

### Series N°4

#### Exercise 1

A piece of iron with a mass of  $m_{Fe} = 1000g$  and a heat capacity of  $c_p(Fe) = 0.11 \text{ Cal/g.K}$  at a temperature of  $T_{Fe} = 77^\circ\text{C}$  is introduced into a lake at a constant temperature of  $T_1 = 7^\circ\text{C}$ .

1. Calculate the entropy change of the iron.
2. Calculate the entropy change of the external environment.
3. Calculate the total entropy change and conclude.

#### Exercise 2

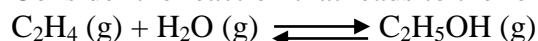
A block of ice with a mass of  $m=10Kg$  at a temperature of  $T_1=263K$  is immersed in a large water tank whose temperature is equal to  $T_2 = 288K$ .

1. Calculate the entropy change of the ice.
2. Calculate the entropy change of the tank.
3. Calculate the entropy change of the universe. Conclude.

**Data :**  $c_p(\text{water}) = 4,18 \text{ J/g.K}$ ,  $c_p(\text{ice}) = 2,09 \text{ J/g.K}$ ,  $L_{\text{fusion}} = 334 \text{ J/g}$ ,  $T_{\text{fusion}} = 273K$

#### Exercise 3

Consider the reaction that leads to the following equilibrium:



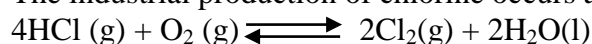
1. Calculate the standard free enthalpy of the reaction at  $25^\circ\text{C}$ : is it favorable to the formation of  $\text{C}_2\text{H}_5\text{OH}(\text{g})$ ?
2. Calculate the equilibrium constant at  $25^\circ\text{C}$ .
3. Calculate the equilibrium constant at  $573K$ , assuming that the  $\Delta H^\circ$  of the reaction is constant between  $298K$  and  $573K$ .
4. What factors must be acted upon, and how, to promote the formation of  $\text{C}_2\text{H}_5\text{OH}(\text{g})$ ?

**Data :** At  $P=1\text{atm}$  and  $T=298K$

Compounds	$\Delta H^\circ_f(\text{kJ/mol})$	$\Delta G^\circ_f(\text{kJ/mol})$
$\text{C}_2\text{H}_4(\text{g})$	52.28	68.12
$\text{H}_2\text{O}(\text{g})$	-241.83	-228.59
$\text{C}_2\text{H}_5\text{OH}(\text{g})$	-235.08	-168.45

#### Exercise 4

The industrial production of chlorine occurs at  $298K$  as follows:



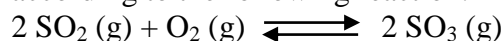
1. Express the equilibrium constant  $K_p$  as a function of the partial pressures.
2. Calculate the enthalpy and free enthalpy changes of the reaction and conclude.
3. Deduce the value of the equilibrium constant  $K_p$  at  $298K$ .
4. Carrying out the above reaction at  $900K$ , we then have:  

$$4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$$
  - a. Express  $K_p$  as a function of the partial pressures.
  - b. Initially, with 3 moles of  $\text{HCl}$  and 2 moles of  $\text{O}_2$ , and calling  $x$  the number of moles of  $\text{O}_2$  reacted, express the partial pressure of  $\text{Cl}_2$  as a function of  $x$  and the total pressure  $P$  at equilibrium.
  - c. Calculate the total pressure  $P$ , given that  $K'_p = 0.28$  and  $x = 0.47$ .
  - d. How must  $P$  vary to increase  $\text{Cl}_2$  production?

**Data :**  $\Delta H^\circ_f(\text{HCl}(\text{g})) = -92,38 \text{ kJ/mol}$ ,  $\Delta H^\circ_f(\text{H}_2\text{O}(\text{l})) = -286,87 \text{ kJ/mol}$ ,  $\Delta S^\circ_R = -365,24 \text{ J/K}$ ,

### **Exercise 5**

In the gas phase, the oxidation of sulfur dioxide (SO<sub>2</sub>) leads to the formation of sulfur trioxide (SO<sub>3</sub>), according to the following reaction:



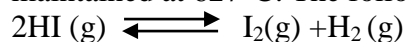
1. Calculate at  $T_1 = 298\text{K}$ ,  $\Delta H^\circ_{\text{R}}$ ,  $\Delta S^\circ_{\text{R}}$ , and  $\Delta G^\circ_{\text{R}}$ .
2. The temperature is raised to  $T_2 = 750\text{K}$ . Then, calculate at  $T_2$  the free enthalpy change ( $\Delta G^\circ_{\text{R}}$ ) for the oxidation reaction of SO<sub>2</sub>(g).
3. In which direction does the equilibrium shift if:
  - a. The temperature is decreased.
  - b. The total pressure is increased.
  - c. SO<sub>3</sub> (g) is added.
  - d. Oxygen (O<sub>2</sub>) is removed.

**Data :** At  $P=1\text{atm}$  and  $T=298\text{K}$ .

Compounds	$\Delta H^\circ_{\text{f}}$ (KJ/mol)	$S^\circ$ (J/K. mol)	$C_p$ (J/K. mol)
SO <sub>2</sub> (g)	-296.8	248.0	47.8
O <sub>2</sub> (g)	0	205.0	31.6
SO <sub>3</sub> (g)	-395.7	256.4	65.3

### **Exercise 6**

Into an empty 6 L container, 2 moles of hydroiodic acid (HI) are introduced. The temperature is maintained at 627°C. The following equilibrium is established:



At equilibrium, the sum of the partial pressures of iodine and hydrogen is equal to 6.15 atm.

1. Calculate the total pressure at equilibrium and the dissociation coefficient of HI, as well as the equilibrium constant  $K_p$ .
2. What would be the composition of the mixture at equilibrium if the initial mixture consisted of 2 moles of HI and 1 mole of I<sub>2</sub>?

Are these results consistent with the qualitative predictions that could be made?