# CHEM 232 - CEMICAL THERMODYNAMICS
# 3 credit hours (2 +0 + 1)

**First: Theoretical lectures syllabus**

| Topic | Hours |
|---|---|
| **1. Importance of thermodynamics and terminology:** | |
| • The system, boundaries, surroundings<br>• State of the system<br>• States' functions (variables)<br>• Intensive and extensive properties<br>• Path of changing the system state and path functions<br>• Types of processes (isothermal, adiabatic, isochoric, and isobaric processes)<br>***Exercises*** | **3** |
| **2. Work and heat** | |
| • P-V work<br>• Specific heat<br>• Hat capacities of an ideal gas at constant volume and at constant pressure<br>• Thermal energy, kinetic energy, and temperature: definitions and relationships between them<br>***Exercises + First quiz*** | **3** |
| **First midterm exam** | **1** |
| **3. The Zeroth law** | |
| • Thermal equilibrium<br>• The zeroth law statement<br>• Celsius scale for temperature<br>***Exercises*** | **2** |
| **4. The first law** | |
| • Internal energy "U" (the heat content at constant T and V)<br>• Change in internal energy (ΔU)<br>• The law of conservation of energy and he mathematical expression of the first law<br>• Joule's experiment<br>• Calculations of ΔU for an ideal gas expansion and compression:<br>✓ Isothermal reversible and irreversible processes<br>✓ Adiabatic reversible and irreversible processes<br>• The Enthalpy (H): the heat content at constant T and P<br>• Change in enthalpy (ΔH)<br>• Joule and Thomson's experiment<br>• Calculations of ΔH for an ideal gas expansion and compression:<br>✓ Isothermal reversible and irreversible processes<br>✓ Adiabatic reversible and irreversible processes<br>• Relation between ΔU and ΔH<br>***Exercises + Second quiz*** | **4** |
| **Second midterm exam** | **1** |

| Topic | Hours |
|---|---|
| **5. Thermochemistry** | |
| • The standard state of matter<br>• Enthalpies of some transitions (physical changes): fusion, vaporization, sublimation, atomization.<br>• Enthalpies of some reactions (chemical changes) combustion, neutralization, and formation<br>• Factors affecting the value of ΔH<br>✓ Effect of the type of change<br>✓ Effect of the amount of substances involved<br>✓ Effect of pressure<br>✓ Effect of temperature<br>• Ways of determination of ΔH<br>✓ Calculation of ΔH from ΔU<br>✓ Calculation of ΔH using Hess's law of heat summation<br>✓ Calculation of ΔH using bonding energies<br>✓ Calculation of ΔH using Kirchhoff law<br>• Lattice energy and the born-Haber cycle<br>***Exercises + Third quiz*** | **4** |
| **6. The second law** | |
| • Carnot cycle and the thermal engine efficiency<br>• The concept of spontaneity<br>• The concept of entropy (S)<br>• Spontaneity and entropy<br>• Selected statements of the second law<br>• Calculations of ΔS of an ideal gas as result of:<br>✓ Reversible change in its volume or pressure at constant temperature<br>✓ Reversible change in its temperature at constant volume and at constant pressure<br>• Calculations of changes in entropy of an ideal gas as a result of irreversible changes in its volume, pressure, and temperature including its change to another physical state<br>***Exercises + fourth quiz*** | **4** |
| **7. The third law** | |
| • Statement of the third law<br>• The absolute entropy<br>• The absolute entropy at the absolute zero temperature and the residual entropy<br>• Use of heating curves to calculate absolute entropy of a substance at any temperature at constant pressure<br>• Calculation of ΔS at any temperature using ΔS at another temperature<br>• Calculation of ΔS° of any reaction at using the values of standard absolute entropy (S°) of reactants and products<br>***Exercises + fifth quiz*** | **2** |

| Topic | Hours |
|---|---|
| **8. The free energy and equilibrium** | |
| • The concept of the free energy<br>• The free energy and the change in the free energy of an ideal gas at constant temperature and volume (The Helmholtz free energy)<br>• The free energy and the change in the free energy of an ideal gas at constant temperature and pressure (The Gibbs free energy)<br>• Spontaneity and changes in the free energy<br>• The four criteria of equilibrium<br>• Relation between change in the standard free energy and the equilibrium constant (van't Hoff isotherm)<br>• Factors affecting equilibrium<br>✓ Effect of changing concentration<br>✓ Effect of changing pressure/volume and $K_p$ and $K_c$<br>✓ Effect of changing temperature<br>• physical equilibrium: Definition and brief explanation<br>**Exercises** | **4** |
| **Final exam** | **2** |
| **Total contact hours** | **30** |