LAIKIPIA UNIVERSITY

UNIVERSITY EXAMINATIONS

1ST SEMESTER 2022/2023 ACADEMIC YEAR

THIRD YEAR EXAMINATION FOR THE DEGREES OF BACHELOR OF SCIENCE (GEN), BACHELOR OF EDUCATION (SCIENCE)

CHEM 311: CHEMICAL THERMODYNAMICS

STREAM: R ***TIME: 2 HRS***

DAY: TUE [2.30PM – 4.30] ***DATE: 6/12/2022***

THIS QUESTION PAPER CONSISTS OF FOUR (4) PAGES

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INSTRUCTIONS: Attempt all questions

QUESTION ONE

(a) i) Define Thermodynamics (1 mark)

ii) Briefly discuss the limitations of Thermodynamics (2marks)

(b) With the help of a diagram, define the terms; system, boundary and surroundings. (3 marks)

(c) Name and explain the three types of thermodynamic systems. ($4\frac{1}{2}$ marks)

(d) Define and state the conditions for achieving the following thermodynamic processes

i) Isothermal process

ii) Adiabatic process

iii) Isochoric process (3 marks)

(e) (i) Mechanical work is not a state function. Explain. (1 mark)

(ii) One mole of an ideal gas at 25°C is allowed to expand reversibly at constant temperature from volume 10 litres to 20 litres. Calculate the work done by the gas in Joules. (R= 8.314 J$K^{-}mol^{-}$) (3 marks)

(iii) Find the work done when one mole of a gas is expanded reversibly and isothermally from 5 atm to 1 atm at 25℃ ($2\frac{1}{2}$ marks)

(f) (i) State the first law of thermodynamics (1 mark)

(ii) Find ΔE, q and w if two moles of hydrogen at 3 atm pressure expand isothermally at 50℃ and reversibly to a pressure of 1 atm. (R= 8.314 J$K^{-}mol^{-}$) (3 marks)

(g) (i) Show that the heat absorbed by a system at constant volume is equal to increase in internal energy of the system. ($1\frac{1}{2}$ marks)

(ii) Show that heat absorbed by a system at constant pressure is equal to the increase in the enthalpy. ($1\frac{1}{2}$ marks)

(iii) Calculate the amount of heat in Joules needed to heat 2.0 mol of liquid water from 20.0℃ to 50.0℃ at constant pressure. specific heat capacity of water C= 4.184J$K^{-}g^{-}$ (3 marks)

QUESTION TWO

(a) (i) Define the term molar heat capacity C, and explain the difference between C_v and C_p (3 marks)

(ii) Calculate the amount of heat necessary to raise 313.5g of water from 25°C to 100°C. Molar heat capacity of water is 18 cal$mol^{-}K^{-}$. (H=1, O=16) (3 marks)

(b) (i) Show thermodynamically that for an ideal gas $C_P - C_V = R$. *Given that H=E +PV* (3 marks)

(ii) Three moles of an ideal gas at 10 atm and 0°C are converted to 2.0atm at 50°C .Calculate the value of ΔE and ΔH for the change. Given $C_v = 5\ cal\ deg^{-}mol^{-}$ and R= 2 $cal\ deg^{-}mol^{-}$ (3marks)

(c) (i) What is meant by the Joule Thomson effect? (1 mark)

(ii) Define the Joule Thomson coefficient ($\mu = \frac{dT}{dP}$), what are the implications of the positive or negative sign of the coefficient? (2 marks)

(d) (i) Derive an expression relating ΔG of a chemical reaction to ΔS and ΔH? (2 mark)

ii) Calculate standard Gibb's Free energy change for the combustion of methane:

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{(g)} + 2H_2O_{(g)}$ at 25°C. $\Delta H° = -191.8$ kcal and $\Delta S° = 1.2$ cal K^{-1} (3marks)

QUESTION THREE

(a) (i) What is a heat engine? (1mark)

(ii) State Carnot's theorem and second law of thermodynamics. (2 marks)

(iii) Heat supplied to a Carnot engine is 1897.86 kJ. How much useful work can be done by the engine which works between 0°C and 100°C? (3 marks)

(b) (i) Explain the term Thermodynamic efficiency. (1mark)

(ii) An engine operates between 100°C and 0°C and another engine operates between 100°C and 0 K (absolute zero). Find the efficiencies in two cases. (3 marks)

(c) (i) State five applications of the Clapeyron integral equation $log\frac{P_2}{P_1} = \frac{\Delta H}{2.303R}[\frac{T_2 - T_1}{T_1 T_2}]$ (4 marks)

(ii) If the vapour pressure of water at 95$^\circ C$ and 100$^\circ C$ are 634 and 760 mmHg respectively. Calculate the latent heat of vaporization per mole. (R=3.184J$K^{-}mol^{-}$)

(3 $marks$)

(iii) Water boils at 373 K at 760 mmHg pressure. At what temperature will it boil at a hill station where the atmospheric pressure is 500 mm Hg? (Latent heat of vaporization of water is 2.3 kJ g^{-1} and R = 8.314 JK^{-1} mol^{-1}) (3 marks)