Badji Mokhtar University Annaba **2024/2025**
Faculty of Science
Department of Material Sciences

Series N°2 Part 1

First principle of thermodynamics

Exercise 1:

A sample of methane (considered a perfect gas) weighing 4.5 g occupies a volume of 12.7 L at 310 K.
1- Calculate the work done when there is isothermal expansion in the face of an external pressure of 200 mm Hg increasing the volume by 3.3 L.
2- Calculate the work that would be done in the case of reversible isothermal expansion.
3- For each transformation, determine the heat involved. Is it given off or received?

Exercise 2:

One mole of perfect gas at an initial temperature of 298 K expands from a pressure of 5 atm to a pressure of 1 atm. In each of the following cases: 1- Isothermal and reversible expansion.
2- Isothermal and irreversible expansion.
3- Adiabatic and reversible expansion.
4- Adiabatic and irreversible expansion.

Calculate: the final temperature of the gas; the internal energy variations of the gas; the work done by the gas; the amount of heat involved and enthalpy variations of the gas.
We give: Cv = 3R/2 and Cp=5R/2.
Notes: For the cases of reversible and irreversible adiabatic transformations (cases 3 and 4), establish the relationships used for the calculations.

Exercise 03:

Consider a diatomic gas, which can be assimilated to a perfect gas occupying a volume of 8 liters, at 27°C under 1atm.

I- The gas is reversibly and isothermally compressed until its volume is 5 L; calculate :
  1- The final temperature and pressure.
  2- The quantity of heat exchanged with the external environment and the work done during this transformation.
  3- The internal energy variations and enthalpy.

II- The gas is reversibly and adiabatically compressed until its volume is 5 L; calculate :
  1- The final temperature and pressure.
  2- The quantity of heat exchanged with the external environment and the work done during this transformation.
  3- The internal energy variations.

Given: C_V= 5.

Exercise 04:

A container closed by a movable piston holds 2g of helium (a perfect monoatomic gas) at conditions (P_1= 1atm; V_1= 10L). The gas is compressed adiabatically, reversibly, to conditions (P_2= 3atm, V_2).
Determine: the final volume V_2; the work received by the gas; the internal energy variations of the gas and deduce the change in temperature of the gas, without calculating the initial temperature T_1.

Exercise 05:

Consider 10 g of oxygen (γ= 7/5, M = 32g) under standard conditions A (P_0 = 1atm, T_0 = 273K, V_0 = 22.4l).
a- Calculate the number of moles of oxygen and the value of the product P_0V_0.
b- An isochoric transformation AB is carried out which doubles the pressure. Calculate T_B.
c- An isobaric transformation AC is carried out which doubles the volume. Calculate T_C.
d- Calculate the changes in internal energy ΔU_{AC}, ΔU_{AB} and enthalpy ΔH_{AC}, ΔH_{AB} of the system.

Thermochemistry

Exercise 01:

1- Which of the following reactions correspond to formation reactions under standard conditions? Justify:

$$a) C_{diamont} + O_{2(g)} \rightarrow CO_{2(g)} \qquad b) C_{graphite} + 2H_{2(g)} \rightarrow CH_{4(g)}$$

$$c)\ Hg_{(s)} + {}^{1}/_{2}\,O_{2(g)} \rightarrow HgO_{(s)} \qquad d)\ {}^{1}/_{2}\,Cl_{2(g)} + {}^{1}/_{2}\,H_{2(g)} \rightarrow HCl_{(l)}$$

2- Write down the formation reactions corresponding to the ΔH_f° of the compounds: $HF_{(g)}$, $HI_{(g)}$, $HBr_{(g)}$, $Fe_2O_{3(s)}$, $NO_{(g)}$, $CaO_{(S)}$.

Exercise 02:

a) What is the value of the standard enthalpy variation at 25°C for the reaction?

$\mathbf{2Na_2O_{2(s)} \rightleftarrows 2Na_2O_{(s)} + O_{2(g)}}$ **P=1atm** $\Delta H^\circ_{f,}(\mathbf{Na_2O_{2(s)}}) = -513{,}2 KJ/mol$

$\Delta H^\circ_{f}(\mathbf{Na_2O_{(s)}}) = -418{,}0 KJ/mol$

a) At 25°C the change in enthalpy of the reaction: $\mathbf{H_{2(g)} + 1/2O_{2(g)} \longrightarrow H_2O_{(g)}}$ is **-241,8KJ** ; the partial pressure of each of the gases being 1atm, and the reaction taking place at constant pressure.

- What is the heat Q_p released during this reaction?
- What is the standard enthalpy of formation of one mole of water vapour at 25°C?

Exercise 03:

Combustion in a calorimetric bomb, at constant volume, of 3,762g of benzoic acid: ($C_6H_5CO_2H\ _S$) gives off 99,44 KJ at 298K. M ($C_6H_5CO_2H$) =122 g.mol^{-1}.

1- Write down the balance equation for the combustion reaction.
2- Calculate the molar internal energy ΔU_C° and the molar enthalpy ΔH_C° of combustion of $C_6H_5CO_2H$.
3- Calculate the enthalpy of formation ΔH_f° from $C_6H_5CO_2H$.

We give: $\Delta H_f^\circ\ H_2O_l = -285{,}84 KJ.mol^{-1} \quad \Delta H_f^\circ\ CO_{2_g} = -393{,}51 KJ.mol^{-1}$

Exercise 04:

Calculate the H-I bond energy from the gas phase reaction:

$$\boldsymbol{C_2H_5I \rightarrow HI + C_2H_4} \qquad \Delta H^\circ_{R,298K} = 70 kJ.mol^{-1}$$

Data: binding energy (KJ.mol^{-1}) : E_{C-C}= -345, $E_{C=C}$ = -615, E_{C-I} = -230, E_{C-H}= -415,

Exercise 05 :

1- Calculate ΔH_R° et ΔU_R° of the following reaction at 25°C : $2HCl_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} + Cl_{2(g)}$

We give : $\Delta H^\circ_{f,298K}\ (HCl_g) = -92{,}30\ KJ.mol^{-1}$, $\Delta H^\circ_{f,298K}\ (H_2O_l) = -285{,}84 KJ.mol^{-1}$.

2- Calculate ΔH_R° methanol synthesis according to : $2H_{2(g)} + CO_{(g)} \rightarrow CH_3OH_{(l)}$

We give : $\Delta H^\circ_{combustion}$ /KJ.mol^{-1} ; $C_{s\,(gr)} \longrightarrow CO$ $\Delta H^\circ_{C,C_s} = -110{,}53$; $CO_g \longrightarrow CO_2$ $\Delta H^\circ_{C,CO_g} = -284{,}20$ $H_{2\,g} \longrightarrow H_2O_l$ $\Delta H^\circ_{C,H_2\,g} = -285{,}83$ $CH_3OH_l \longrightarrow CO_{2\,g}$ and H_2O_l $\Delta H^\circ_{C,CH_3OH_l} = -726{,}00$;

Deduct $\Delta H^\circ_{f,CH_3OH\ l}$ and $\Delta H^\circ_{vap,CH_3OH\ l}$ at the temperature considered. $\Delta H^\circ_{f,CH_3OH\ g} = -200{,}66$