University of Tlemcen *Academic year 2024-2025*
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Tutorial Series N°5

Exercise 1

Consider the following equilibrium:

$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$ $\Delta_r H = +41{,}38$ kJ

How does the equilibrium move if:

a) $CO_2(g)$ is added
b) $H_2O(g)$ is added
c) $CO(g)$ is removed
d) A catalyst is added
e) We raise the temperature
f) The volume of the container is reduced at constant temperature

Exercise 2

Consider the following chemical equilibria:

a. $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$
b. $Ca(OH)_2(s) \rightleftharpoons Ca^{2+}_{aq} + 2OH^-_{aq}$
c. $Ni(s) + 4\,CO(g) \rightleftharpoons Ni(CO)_4(g)$
d. $CO_2(g) + H_2(g) \rightleftharpoons H_2O(l) + CO(g)$

1. Indicate if the previous equilibria are homogeneous or heterogeneous.
2. Write the expressions for K_C , K_p and those linking K_p to K_C.

Exercise 3

Convert the values of *Kc* to values of *KP* or the values of *KP* to values of *Kc*.

(a) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $K_c = 0{,}50$ at 400 °C
(b) $H_2 + I_2 \rightleftharpoons 2HI$ $K_c = 50{,}2$ at 448 °C
(c) $H_2O(l) \rightleftharpoons H_2O(g)$ $K_P = 0{,}122$ at 50 °C

Exercise 4

We introduced into a vacuum vessel at 500 K; 0,4 moles of CO and 0,2 moles of H_2O,
The following equilibrium is obtained:

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

1- At equilibrium, 0,199 moles of CO_2 are formed
a- Calculate the constant K_p and deduce KC
b- Calculate the free enthalpy at 500 K. Is the reaction spontaneous at this temperature
2- Which way does the equilibrium move if:
a-the total pressure is increased
b-the quantity of carbon monoxide is reduced

Exercise 5

We introduce 1,15 g of solid N_2O_4 into a container of 1 litter, which is heated to 27 °C, this compound vaporises completely and dissociates in part according to the reaction:

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

When equilibrium is established, the total pressure is 4000 KPa calculate:

1- the number of moles of each of the two gases in the equilibrium mixture
2- the equilibrium constant K_P of the equilibrium
3- the change in the free enthalpy of formation of N_2O_4 (g), given that the free enthalpy of the reaction is constant
4- calculate the change in the standard entropy of the reaction. Can you predict its sign?

Data: molar masse (g/mol) : N (14), O (16)
$\Delta H°_f (N_2O_4)g$ = 12.5 KJ/mol, $\Delta H°_f (NO_2)g$= 33.4 KJ/mol, $\Delta G°_f (NO_2)g$= 52.3 KJ/mol