UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

FIRST SEMESTER EXAMINATIONS, NOV/DEC 2018

COURSE NO: PE 275
COURSE NAME: CHEMICAL THERMODYNAMIC
CLASS: PE II TIME: 3 HRS

Name**:** _____Index Number: _____

Answer all questions UNDER sections A and two questions under section B.

SECTION A (20 MARKS)

Calculate $\Delta r\, H°$ for the reaction, $Cl_2\,(g) + 2HF\,(g) \rightarrow 2HCl\,(g) + F_2\,(g)$

1. Using enthalpy of formation data below

$\Delta_f\, H°\,(HCl) = -92.5$ kJ

$\Delta_f\, H°\,(HF) = -269$ kJ

a. 335 kJ
c. 345 kJ
b. 354 kJ
d. 353 kJ

2. Using bond enthalpy data

B.E. (H – Cl) = 431 kJ mol^{-1}

B.E. (F – F) = 155 kJ mol^{-1}

B.E. (H – F) = 563 kJ mol^{-1}

B.E. (Cl – Cl) = 242 kJ mol^{-1}

B.E. (C – H) = 415 kJ mol^{-1}

B.E. (H – H) = 435 kJ mol^{-1}

B.E. (C – Cl) = 339 kJ mol^{-1}

a. 782 kJ mol^{-1}

b. -782 kJ mol^{-1}

c. 0 kJ mol^{-1}

d. 792 kJ mol-1

3. Use bond enthalpy data given above in question (2) to calculate the enthalpy of the reaction.

CH_4 (g) + Cl_2 (g) → CH_3Cl (g) + HCl (g)

a. -113 kJ mol^{-1}

b. 113 kJ mol^{-1}

c. 311 kJ mol^{-1}

d. 313 kJ mol^{-1}

4. Calculate the enthalpy change for complete combustion of 29.0 g of butane, if

C_4H_{10} (g) + O_2 (g) → $4CO_2$ (g) + $5H_2O$ (l); $\Delta comb\Delta H^0$ = – 2658 kJ

a. 1329 kJ

b. -1329 kJ

c. -1339 kJ

d. 1392 kJ

5. Calculate the standard enthalpy of the reaction

$2H_2S$ (g) + SO_2 (g) → 3S (s) + $2H_2O$ (l) given that

$\Delta_f H^0$ (H_2S) = – 20.6 kJ mol^{-1}

$\Delta_f H^0$ (SO_2) = – 296.9 kJ mol^{-1}

$\Delta_f H^0$ (H_2O) = – 289.9 kJ mol^{-1}

a. -241.7 $kJmol^{-1}$

b. 241.7 $kJmol^{-1}$

c. -241 kJmol-1

d. 271.4 $kJmol^{-1}$

6. Calculate the enthalpy of combustion of propane

C_3H_8 (g) + $5O_2$ (g) →$3CO_2$ (g) + $4H_2O$ (l)

Given the following:

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l)$; $\Delta_f H = -285.5$ kJ/mol

$C(s) + O_2(g) \rightarrow CO_2(g)$; $\Delta_f H = -393$ kJ/mol

$3C(s) + 4H_2(g \rightarrow C_3H_8(g)$; $\Delta_f H = -104$ kJ/mol

a. -645 kJ/mol
b. -2217 kJ/mol
c. 2217 kJ/mol
d. 2127 kJ/mol

7. For an isolated system, any process that leads to an increase in the disorder of the system will be …….

From question 8 to 15, state whether it is true or false for each of the given statement.

8. The reaction quotient, Q_C is equal to the equilibrium constant, Kc at equilibrium…..……..

9. The enthalpy of reaction is dependent of the number and nature of the intermediate steps ……..

10. Standard state condition for a gaseous system is 1 bar pressure at a specified temperature……..

11. Enthalpy of formation of any elementary substance is equal to zero…….

12. When a reaction is favored by both enthalpy ($\Delta H^o < 0$) and entropy ($\Delta S^o > 0$), there is no need to calculate the value of ΔG^o to decide whether the reaction should proceed……

13. Enthalpy of formation is the heat evolved or absorbed when one gram of a substance is formed from its elements in their most stable states……..

14. When one mole of H+ (aq) and 1 mole of OH— (aq) react, 57.1 kJ of energy is absorbed…….

15. Reversible processes are those processes in which the changes are carried out so slowly that the system and surrounding are always in equilibrium…….

Given the following reaction at 300 K,

CH_4 (g) + Cl_2 (g) → CH_3Cl (g) + HCl (g); ΔH= - 140 kJ , R= 8.314$JK^{-1}mol^{-1}$

16. What is the value of Δng?

.....

17. Calculate the value of ΔU at 300 K?

.....

…….

……

18. According to the first law of thermodynamics, what are the two main driving forces that describe the internal energy of a system?

……

19. State one importance of the third law of thermodynamics……...

20. The energy available for a work done in system or reaction is known as……

SECTIOND B (40 marks)

Answer question one compulsorily and either question 2 or 3.

Question 1

(i) Calculate the standard-state entropy of reaction and the standard state enthalpy for reaction for the following reactions:

$N_2(g) + O2(g) \rightleftharpoons 2NO(g)$

Data:

Compound	S^o (J/mol-K)	ΔH^o_f (kJ/mol)
NO(g)	210.76	90.25
$N_2(g)$	191.61	0
$O_2(g)$	205.14	0

(ii) From the results obtained above, can we straight away conclude that the reaction is spontaneous?

(iii) If the reaction is to occur at 25 ^oC, Evaluate with the results from (i) whether the reaction will occur spontaneously or not.

(iv) Determine the equilibrium constant for this reaction at 100 ^oC

Question 2 (20 marks)

(i) Calculate ΔH and ΔS for the following reaction:

$$NH_4NO_3(s) + H_2O\ (l) \longrightarrow NH_4^+\ (aq) + NO_3^-\ (aq)$$

Data

Compound	ΔH_f^o(kJ/mol)	S^o(J/mol-K)
NH4NO3(s)	-365.56	151.08
NH4+ (aq)	-132.51	113.4
NO3- (aq)	-205.0	146.4
H_2O (l)	0	0

(ii) Use the results of this calculation to determine the value of ΔG^o for this reaction at 25°C

(iii) Will NH_4NO_3 spontaneously dissolves in water at room temperature? Explain.

(iv) What happens as the temperature of the reaction is increased to 400 °C ?

(v) Determine the equilibrium constant at 400 °C

Question 3 (20marks)

(i) Calculate ΔH and ΔS for the following reaction

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Data

Compound	ΔH^o_f (kJ/mol)	S^o (J/mol-K)
N2 (g)	0	191.61
H2 (g)	0	130.68
NH3 (g)	-46.11	192.45

(ii) Determine whether the reaction is spontaneous or not?

(iii) Calculate ΔG for the reaction

(iv) Will the reaction shift to the left or right to attain equilibrium given the answer you obtained at (iii)?

(v) When two moles of H_2 gas and one mole of O_2 gas react to produce two moles of gaseous water at 373 K and 1 bar pressure, a total of 484 kJ are evolved. What are (a) ΔH and (b) ΔU for the production of a single mole of H_2O (g).

EXAMINER:

AMARFIO, Eric Mensah/ Dr Solomon Adjei-Marfo