



SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

SECOND SEMESTER EXAMINATION FOR THE DEGREES OF BACHELOR OF EDUCATION (SCIENCE) AND BACHELOR OF SCIENCE (CHEMISTRY)

SCH 303: THERMODYNAMICS II AND PHASE EQUILIBRIA

DATE: 13TH APRIL, 2017

TIME: 1.30-3.30 P.M

INSTRUCTIONS TO CANDIDATES

- (a) Answer question One and any other Two questions**
- (b) Question 1 carries 30 marks while the other questions carry 20 marks each**
- (c) Illustrate your answers with well label diagrams where applicable**

Constants

$R = 0.0820575 \text{ (L atm)/(mol K); } 8.314 \text{ Jmol}^{-1}\text{K}^{-1}; 0.08314\text{Lbarmol}^{-1}\text{K}^{-1}, 8.314\text{M}^3\text{Pa}/(\text{Kmol})$

Boltzmann's constant (k) = $1.381 \times 10^{-23} \text{ JK}^{-1}$

$C_v = 3/2R; C_p = 5/2R$

Question 1 (30 marks)

- A). Define the second law of thermodynamics in terms of: [6 marks]
 - i). Clausius statement
 - ii). Kelvin planck statement
 - iii). Entropy
- b). Sketch well labeled graphs illustrating the second law of thermodynamics based on: [4 marks]

- i). Temperature versus volume
 ii). Temperature versus entropy

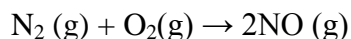
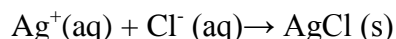
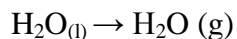
c). Fill the table for ΔH , ΔS and ΔG° on spontaneity.

[6 marks]

ΔH	ΔS	ΔG°	Result
+	+	+	
+	+	-	
-	+	-	
-	-	+	
-	-	-	
+	-	+	

d). Predict the nature of ΔS whether positive or negative for the systems below taking place at constant temperature. Explain the reason.

[6 marks]



e). Give $\partial u = T\partial S - P\partial V$, show that the entropy change (ΔS) for an ideal gas is;

[5 marks]

$$\Delta S/C_v = \ln T_2/T_1 + (\gamma-1)\ln (V_2/V_1)$$

f). The vapour pressure of ice at 268 K is 2.965 atm, determine the value for its vapour pressure at 273 K. if the heat sublimation of ice is 52370 J/mol.

[3 marks]

Question 2 (20 marks)

a). An ideal carnot engine with efficiency $\eta = 0.4$ operates using 500 moles of an ideal diatomic gas as the working substance. During isothermal expansion stage, the pressure of the gas decreases to half the maximum pressure on the cycle. At the end of the adiabatic expansion stage the pressure is 9×10^5 Pascals and its volume is 2 M^3 .

i). Sketch the carnot engine cycle and label all the stages involved.

[4 marks]

ii). Calculate the heat at the isothermal compression stage.

[4 marks]

iii). Heat absorbed from the high temperature reservoir.

[6 marks]

iv). Calculate the entropy changes at each stage.

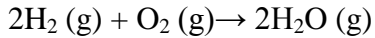
[6 marks]

Question 3 (20 marks)

a). If $\partial u = \partial q + \partial w$, proof the carnot heat pump coefficient: [10 marks]

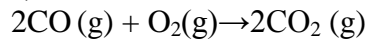
$$\text{CoP} = T_H / (T_H - T_C)$$

b). Calculate the standard entropy change ΔS for the reaction. [5 marks]



	$S^\circ \text{ J}/(\text{Kmol})$
$\text{H}_2\text{O}(\text{g})$	188.7
$\text{H}_2(\text{g})$	131
$\text{O}_2(\text{g})$	205

c). Solve for the value of ΔG change in the reaction; [5 marks]



Given;

	pressure(atm) at 25°C	$\Delta G^\circ \text{ kJ/mol}$
O_2	0.50	0
CO	0.30	137.2
CO_2	0.45	394.4

Question 4 (20 marks)

a). Find ΔG° for the reaction at 25°C and 1000°C. Explain whether the reaction is spontaneous or nonspontaneous, hence determine the temperature of spontaneity. [10 marks]

	$\Delta H_f^\circ \text{ kJ/mol}$	$S^\circ \text{ J}/(\text{Kmol})$
CaCO_3	-1207	92.9
CaO	92.9	38.2
CO_2	-394	214

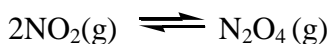
b). Derive the equation of Helmholtz energy (A), if; [5 marks]
 $A = U - TS$

c). If $\partial E = T\partial S - P\partial V$, show that; [5 marks]
 $\partial T / \partial V = -\partial P / \partial S$

Question 5 (20 marks)

a). Derive the Gibbs-duhem equation, if $G = U + PV - TS$ [5marks]

b). Calculate the value of the equilibrium constant (K_p) at 25 °C for the reaction below. [5 marks]



$$\Delta G_f^\circ \text{ kJ/mol}$$

NO ₂ (g)	51.3
N ₂ O ₄ (g)	99.8

- c). State four assumptions of the Gibbs phase rule. [4 marks]
- d. Proof that $\Delta S = C_p \ln(T_2/T_1)$ for the entropy change when one mole of a gas undergoes a reversible expansion at constant pressure (P1) from P₁, V₁, T₁ to P₁, V₂, T₂ [6 marks]