# 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: 13 TH 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**

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**Constants**

**R = 0.0820575 (L atm)/(mol K); 8.314 $Jmol^{-1}K^{-1}$; 0.08314Lbarmol$^{-1}$K$^{-1}$, 8.314M$^3$Pa/(Kmol)**
**Boltzmann's constant (k) = 1.3 81 x $10^{-23}JK^{-1}$**
**$C_v$ = 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 $\Delta H$, $\Delta S$ and $\Delta G^o$ on spontaneity. [6 marks]

| $\Delta H$ | $\Delta S$ | $\Delta G^O$ | Result |
|---|---|---|---|
| + | + | + | |
| + | + | - | |
| - | + | - | |
| - | - | + | |
| - | - | - | |
| + | - | + | |

d). Predict the nature of $\Delta S$ whether positive or negative for the systems below taking place at constant temperature. Explain the reason. [6 marks]

$H_2O_{(l)} \rightarrow H_2O\ (g)$

$Ag^+(aq) + Cl^-\ (aq) \rightarrow AgCl\ (s)$

$N_2\ (g) + O_2(g) \rightarrow 2NO\ (g)$

e). Give $\partial u = T\partial S - P\partial V$, show that the entropy change ($\Delta S$) 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 52370j/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 $9 \times 10^5$ Pascals and its volume is 2 $M^3$.

i). Sketch the carnot engine cycle and label all the stages involved. [4 marks]
i). Calculate the heat at the isothermal compression stage. [4 marks]
ii). Heat absorbed from the high temperature reservoir. [6 marks]
iii). 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]

$CoP = T_H/(T_H - T_C)$

b). Calculate the standard entropy change $\Delta S$ for the reaction. [5 marks]

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

| | $S^o$ J/(Kmol) |
|---|---|
| $H_2O(g)$ | 188.7 |
| $H_2(g)$ | 131 |
| $O_2(g)$ | 205 |

c). Solve for the value of $\Delta G$ change in the reaction; [5 marks]

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

Given;

| | pressure(atm) at 25$^o$C | $\Delta G^o$ kJ/mol |
|---|---|---|
| $O_2$ | 0.50 | 0 |
| CO | 0.30 | 137.2 |
| $CO_2$ | 0.45 | 394.4 |

**Question 4 (20 marks)**

a). Find $\Delta G^o$ for the reaction at 25$^o$C and 1000$^o$C. Explain whether the reaction is spontaneous or nonspontaneous, hence determine the temperature of spontaneity. [10 marks]

| | $\Delta H^o_f$kJ/mol | $S^o$J/(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 $^o$C for the reaction below. [5 marks]

$2NO_2(g) \rightleftharpoons N_2O_4(g)$

$\Delta G^o_f$ kJ/mol

| | |
|---|---|
| $NO_2(g)$ | 51.3 |
| $N_2O_4(g)$ | 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 $P_1$, $V_1$, $T_1$ to $P_1$, $V_2$, $T_2$ [6 marks]