3$  <sup>from</sup> to 1 litre (3 Marks)

d) Giving relevant examples where necessary, differentiate between the following terms

- 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  $4.0 \times 10^4$  Pa pressure occupies  $0.42 \text{ m}^3$  space. Calculate the minimum amount of work required to compress the gas isothermally and reversibly so that the final pressure is  $8.0 \times 10^5$  Pa? (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.

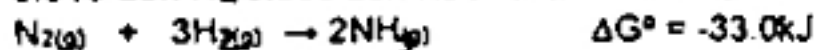


- i) Is this reaction spontaneous at  $25^\circ\text{C}$ ? (3 Marks)
  - ii) At what temperature will the reaction become spontaneous? (2 Marks)
- b) State the first law of thermodynamics (2 Marks)

- c) Calculate the free energy change for ammonia synthesis at  $25^\circ\text{C}$  given the following sets of partial pressures:

i) 1.0 atm  $\text{N}_2$ , 3.0 atm  $\text{H}_2$  and 0.020 atm  $\text{NH}_3$  (4 Marks)

ii) 0.010 atm  $\text{N}_2$ , 0.030 atm  $\text{H}_2$  and 2.0 atm  $\text{NH}_3$  (4 Marks)



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

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

**QUESTION THREE**

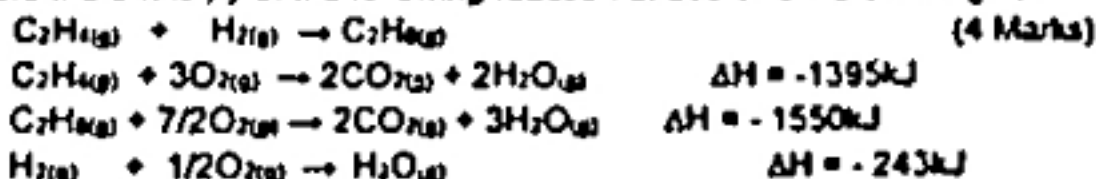
- a) Classify the following variables as either intensive or extensive. (6 Marks)

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

vi) Volume

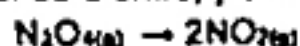
b) i) State the Hess's law of constant heat summation. (2 Marks)

ii) Calculate the enthalpy of the following reaction at 298K from the data given



c) Show that for an adiabatic change carried out reversibly  $P_1 T_2^{C_p/R} = P_2 T_1^{C_p/R}$  Given that from the first law of thermodynamics:  $dE = -dw$  (5 Marks)

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



Given that:

Substance(Formula)	Molar entropies( $S^\circ$ in J/Kmol)
$\text{N}_2\text{O}_4$	304.2
$\text{NO}_2$	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  $\Delta S_T = -R \ln(P_2/P_1)$ . (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)

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

d) A cylinder 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  $\Delta E$ . (5 Marks)