FOUN007 Chemistry – Structure and Bonding

Module 1: Structure, Bonding and Quantitative Chemistry
Module 2: Organic and Biological Chemistry

Section 1: General Information

1.1 Administrative Details

Subject:	Chemistry
Code:	FOUN007
Stream	Science
Points	12
Pre-requisite	None

1.2 Subject Workload

Number of timetabled hours per week	Number of Personal study hours per week	Total workload hours per week
4	4	8

1.3 Pre-requisites

Students are not required to have undertaken a pre-requisite subject.

1.4 Other resource requirements

List specialist facilities and/or equipment required for the delivery of this subject:

- Suitable calculator, but without communication function.
- Lab coat required
- University-level chemistry lab with technical support

Section 2: Academic Details

2.1 Subject Overview

The principle topics in Modules One and Two are Atomic Structure, Bonding, Molecular Skape, Organic Chemistry, Reaction Mechanisms, and Life Chemistry. Sufficient skills will be imparted such that students will have a head start on Chemistry 191 at University, which is a pathway course for medical school and related fields.

We emphasize the following general areas: background knowledge, computational skills, correct use of English language in science, and chemistry laboratory skills.

2.2 Learning Objectives and Outcomes

By the end of each lecture and tutorial you should be able to:

Lecture 1 / Tutorial 1: The Chemical World

1. Understand the particle nature of matter
2. Recall the standard units and be able to use the system of prefixes to indicate the magnitude of a given unit
3. Calculate the number of significant figures in a measurement and round a value according to the number of SF
4. Use chemical symbols correctly
5. Name covalent and ionic compounds given their formulae and write formulae for given compounds (A table of ions will not be included in any assessment tasks)

Lecture 2 / Tutorial 2: Chemical Families and Equations

1. Recall the structure of the modern periodic table
2. State the main physical properties of the group 1, 17 and 18 elements
3. Relate the similar chemical properties of a group in the periodic table to their similar electron arrangements
4. Recall the names and formulas of common laboratory reagents
5. Write balanced formulae equations
6. For a given equation, state the number (coefficient) of each species present, and say whether they are reactant or product

Lecture 3 / Tutorial 3: Atomic Structure

1. Recall the structure of Dalton's and Rutherford's atom
2. Understand the basic structure of an atom
3. Define an isotope
4. Define atomic number and mass number
5. Use atomic number and mass number to calculate the number of neutrons in an atom
6. Define an ion
7. Write equations for the ionisation energy of an element, and know the trends across a row/period
8. Write the electron arrangement (using s, p, d format) of any element or ion up to number 36 (Kr)

Lecture 4 / Tutorial 4: Chemical Bonding

1. Describe covalent bonds as electron sharing and ionic bonds as electron transfer
2. Recognise electronegativity as a measure of the electron-attracting power of an atom
3. Recall trends in the electronegativities of elements on the periodic table, and contrast with ionisation energy
4. Use electronegativity differences to predict whether a bond will be ionic, polar covalent, or non-polar covalent
5. Draw the Lewis diagrams (electron dot diagrams) of polyatomic molecules and ions with up to 6 electron pairs around the central atom, including those that have multiple bonds
6. Understand the concept of resonance

Lecture 5 / Tutorial 5: Solids

1. Relate the melting and boiling point of a substance to the strength of the forces between its particles
2. Name the forces between particles of a solid given its name, type or physical properties
3. Identify the type of structure a solid has from its physical properties
4. Explain the physical properties of ionic solids, molecular solids, metals and network solids in terms of the nature of the particles they contain and the forces between those particles
5. Account for the properties of water by reference to its structure

Lecture 6 / Tutorial 6: Molecular Shapes and Polarity

1. Use the VSEPR Theory to predict the shapes of molecules with up to 6 electron pairs surrounding the central atom
2. Predict the bond angles obtained in molecules
3. Determine the polarity of a molecule by considering the nature of the bonds within that molecule and its shape

Lecture 7 / Tutorial 7: Intermolecular Bonding and Solubility

1. Use the terms intramolecular force and intermolecular force correctly
2. Correctly describe the three types of intermolecular force – namely dispersion, dipole-dipole and Hydrogen bonding
3. Recognise the relative strength of the intermolecular forces within polar and non-polar compounds
4. Know the meaning of the terms hydration, solute, solvent, solution, miscible, immiscible and precipitate.
5. Draw a diagram showing the orientation of water molecules around the hydrated ions.
6. Predict and explain the solubilities of polar, non-polar or ionic solids in common solvents.

Lecture 8 / Tutorial 8: The Mole

1. Define the mole and state Avogadro's number
2. Define the term molar mass, M, with units
3. Calculate molar masses given the relavant atomic masses and formulae
4. Use the relationship n=m/M to calculate one variable given the other two
5. Determine mole ratios from a balanced chemical equation
6. Calculate the mass of a substance produced or consumed in a chemical reaction given suitable data
7. Understand the concept of a limiting reagent
8. Calculate the percentage yield given appropriate data

Lecture 9 / Tutorial 9: Gravimetric Analysis

1. Calculate the percentage composition of compounds given suitable data
2. Write the empirical formula of a compound from its molecular formula
3. Calculate the empirical formula of a compound given suitable data
4. Calculate the molecular formula of a compound given suitable data
5. Calculate the water of crystallisation of a compound given suitable data

Lecture 10 / Tutorial 10: The Chemistry of Carbon

1. Define the term "Organic Chemistry"
2. Understand the differences between open structural formulae, condensed structural formulae and line structures
3. Define the term "isomer" and recognise the different types of isomers
4. Identify the homologous series of organic compounds from the functional groups

5. Identify the functional groups in the structural formula of an organic compound

Lecture 11 / Tutorial 11: Introduction to Hydrocarbons

1. Define the terms "hydrocarbon, saturated and unsaturated"
2. Recognise the general formula for alkanes, alkenes and alkynes
3. Use the IUPAC system to name straight and branched chain hydrocarbons
4. State the physical properties of hydrocarbons and the trends in those physical properties as the number of carbon atoms increases
5. Use the cis-trans and E-Z system for naming isomers of alkenes

Lecture 12 / Tutorial 12: Reactions of Hydrocarbons and Stereochemistry

1. Write equations, using structural formula for the reactions of hydrocarbons
    a. Complete combustion of hydrocarbons
    b. Substitution of alkanes with halogens
    c. Addition reactions of alkenes with halogens, hydrogen halides, water and hydrogen gas
2. Identify the major and minor products of addition reactions involving asymmetric alkenes (Markovnikov's rule)
3. Recall the structure of benzene, toluene, and phenol
4. Identify enantiomers (optical isomers) from the structural formula of an organic compound

Lecture 13 / Tutorial 13: Haloalkanes

1. Use the IUPAC system to name haloalkanes
2. Recall the reactions used to prepare haloalkanes
3. Recall the physical properties of haloalkanes
4. Classify haloalkanes as primary, secondary or tertiary
5. Describe the reactions of haloalkanes
    a. Nucleophilic substitution: SN_1 and SN_2
    b. Elimination to form alkenes including the possibility of major and minor products, and cis/trans isomers as well

Lecture 14 / Tutorial 14: Alcohols, Ethers and Amines

1. Use the IUPAC system to name alcohols and amines
2. Classify alcohols as primary, secondary or tertiary
3. Describe and explain the physical properties of alcohols and amines
4. Describe the reactions for making alcohols and amines
5. Write equations for the reactions of alcohols
    a. Nucleophilic substitution to make haloalkanes
    b. Dehydration to form alkenes
    c. Oxidation to form aldehydes, ketones and carboxylic acids
    d. Condensation to form esters
6. Understand the basic nature of amines
7. Write equations for the reaction of amines to form amides
8. Understand the structural similarities of alcohols and ethers.

Lecture 15 / Tutorial 15: Organic Mechanisms

1. Define organic reactions as bond breaking and forming
2. Understand that a reaction mechanism shows the movement of electrons using arrows
3. Use a reaction mechanism to show bond breaking
    a. Heterolytic bond cleavage
    b. Homolytic bond cleavage

4. Use a reaction mechanism to show bond making
5. Use a reaction mechanism to show;
    a. Electrophilic addition
    b. Nucleophilic substitution
6. Describe the differences between S_N1 and S_N2 mechanisms

Lecture 16 / Tutorial 16: Aldehydes and Ketones

1. Use the IUPAC system to name aldehydes and ketones
2. Describe and explain the physical properties of aldehydes and ketones
3. Describe the reactions for making aldehydes and ketones
4. Write equations for the reactions of aldehydes and ketones with
    a. Strong oxidising agents
    b. Tollen's reagent
    c. Benedict's solution
    d. Reducing agents

Lecture 17 / Tutorial 17: Carbohydrates

1. Define the term "carbohydrate"
2. Describe the differences between monosaccharides, disaccharides and polysaccharides
3. Recognise that some carbohydrates exhibit enantiomerism
4. Recall the differences between a linear and ringed monosaccharide
5. Write an equation to show the hydrolysis of a disaccharide
6. Recall the structure of amylose and glycogen and cellulose as examples of polysaccharides

Lecture 18 / Tutorial 18: Carboxylic Acids etc.

1. Use the IUPAC system to name carboxylic acids, acid chlorides, amides and esters
2. Describe and write equations for the reactions of carboxylic acids, acid chlorides, amides and esters
    a. Condensation of carboxylic acids and alcohols to form esters
    b. Hydrolysis of amides, esters and acid chlorides.

Lecture 19/ Tutorial 19: Polymers

1. Define the term "polymer"
2. Recall the different types of polymers
3. Describe the process of addition polymerisation
4. Recall some examples of addition polymers
5. Describe the process of condensation polymerisation
    a. Polyamides
    b. Polyesters
6. Recall some examples of condensation polymers

Lecture 20 / Tutorial 20: Amino Acids and Proteins

1. Draw the general structure of an amino acid
2. Recognise most amino will form a pair of enantiomers
3. Recall the structure of glycine, alanine and valine
4. Describe amino acids as non-polar, polar, basic or acidic based on the side chain
5. Write an equation showing the formation of a peptide bond
6. Write an equation showing the hydrolysis of a peptide bond
7. Describe the primary, secondary, tertiary and quaternary structure of a protein

Lecture 21 / Tutorial 21: DNA

1. Recall what DNA stands for
2. Describe the three components of a nucleotide
3. Name the 4 bases that are present in the nucleotides of DNA
4. Draw a diagram to show how DNA is constructed of nucleotides joined together
5. Describe “base pairs”
6. Describe the double helix nature of DNA
7. Understand the process of DNA supercoiling
8. Recall what RNA stands for
9. State the differences between RNA and DNA
10. Describe how DNA is used in the synthesis of proteins
    a. Genetic code
    b. Transcription
    c. Translation

2.3 Subject Content

Week	Lecture / Tutorial	Lecture / Tutorial	Lab (approx dates)
1	The Chemical World	Chemical Families and Equations	
2	No Lecture (Labour Day holiday)	Atomic Structure	Identifying a substance
3	Chemical Bonding	Solids	
4	Molecular Shape and Polarity	Intermolecular Bonding and Solubility	Structure and Properties
5	The Mole	Gravimetric Analysis	
6	Revision Lecture	Test – 20% (Lectures 1-9)	Hydrocarbons
7	The Chemistry of Carbon	Introduction to Hydrocarbons	
8	Reactions of Hydrocarbons and Stereochemistry	Haloalkanes	
9	Alcohols and Amines	Organic Mechanisms	
10	Aldehydes and Ketones	Carbohydrates	
11	Carboxylic Acids etc.	Polymers	
12	Amino Acids and Proteins	DNA	

2.4 Teaching Method/Strategies

Lectures are face to face instruction. Tutorials start with a recap of the last lecture and then students work through some problems. Lab work is completed in teams of two or three. An "exit text" is administered to individual students at the conclusion of the practical.

2.5 Assessment

Assessment Type	**When**	**Weighting**	**Learning Outcomes Assessed**
Internal Test	Week 7	20%	Outcomes 1-10
Labs	Throughout term	10%	Outcomes 1-21
Final Examination	Week	70%	Outcomes 1-21

2.5.1 Assessment Strategy

Assessment is via timed tests.

2.5.2 Hurdle Requirement

In order to pass this paper, students must obtain an overall mark of 50% (C-) or better.

2.5.3 Assessment Details

Assessment	Content/ Format	Time	Details
Internal Assessment Task 1 20%	45 minute written test. A periodic table is provided.	Week 7	This test covers all material from the first book. It has both calculation questions and short answers questions.
Internal Assessment Task 2	Labs. Students will attend 3 labs of 2 hours each.	Throughout the term.	A 15 minute exit test is given. Students will be given a lab book that they need to use as a guide and to write in their results, as well as some discussion questions
Final Examination		2 hours	This test covers all material from both of the books. It has both calculation questions and short answers questions.

3.1 Weekly Schedule

Week	Lecture / Tutorial	Lecture / Tutorial	Lab (approx dates)
1	The Chemical World	Chemical Families and Equations	
2	No Lecture (Labour Day holiday)	Atomic Structure	Identifying a substance
3	Chemical Bonding	Solids	
4	Molecular Shape and Polarity	Intermolecular Bonding and Solubility	Structure and Properties
5	The Mole	Gravimetric Analysis	
6	Revision Lecture	Test – 20% (Lectures 1-9)	Hydrocarbons
7	The Chemistry of Carbon	Introduction to Hydrocarbons	
8	Reactions of Hydrocarbons and Stereochemistry	Haloalkanes	
9	Alcohols and Amines	Organic Mechanisms	
10	Aldehydes and Ketones	Carbohydrates	
11	Carboxylic Acids etc.	Polymers	
12	Amino Acids and Proteins	DNA	