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Series N°4

Exercise 1

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 (water) = 4,18 J/g.K, c_p(ice) = 2,09 J/g.K, L_{fusion} = 334 J/g, T_{fusion} = 273K

Exercise 2

A piece of iron with a mass of m_{Fe} = 1000g and a heat capacity of cp (Fe) = 0.11 Cal/g.K at a temperature of T_{Fe} = 77°C is introduced into a lake at a constant temperature of T_1 = 7°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 3

Consider the reaction that leads to the following equilibrium:

C_2H_4 (g) + H_2O (g) $\rightleftharpoons$ C_2H_5OH (g)

1. Calculate the standard free enthalpy of the reaction at 25°C: is it favorable to the formation of C_2H_5OH (g)?
2. Calculate the equilibrium constant at 25°C.
3. Calculate the equilibrium constant at 573K, assuming that the ΔH° of the reaction is constant between 298K and 573K.
4. What factors must be acted upon, and how, to promote the formation of C_2H_5OH (g)?

Data : At P=1atm and T=298K

Compounds	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)
C_2H_4 (g)	52.28	68.12
H_2O (g)	-241.83	-228.59
C_2H_5OH (g)	-235.08	-168.45

Exercise 4

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

4HCl (g) + O_2 (g) $\rightleftharpoons$ $2Cl_2$(g) + $2H_2O$(l)

1. Express the equilibrium constant Kp 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 Kp at 298K.
4. Carrying out the above reaction at 900K, we then have:

4HCl (g) + O_2 (g) $\rightleftharpoons$ $2Cl_2$(g) + $2H_2O$(g)

a. Express Kp as a function of the partial pressures.

b. Initially, with 3 moles of HCl and 2 moles of O_2, and calling x the number of moles of O_2 reacted, express the partial pressure of 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 Cl_2 production?

Data : $\Delta H°_f$ (HCl(g)) = - 92,38 kJ/mol, $\Delta H°_f$ (H_2O(l)) = - 286,87 kJ/mol, $\Delta S°_R$ = - 365,24 J/K,

Exercice 5

In the gas phase, the oxidation of sulfur dioxide (SO_2) leads to the formation of sulfur trioxide (SO_3), according to the following reaction:

$2\ SO_2\ (g) + O_2\ (g) \rightleftarrows 2\ SO_3\ (g)$

1. Calculate at $T_1 = 298K$, $\Delta H°_R$, $\Delta S°_R$, and $\Delta G°_R$.
2. The temperature is raised to $T_2 = 750$ K. Then, calculate at T_2 the free enthalpy change ($\Delta G°_R$) for the oxidation reaction of $SO_2(g)$.
3. In which direction does the equilibrium shift if:

a. The temperature is decreased.
b. The total pressure is increased.
c. SO_3 (g) is added.
d. Oxygen (O_2) is removed.

Data : At P=1atm and T=298K.

Compounds	$\Delta H°_f$ (KJ/mol)	S° (J/K. mol)	Cp (J/K. mol)
SO_2 (g)	-296.8	248.0	47.8
O_2 (g)	0	205.0	31.6
SO_3 (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:

$2HI\ (g) \rightleftarrows I_2(g) + H_2\ (g)$

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 Kp.
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_2?

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