Chemistry 3

Set of exercises-1

General informations: Gibbs free energy and chemical equilibrium

Exercise 1

At 298K : $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(g)}$

Based on the values of absolute entropy given in the table below, calculate the entropy of the

reaction at 298K. Comment.

State	**Body**	**$S°_{298}$ (cal/K.mol)**
Solid	Ag	10.2
Solid	C	1.37
Liquid	H_2O	16.73
Liquid	Hg	18.17
Gas	He	30.13
Gas	H_2O	45.1
Gas	H_2	31.21
Gas	O_2	49
Gas	CO_2	51.5

Exercise 2

Consider the decomposition of yellow mercury(II) oxide.

$HgO_{(s)} \rightarrow Hg_{(l)} + ½\ O_{2(g)}$

1. Calculate the standard free energy change at room temperature, $\Delta G°_{298}$ using (a) standard free energies of formation and (b) standard enthalpies of formation and standard entropies.

2. Do the results indicate the reaction to be spontaneous or nonspontaneous under standard conditions?

Compound	**$\Delta G°_f$(kJ/mol)**	**$\Delta H°_f$ (kJ/mol)**	**$S°_{298}$(J/K·mol)**
$HgO_{(s)}$	-58.43	-90.46	71.13
$Hg_{(l)}$	0	0	75.9
$O_{2(g)}$	0	0	205.2

Exercise 3

Consider the following equilibrium :

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $T_0 = 298$ K and P = 1 atm.

Is the reaction spontaneous at $T_0 = 298$ K and at $T_1 = 500$ K ? Conclude.

Compound	$N_{2(g)}$	$H_{2(g)}$	$NH_{3(g)}$
$\Delta H_f°$(kJ/mol)	0	0	-46

$S_f°(JK^{-1}mol^{-1})$	191.61	130.68	192.45
$C_P(JK^{-1}mol^{-1})$	29.13	28.82	35.06

Exercise 4 (home work to be returned next week)

The formation and the decomposition of water molecule is governed by the following data.

Compound	H_2O	H_2	O_2
Enthalpy	-285.83 kJ/mol	0	0
Entropy	69.91 J/K mol	130.68 J/K mol	205.14 J/K mol

1. Say if the formation and the decomposition reactions are exergonic or endergonic.

2. Discuss the spontaneity is case of electrolysis and fuel cell applications.

Exercise 5

Consider the following reaction for an ideal gas:

$n_1A_1 + n_2 A_2 \rightleftharpoons m_1B_1 + m_2 B_2$

1.Give the expressions of the following equilibrium constants K_p, K_c, and K_x .

2.Deduce the relationship between these constants.

Exercise 6

Find out the value of equilibrium constant for the following reaction at 298 K.

$2\ NH_{3(g)} + CO_{2(g)} \rightleftharpoons NH_2CONH_{2(aq)} + H_2O$

Standard energy change, $\Delta G°$ at the given temperature is -13.6 kJ/mol.