KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2016/2017 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER
SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE)

COURSE CODE: SCH 240

COURSE TITLE: CHEMICAL THERMODYNAMICS

DURATION: 2 HOURS

DATE: 27TH SEPTEMBER 2017 TIME: 11:30AM – 1:30 PM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **6** printed pages. Please Turn Over

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QUESTION ONE (30 MARKS)

a) State the four laws of thermodynamics (give the mathematical expression of each) **(4)**

b) Define the following terms;

(i) Open system

(ii) Closed system

(iii) Isolated system

(3)

c) Differentiate by defining the following terms give examples of each.

i) Extensive and intensive properties of a system

ii) State function and path function of a system

(4)

d) State the equation of state for

(i) An Ideal gas

(ii) A real gas

(2)

For a system containing one mole of a mono-atomic ideal gas, show that the heat capacity at constant volume C_V, and the heat capacity at constant pressure, C_P are related by

$C_P - C_V = R$ where R is the gas constant.

(6)

e)

i) State Hess's Law.**(1)**

ii) The combustion of octane is a common reaction in automobile engines.

1) $2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)\ \Delta H_1 = -250$ kJ/mole

2) $18\ H_2O\ (l) \rightarrow 18\ H_2O\ (g)\ \Delta H_2 = 88$ kJ/mole

Net Reaction:

3) $2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (l)\ \Delta H_3 = ?$

Given ΔH_1 and $\Delta H2$, what is ΔH_3 for the net reaction above? **(5)**

iii) Use the values for standard enthalpy of formation to calculate the standard enthalpy change for the reaction:

$NH_{3(g)} + HCl_{(g)} \longrightarrow NH_4Cl_{(s)}$

$\Delta H_f(NH_{3(g)}) = -46.1 \text{ kJ mol}^{-1}$
$\Delta Hf(HCl_{(g)}) = -92.3 \text{ kJ mol}^{-1}$
$\Delta H(NH_4Cl_{(s)}) = -314.4 \text{ kJ mol}^{-1}$ **(5)**

QUESTION TWO (20 MARKS)

a) Choose the sample of matter that has greater entropy in each pair, and explain your choice:

i) 1 mol of NaCl(s) or 1 mol of HCl(g) at 25°C,

ii) 2 mol of HCl(g) or 1mol of HCl(g) at 25°C,

iii) 1 mol of HCl(g) or 1 mol of Ar(g) at 298 K.

(6)

b) Calculate the change in entropy when transferring 100kJ of heat to a large mass of water at 0^oC and when the same is transferred at 100^oC . Comment on your results.

(4)

c) The element mercury, Hg, is a silvery liquid at room temperature. The normal freezing point of mercury is –38.9°C, and its molar enthalpy of fusion is $\Delta Hfusion = 2.29$ kJ/mol. What is the entropy change of the system when 50.0 g of Hg(l) freezes at the normal freezing point?

(5)

d) The normal boiling point of ethanol, C_2H_5OH, is 78.3°C, and its molar enthalpy of vaporization is 38.56 kJ/mol. What is the change in entropy in the system when 68.3g of $C_2H_5OH(g)$ at 1atm condenses to liquid at the normal boiling point?

(5)

QUESTION THREE (20 MARKS)

a)

i. Gibb's free energy is a measure of '*thermodynamic stability*' but not *'kinetic stability'*. Explain.
(2)

ii. For the formation of Benzene from its elements
$6C + 3H_2 \longrightarrow C_6H_6$ ($\Delta G = +124KJmol^-$ at rtp)
Explain why benzene freely participates in organic reactions.
(3)

b) The decomposition of baking powder (bicarbonate) is governed by the reaction below

$NaHCO_{3(s)}Na_2CO_{3(s)} \rightarrow CO_{2(s)} + H_2O_{(l)}$

($\Delta H = +135.6KJmol^-$ and $\Delta S = +0.334KJmol^-$ at rtp)

i) Write the equation relating ΔG, ΔH and temperature hence show that ΔG is a linear function of T.**(3)**

ii) What is the critical temperature?
(1)

iii) Calculate critical temperature T* for the decomposition of baking powder above.
(3)

Use standard entropy values given in table to answer c(i) and c(ii)

Substance	S in J/mol-K
Gases	
$H_{2(g)}$	130.6
$N_{2(g)}$	191.5
$O_{2(g)}$	205.0
$H_2O_{(g)}$	188.8
$NH_{3(g)}$	192.5
$CH_3OH_{(g)}$	237.6
$C_6H_{6(g)}$	269.2
Liquids	
$H_2O_{(l)}$	69.9
$CH_3OH_{(l)}$	126.8
$C_6H_{6(l)}$	172.8
Solids	
$Li_{(s)}$	29.1
$Na_{(s)}$	51.4
$K_{(s)}$	64.7
$Fe_{(s)}$	27.23
$FeCl_{3(s)}$	142.4
$NaCl_{(s)}$	72.3

c) The Haber process for the production of ammonia involves the equilibrium

$N_2 + 3H_2 \longrightarrow 2NH_3$

Assume that $\Delta H°$ and $\Delta S°$ for this reaction do not change with temperature.

(i) Predict the direction in which $\Delta G°$ for this reaction changes with increasing temperature.**(3)**

(ii) Calculate the values of $\Delta G°$ for the reaction at 25°C and 500°C.
(5)

QUESTION FOUR (20 MARKS)

a) State Law of corresponding states.**(2)**

b) Calculate the pressure for 1 mole of a gas at 313 K occupying a volume of 0.107 $dm^3 mol^{-1}$ using law of corresponding states. (Vc = 0.0957 dm3 mo l^{-1} ; Tc = 31°C ; pc = 73.0 atm . ; R = 0.0821 atm . dm^3 K^{-1}mo l^{-1}) **(3)**

c) Draw the graphs for compressibility factor against Pressure for real a gas like N_2 and explain the nature of the graph.**(3)**

d) What is:

i) critical temperature of a real gas

ii) Critical pressure of a real gas**(2)**

e) The graph below shows how changes in volume were affected by changes in pressure for CO_2. Use it to answer questions that follow.

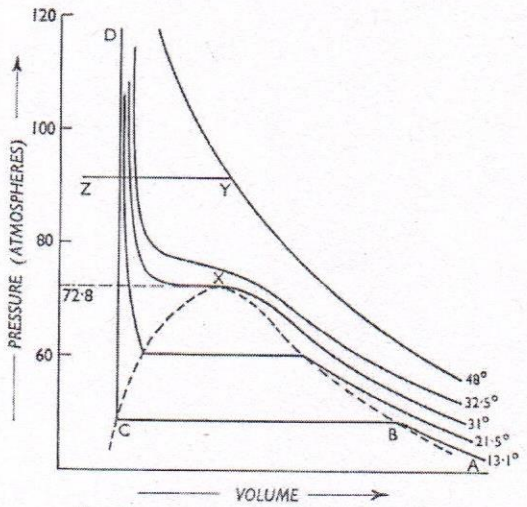

FIG. 12. p, V isothermals for carbon dioxide.

i) What is a volume Isotherm?**(2)**

ii) Explain the behavior of CO_2 between points; A-B; B-C; and C-D. **(3)**

iii) Which graph corresponds to ideal gas behavior for CO_2?**(1)**

iv) Identify the critical Temperature and pressure for CO_2 from the graph. Explain your answer. **(4)**