University of Tlemcen *Academic year 2024-2025*
Faculty of technology *ST Engeener*
Department of Hydraulics

Tutorial Series N°4

Exercise 1

A. Predict the sign of $\Delta S_{reaction}$ (positive or negative) for the following reactions:

$2\ Mg_{(s)} + O_{2\ (g)} \rightarrow 2\ MgO_{(s)}$

$C_6H_{12}O_{6(s)} \rightarrow 2C_2H_5OH_{(l)} + 2CO_{2(g)}$

$2NH_{3(g)} + CO_{2(g)} \rightarrow H_2O_{(l)} + NH_2CONH_{2(aq)}$

$Cu_{(s)} \rightarrow Cu_{(l)}$

One mole of liquid water at room temperature → one mole of liquid water at 50°C

B. Which of the following processes are accompanied by an increase in entropy?

1) evaporation of water - 2) precipitation of AgCl(s) - 3) condensation of water vapour to ice - 4) mixing of natural gas (CH_4) and air - 5) dissolution of KBr(s) in water

Exercise 2

NF_3 is a synthetic gas that is a powerful greenhouse gas (GHG) with a global warming potential (GWP) 17,000 times greater than that of CO_2 (over 100 years) and a lifetime in the atmosphere of 740 years.

Predict the sign of ΔS°, then calculate the value of ΔS° for the reaction, using the following data:

$$\mathbf{N_{2\ (g)} + 3\ F_{2\ (g)} \rightarrow 2\ NF_{3\ (g)}}$$

Substance	$S_{298K}°$ (J/mol•K)
F_2 (g)	203
N_2 (g)	192
NF_3 (g)	261

Exercise 3

Determine the change in entropy when one mole of ice at -10°C is transformed into one mole of water at 25°C under atmospheric pressure.

Given: Normal melting temperature of ice $t_f = 0°C$

Latent heat of fusion or enthalpy of fusion of ice $L_F = \Delta_F H^{\circ}_{273,15K}$ =6019 J mol^{-1}

C_p(ice)=37,62 J $mol^{-1}K^{-1}$; C_p(water)=75,24 J $mol^{-1}K^{-1}$

Exercise 4

A.

1. Calculate $\Delta S°_{298K}$ the entropy change of the following reaction:

$$\mathbf{H_{2\ (g)} + ½\ O_{2\ (g)} \rightarrow H_2O_{(g)}}$$

knowing that:

$S°_{298K}$ ($H_{2(g)}$)=31,2 cal $mol^{-1}K^{-1}$ $S°_{298K}$ ($O_{2(g)}$)=49,0 cal $mol^{-1}K^{-1}$; $S°_{298K}$ ($H_2O_{(g)}$)=45,1 cal $mol^{-1}K^{-1}$

2. For this same reaction, what would be the change in entropy ($\Delta S°_{800K}$) at 800 K.

We give : $C_p(H_{2(g)})$= 6,9 cal $mol^{-1}K^{-1}$, $C_p(O_{2(g)})$= 7,0 cal $mol^{-1}K^{-1}$ et $C_p(H_2O_{(g)})$= 8,0 cal $mol^{-1}K^{-1}$

B. Calculate the entropy change that accompanies the preparation of a mixture of ideal gases made up of 1.00 moles of oxygen and 2.00 moles of hydrogen, in the absence of a chemical reaction and when the process is isothermal.

Exercise 5 (for students)

Combustion of methane leads to the following reaction:

$$\mathbf{CH_4\ (g) + 2\ O_{2\ (g)} \longrightarrow CO_2\ (g) + 2\ H_2O\ (l)}$$

Calculate for this reaction under standard conditions:

1. The standard entropy change of reaction $\Delta_r S^\circ_{298K}$
2. The standard entropy change $\Delta_r S^\circ_T$ at T=373,15 K

***Data*:** R= 8,314 $J.mol^{-1}.K^{-1}$

Compounds	$CH_4(g)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
$S°_{298K}$ ($J.mol^{-1}\,K^{-1}$)	186,26	4205,14	213,74	69,91
C_p ($J.mol^{-1}\,K^{-1}$)	35,31	29,36	37,11	75,29

Exercise 6

Calculate the standard free enthalpy ΔG° at 25°C of the following reaction:

$$\mathbf{N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)}$$

In an aqueous medium and in acidic solution, hydroxylamine NH_2OH is capable of fixing a proton in an instantaneous equilibrium to give the hydroxylamonium ion NH_3OH^+ (protonation reaction) : $NH_2OH_{(aq)} + H^+_{(aq)} = NH_3OH^+_{(aq)}$

Calculate the standard free enthalpy of the reaction.

Data : $\Delta_f G°_{(NH2OH)}$=-23,35kJ·mol^{-1}; $\Delta_f G°_{(NH3OH+)}$=-57,61kJ·mol^{-1}; $\Delta_f G°_{(H+)}$=0 kJ·mol^{-1}

Exercise 7

Calcium carbonate $CaCO_3$ (s) decomposes according to the reaction :

$$\mathbf{CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)}$$

a) Is this reaction thermodynamically possible under standard conditions?

The enthalpy and entropy of the reaction are assumed to be independent of temperature.
The following are given: the molar enthalpies of formation and the absolute molar entropies in the standard state:

	$CaCO_3$ (s)	**CaO**	**CO_2**
$\Delta H°_{f,298K}$ ($KJ.mol^{-1}$)	**-1210.11**	**-393.14**	**-634.11**
$S°_{298K}$ ($J.K^{-1}.mol^{-1}$)	**92.80**	**213.60**	**39.71**