KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE)

COURSE CODE: SCH 240

COURSE TITLE: BASIC CHEMICAL THERMODYNAMICS

DURATION: 2 HOURS

DATE: 17/10/2018 **TIME: 11:30-1:30PM**

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 **3** printed pages. Please Turn Over

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Question 1

a. State any FOUR assumptions of kinetic theory of gases. **[4mks]**

b) State THREE differences between real gases and perfect gases? **[3mks]**

c) Oxygen occupies 20 dm^3 and exerts pressure of 1.68×10^5 NM^{-2} at -43°c. Determine the mass of oxygen present, assuming ideal gas behavior. (O=16, R=8.314 $NMK^{-1}mol^{-1}$). **[4mks]**

d) A fixed mass of gas has a volume of 76cm^3 at 27˚C and 100kPa pressure. Determine the volume that the gas would occupy at stp. (Take stp values as 0˚C and 101.3 kPa) **[4mks]**

e) The van der waals equation for real gases is $$[P + \frac{an^2}{V^2}](V - nb) = nRT$$

i. What is the significance for nb and an^2/v^2 in the equation? **[4mks]**

ii. Ammonia, NH_3, obeys the van der Waals equation of state, with parameters $a = 4.25$ atm dm^6 mol^{-1} and $b = 0.0379$ dm^3 mol^{-1}. Calculate the pressure exerted by 0.500 mol of NH_3 at a temperature of 298 K in a cylinder of volume 500 cm^3. **[3mks]**

iii. Calculate the compressibility factor z for NH_3 under the conditions in g (ii) above. **[2mks]**

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

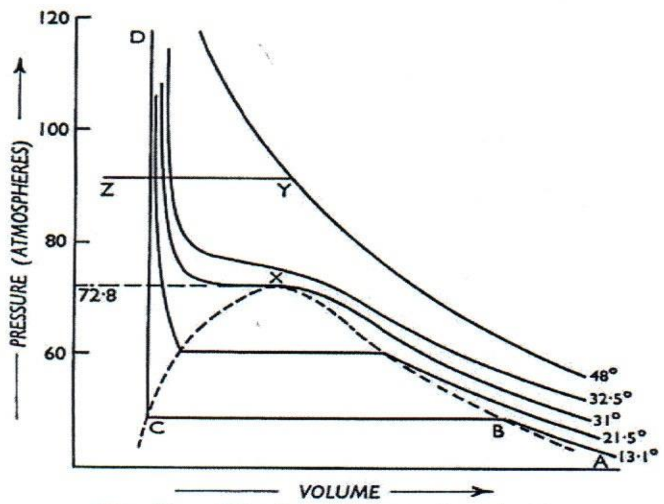


FIG. 12. p . V isothermals for carbon dioxide.

i. Which graph corresponds to ideal gas behavior for CO_2? **[1mk]**

ii. Explain the behavior of CO_2 between points; A-B and B-C **[2mks]**

iii. Identify the critical Temperature and pressure for CO_2 from the graph. **[2mks]**

g) State the Law of corresponding states. **[1mk]**

Question 2

(a) Write mathematical interpretation of the First law of thermodynamics **[1mk]**

(b) What is meant by the following terms as used in thermodynamics. **[4mks]**

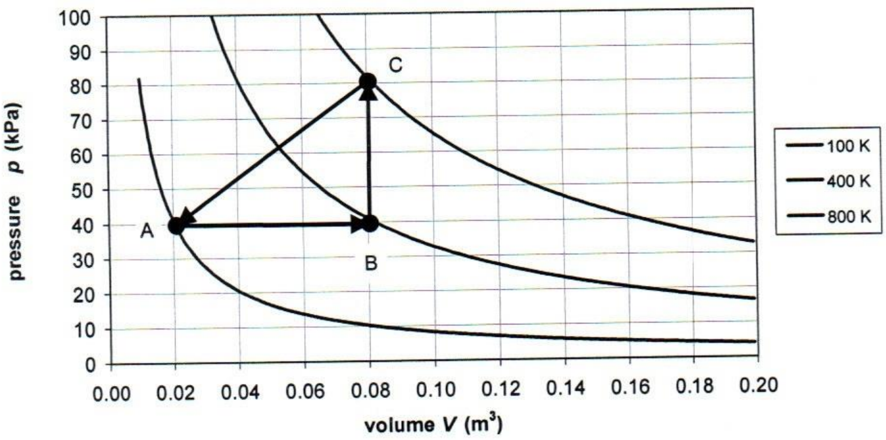
I. Isothermal process

II. Isochoric process

III. Isobaric process

IV. Adiabatic process.

c) Oxygen enclosed in a cylinder with a movable piston (assume the gas is ideal) is taken from an initial state A to another state B then to state C and back to state A.



(i) Name the processes at A-B and B-C **[2mks]**

(ii) How many moles of oxygen are in the cylinder? **[3mks]**

(iii) For the path A to B, Find the values of amount of work done, *W* and amount of heat transferred, *Q*; **[4mks]**

d) Starting from the T-V relation: $C = TV^{\gamma-1}$, derive the P-V relationship for the adiabatic process and show that the adiabatic curve is γ times steeper than the isothermal curve on a P-V diagram. **[6mks]**

Question 3

a) State Gibb's phase rule as an equation. **[1mk]**

b) Using examples, explain the following; **[6mks]**

i. Phase

ii. Components of the system

iii. Degrees of freedom

c) State any THREE conditions that fulfill a phase in a system at equilibrium. **[3mks]**

d) The dissociation of phosphoric acid, H_3PO_4, in water is:

- $H_3PO_4 + H_2O = H_2PO_4^- + H_3O^+$
- $H_2PO_4^- + H_2O = HPO_4^{2-} + H_3O^+$
- $HPO_4^{2-} + H_2O = PO_4^{3-} + H_3O^+$
- $2H_2O = H_3O^+ + OH^-$

i. Identify and determine the number of chemically distinct species, or constituents present. [**3mks**]

ii. State the number of additional constraints imposed by conditions of either electroneutrality or stoichiometry. Hence determine the number of independent components. **[3mks]**

iii. Assuming the system to exist as both liquid and vapour phases, use the phase rule to determine the variance of the system. **[2mks]**

e) Calculate the change in the boiling point of water when the pressure is increased by 1 atmosphere. Boiling point of water is 373 K. Specific volume of steam = 1.671 m^3 kg-1 and latent heat of steam is 2.268 x 106 J Kg^{-1}. **[3mks]**

<u>Question 4</u>

(a) Define Gibb's free energy, G in terms of ΔH and ΔS **[1mk]**

b) State three characteristics of spontaneous processes **[3mks]**

(c). State the criteria used to determine the spontaneity of a reaction. **[3mks]**

(d) Use the data in the table below to answer the questions which follow.

Substance	Fe2O3(s)	Fe(s)	C(s)	Co(g)	CO2(g)
$\Delta H_f^{\ominus}$/ kJ mol^{-1}	–824.2	0	0	–110.5	–393.5
$S^{\ominus}$/ J K^{-1} mol^{-1}	87.4	27.3	5.7	197.6	213.6

The following equation shows one of the reactions which can occur in the extraction of iron.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

Calculate;

(i) the standard enthalpy change ΔH_f^{θ} for this reaction. **[3mks]**

(ii) the standard entropy change for the reaction **[3mks]**

(iii) Explain why this reaction is feasible at all temperatures. **[1mk]**

(e) The reaction shown by the following equation can also occur in the extraction of iron.

$Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(s) + 3CO(g)$ $\Delta H^{\ominus} = +492.7$ kJ mol^{-1}

The standard entropy change, $\Delta S^{\ominus}$, for this reaction is +542.6 J K^{-1} mol^{-1}

i) Use this information to calculate the temperature at which this reaction becomes feasible. **[3mks]**

(ii) Calculate the temperature at which the standard free-energy change, $\Delta G^{\ominus}$ has the same value for the reactions in parts (d) and (e). **[3mks]**

Question 5

a) Explain the following; **[3mks]**

i. Enthalpy of formation

ii. Enthalpy of combustion

iii. Enthalpy of atomisation

b) State four uses of heats of combustion. **[4mks]**

c) State Hess law of heat summation. **[1mk]**

d)(i) Draw a fully-labelled Born–Haber cycle for the formation of solid barium chloride, $BaCl_2$, from its elements. Include state symbols for all species involved. **[5mks]**

(ii)Use your Born–Haber cycle and the standard enthalpy data given below to calculate a value for the electron affinity of chlorine. **[3mks]**

Enthalpy of atomisation of barium	+180 kJ mol^{-1}
Enthalpy of atomisation of chlorine	+122 kJ mol^{-1}
Enthalpy of formation of barium chloride	–859 kJ mol^{-1}
First ionisation enthalpy of barium	+503 kJ mol^{-1}
Second ionisation enthalpy of barium	+965 kJ mol^{-1}
Lattice formation enthalpy of barium chloride	–2056 kJ mol^{-1}

(e)Use data from part (d)(ii) and the entropy data given below to calculate the lowest temperature at which the following reaction becomes feasible. **[4mks]**

$$BaCl_2(s) \rightarrow Ba(s) + Cl_2(g)$$

	$BaCl_2(s)$	Ba(s)	$Cl_2(g)$
$S^{\ominus}$ / J K^{-1} mol^{-1}	124	63	223