CHEM 231 - CEMICAL THERMODYNAMICS
3 credit hours (2 + 0 + 1)

First: Theoretical lectures syllabus

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

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

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

Second: Practical laboratory experiments

Experiment - 1: Thermal equilibrium and the zeroth law
Experiment - 2: Determination of ΔU from q and w
Experiment - 3: Determination of specific heat
Experiment - 4: Enthalpy and entropy changes for the fusion of water
Experiment - 5: Determination of enthalpies of solution of:

- NH_4NO_3 in water
- $(COOH)_2$ in water

Experiment - 6: Determination of enthalpy of neutralization

- Hydrochloric acid with sodium hydroxide
- Ethanoic acid with sodium hydroxide

Experiment - 7: Enthalpy of hydration of copper (II) sulfate
Experiment - 8: Determination of enthalpy of transition of solid salts
Experiment - 9: Determination of equilibrium constant (Partition coefficient) of:

- I_2 between CCl_4 and H_2O
- CH_3COOH between $C_6C_5CH_3$ and H_2O
- C_6C_5COOH between $C_6C_5CH_3$ and H_2O

Experiment - 10: Determination of equilibrium constant (Solubility product) and the common ion effect

Third: Brief description

Importance of thermodynamics and terminology[**3**], Work and heat[**3**], The Zeroth law[**2**], The first law[**4**], Thermochemistry[**4**], The first law[**4**], The second law[**5**], The third law[**2**], The free energy and equilibrium[**4**].

No less than 10 laboratory experiments (2 contact hours every week) are carried out by students and covers different topics of the syllabus.

OR

- Importance of thermodynamics and terminology: The system, functions, Path, Types of processes[3].
- Work and heat: Work, heat capacities at constant V and P, thermal, and kinetic energy and temperature[3].
- The Zeroth law: Thermal equilibrium and Celsius scale[2].
- The first law: Internal energy, Joule and Joule-Thomson experiments, calculations of ΔU and ΔH[4].
- Thermochemistry: Enthalpies of some physical and chemical changes, factors affecting ΔH, ways of determining ΔH, Born-Haber cycle[4].
- The first law: Internal energy, Joule and Joule-Thomson experiments, calculations of ΔU and ΔH[4].
- The second law: Carnot cycle, the entropy, ΔS calculations[5].
- The third law: The absolute entropy, the residual entropy, heating curves, calculating ΔS from S°[2].
- The free energy and equilibrium: Gibbs and Helmholtz free energy, Spontaneity and free energy, criteria of equilibrium, van't Hoff isotherm, Factors affecting equilibrium, physical equilibrium[4].
- No less than 10 laboratory experiments (2 contact hours every week) are carried out by students and covers different topics of the syllabus.

Fourth: Evaluation

1. Distribution of the 100 grades over practical laboratory sessions and over theoretical chapters

Practical				**30**
Theoretical	Capter	Hours	Percentage	Grades
	CH 1	3	11.5%	08
	CH 2	3	11.5%	08
	CH 3	2	07.7%	06
	CH 4	4	15.4%	11
	CH 5	4	15.4%	11
	CH 6	4	15.4%	11
	CH 7	2	07.7	05
	CH 8	4	15.4%	10
Total		**26**	**100%**	**70**
Total				**100**

2. Distribution of the 100 grades over semester works and final exam

		Semester works		**Final exam**	
Practical		**20**		**10**	
Theoretical	CH 1 (08) CH 2 (08)	Homework & quizzes (06) Ist midterm exam(10)	**16**	**00**	
	CH 3 (06) CH 4 (11)	Homework & quizzes (7) Ist midterm exam (10)	**17**		
	CH 5 (11)	Homework & quizzes (07)	**07**	CH5(11)	**30**
	CH6(11)			CH6 (11)	
	CH 7(05)			CH7 (05)	
	CH 8 (10)			CH 8 (10)	
Total		**60**		**40**	
Total		**100**			

- Distribution of the semester grades (60 grades)
  - ✓ 20 grades (two third of the laboratory works)
  - ✓ 06 grades (Homework and quizzes: topics 1 and 2)
  - ✓ 10 grades (1st midterm exam: topics 1 and 2)
  - ✓ 07 grades (Homework and quizzes: topics 3 and 4)
  - ✓ 10 grades (1st midterm exam: topics: 3 and 4)
  - ✓ 07 grades (Homework and quizzes: topics 5, 6, 7 and 8)

  60 total
- Distribution of the final exam grades (40 grades)
  - ✓ 10 grades (one third of the laboratory works)
  - ✓ 30 grades (exam: topics 5, 6, 7 and 8)

  40 total

Homework: Each homework is two carefully chosen problems in every topic to be submitted on a specified with no chance for postponement