Chemistry (S5 – S6)

1 Introduction

Chemistry deals with the composition, structures and properties of matter, the interactions between different types of matter, and the relationship between matter and energy. At HKUGAC, it is possible to acquire relevant conceptual and procedural knowledge of chemistry from everyday experience. A study of chemistry also helps to develop understanding and appreciation of developments in engineering, medicine, and other related scientific and technological fields. Furthermore, learning about the contributions, issues and problems related to innovations in Chemistry will help students develop an understanding of the relationship between science, technology, society, and the environment. In addition, students are being prepared to sit for the International Advanced Subsidiary/ Advanced Level examination in chemistry in S5 and S6.

1.1 Teaching methods

Teachers will provide students with an appropriate level of curriculum and reasonable expectations to suit the capabilities of the students and to engage them in the process of learning.

1.1.1 Contextual approach

Throughout S5 & S6, students can develop their knowledge and understanding of chemistry by applying the concepts in the International Advanced Level specification to a range of different problems, set in a variety of contexts. Students completing units 1 - 3 will be awarded with the International Advanced Subsidiary qualification, and students completing units 1 - 6 will be awarded with the International Advanced Level qualification.

1.1.3 Practical work and practical skills

As chemistry is a practical subject, students are guided to gain personal experience of science through hands-on practical activities, and to develop the skills and scientific thinking with the processes of problem-solving, decision-making and evaluation of evidence. Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out the practical experiments and investigations. Units 3 and 6 will assess students' knowledge and understanding of experimental procedures and techniques.

1.1.4 Problem-based learning

Students are challenged to solve problems based on the concepts and theories learnt. Students will be trained and equipped with appropriate problem-solving strategies to deal with issues that may arise. Students are expected to clarify, analyze, and solve problems related to chemistry by applying their chemistry knowledge and principles of chemistry to solve problems.

1.1.5 Embedding of learning in real-life issues

By reading the latest research and industry products, students will be expected to appreciate the relationship between chemistry and other disciplines, and to be aware of the interconnections among

science, technology, society and the environment in contemporary issues, thereby becoming responsible citizens.

1.1.6 E-learning

E-learning will be implemented in the curriculum. E-learning is a valuable way for interactive learning which complements strategies for learning both inside and outside the classroom.

Through computer animations or simulations, students can visualize abstract concepts and processes. It also allows students to work at their own pace and gives them more time to pursue chemistry knowledge. In addition, e-learning may extend students' learning through the internet, which is an extremely valuable source of scientific information and resources. Using electronic media, we aim to provide students with an enriched and more efficient learning environment, enhance self-directed learning and meet their varied learning needs to become lifelong learners.

1.2 Assessment

Internal assessment will be carried out from S5 to S6. Both formative and summative assessments will be used in promoting learning and monitoring students' progress. Formative assessment is carried out in various ways including within practical work, projects, oral presentation, class discussions, assignments, lab reports and written quizzes, tests, google forms and past paper drilling to provide constructive feedback on students' achievement regularly. The feedback will help students understand their strengths and / or weaknesses, which could enhance their learning in everyday classroom lessons.

Summative assessment takes place at the end of each term to review the standard of achievement reached by each student for each externally assessed unit. In S5 and S6, students will be assessed on the 6 externally assessed units to prepare and qualify for the International A Level curriculum.

2 Aims and objectives

The curriculum is designed to enable students to:

(1) develop the essential knowledge and understanding of different areas of chemistry and how they relate to each other;
(2) construct and apply knowledge of chemistry, and appreciate the relationship between the skills, knowledge and understanding of chemistry and other disciplines;
(3) develop the ability to think scientifically, critically and creatively, and solve various problems with competence and confidence in using practical, mathematical and problem-solving skills;
(4) develop an interest and maintain a sense of curiosity about chemistry, including developing an interest in further studies and careers related to the study of chemistry.

3 Curriculum

The curriculum is based on the Pearson Edexcel International Advanced Level in Chemistry (YCH11) and emphasizes to strengthen students' ability to

The curriculum emphasizes to strengthen students' ability to:

1. demonstrate knowledge and understanding of chemistry;
2. apply knowledge and understanding of chemistry in familiar and unfamiliar contexts;
3. analyze and evaluate scientific information to make judgments and reach conclusions;
4. develop experimental skills in science, including analysis and evaluation of data and methods.

3.1 Curriculum framework

S5	Revision of topics learned in S4: • Reacting Masses • Microscopic World I • Bonding & Structure • Organic Chemistry I
	Energetics Students should be able to: • understand enthalpy change as the heat change at constant pressure and know the convention for exothermic and endothermic reactions • construct and interpret enthalpy level diagrams showing exothermic and endothermic enthalpy changes • define of standard enthalpy change of (1) reaction, (2) formation, (3) combustion, (4) neutralization, (5) atomization, (6) solution, (7) hydration • calculate, experimental data, the energy transferred and enthalpy change of reaction • use Hess's Law to construct enthalpy cycles and calculate enthalpy change • use bond enthalpy to calculate enthalpy change
	Microscopic World II Students should be able to: • understand the nature of the following intermolar forces: (1) instantaneous dipole-induced dipole, (2) permanent dipole-permanent dipole, (3) hydrogen bond • understand how hydrogen bond is formed and how the physical properties are influenced due to the presence of hydrogen bonding • explain physical properties of substances in terms of intermolecular forces
	Redox Chemistry & Groups 1, II and VII Students should be able to: • understand oxidation and reduction, in terms of electron transfer and oxidation number • write ionic half-equations and use them to construct full ionic equations • understand reasons for the trend in reactivity, solubility, thermal stability in Group I, II and VII elements • use chemical tests to distinguish different ions • calculate the concentration of solution using acid-base titrations

	Kinetics and Equilibria Students should be able to: • understand, in terms of the collision theory, the effect of changes in concentration, temperature, pressure and surface area on the rate of a chemical reaction • understand the concept of activation energy • draw energy profiles for uncatalysed and catalyzed reactions • draw and explain Maxwell-Boltzmann distribution curves • understand the concept of dynamic equilibrium • explain how changes in physical variables affect equilibrium position • understand and use the rate law for calculations and measuring progress of reaction • deduce order of reaction with respect to a substance in a rate equation (from a concentration-time graph and rate-concentration graph • understand the terms: rate of reaction, rate equation, overall order of rection, rate constant, half-life, rate-determining step, activation energy, heterogeneous and homogeneous catalyst • calculate the half-life of a reaction, using data from a suitable graph, and identify a reaction with a constant half-life as being first order • select and justify a suitable experimental technique to obtain rate data for a given reaction • understand experiments that can be used to investigate reaction rates by initial rate method and continuous monitoring • deduce order of reaction with given data • do calculations with The Arrhenius equation
	Organic Chemistry II Students should be able to: • classify reactions as addition, elimination, substitution, oxidation, reduction, hydrolysis or polymerization • understand the nomenclature of haloalkanes, alcohols and draw their structural and skeletal formula • understand the reactions and mechanisms of reactions of haloalkanes, alcohols, • understand the techniques in preparation or purification of a liquid organic compound
	Entropy and Energetics • understand that enthalpy changes alone do not control whether reactions occur • understand entropy as a measure of disorder of a system in terms of the random dispersal of molecules and of energy quanta between molecules • understand that the entropy of a substance increases with temperature, that entropy increases as solid → liquid → gas and that perfect crystals at zero kelvin have zero entropy • calculate entropy change of the system and surroundings for a reaction • understand the factors that the feasibility of a reaction depends on • understand and distinguish between the concepts of thermodynamic stability and kinetic stability • construct Born-Haber cycles and carry out related calculations • use entropy and enthalpy changes of solution values to predict the solubility of ionic compounds and discuss trends in the solubility of ionic compounds

	Chemical Equilibria Students should be able to: • deduce Kc and Kp expression for different reaction systems • explain how a change in temperature, pressure or the presence of a catalyst affects the equilibrium composition in a homogeneous or heterogeneous system • explain the effect of a change in temperature on entropy and Kc
	Acid-base Equilibria Students should be able to: • define Bronsted-Lowry acids and bases • calculate pH value • compare strength of acids in terms of degree of dissociation • deduce expression for acid dissociation constant for weak acid and do related calculations • draw and interpret titration curves and carry out titrations with suitable indicators • calculate concentrations of solutions required to prepare a buffer solution of a given pH
S6	Organic Chemistry III Students should be able to: • know that optical isomerism is a result of chirality in molecules with a single chiral center • understand that properties of optical isomers • use data on optical activity of reactants and products as evidence for Sn1 and Sn2 mechanisms and addition to carbonyl compounds • understand the nomenclatures of aldehydes, ketones, carboxylic acids and its derivatives and learn about their interactions with water • understand the reactions of carbonyl compounds, carboxyl compounds and carboxylic acid derivatives • use data from mass spectra, carbon-13 NMR spectroscopy, proton NMR spectroscopy to predict the chemical environments of carbon and types of proton present in a molecule • know the chemical principle behind chromatography
	Redox Equilibria Students should be able to: • understand what is “standard electrode potential” and describe different methods to measure standard electrode potentials of metals or non-metals in contact with their ions in aqueous solution • calculate standard emf by combining two standard electrode potentials • write cell diagrams using conventional representation of half-cells • understand the working mechanism of fuel cells • carry out titration calculations involving redox reactions
	Transition Metals and their Chemistry Students should be able to: • know what are transition metals, deduce their electronic configuration and their characteristics • describe the formation of complex ions and its properties • describe the formation of ligands and their respective shapes in transition metal

	complexes and what ligand exchange is • understand redox reactions for the interconversion of the oxidation states
	<u>Organic Chemistry – Arenes</u> • use thermochemical, X-ray diffraction and infrared data as evidence for the structure and stability of the benzene ring • understand that the delocalized model for the structure of benzene involves overlap of p-orbitals to form pi-bonds • know the reactions and mechanism of reactions of benzene including substitution reaction and Friedel-Crafts reaction
	<u>Organic Nitrogen Compounds</u> Students should be able to: • understand the nomenclature of amides, amines and amino acids and be able to draw their skeletal and structural formulae • understand the reactions of primary aliphatic amines and aromatic amines • describe the physical properties of amines, amides and polyamides • describe condensation polymerization to form polyamides such as nylon and proteins • describe experiments to investigate the characteristic behaviour of amino acids
	<u>Organic Synthesis</u> Students should be able to: • plan reaction schemes of up to four steps, using the reactions learnt in Organic chemistry I, II and III • understand techniques used in preparation and purification of organic compounds • deduce formulae of organic compound from data drawn from combustion analysis, NMR sepctra, etc. • understand techniques used in the preparation and purification of organic compounds

3.2 Delivery schedule

	S5 Chemistry (iAS year)	**S6 Chemistry (iAL year)**
1st Term	(1) Revision of S4 content (2) Energetics (3) Intermolecular Forces (4) Redox Chemistry & Groups 1, 2 and 7	(1) Organic Chemistry III (2) Redox Equilibria (3) Transition Metals and their Chemistry (4) Organic Chemistry: Arenes
2nd Term	(1) Kinetics and Equilibria (2) Organic Chemistry II (3) Entropy and Energetics (4) Chemical Equilibria (5) Acid-base equilibria	(1) Organic Nitrogen Compounds (2) Organic Synthesis

4 Assessing students

4.1 Internal assessment in HKUGAC

4.1.1 Assessment criteria

4.1.1.1 Assessment of knowledge and understanding

Students should be able to demonstrate knowledge and understanding in relation to

1. phenomena, facts and concepts in science;
2. scientific vocabulary and terminology;
3. application of concepts to familiar and unfamiliar situations;
4. application of science in society and students' everyday life.

Oral questioning, class assignments, module tests and examination can be used to allow students to demonstrate their understanding and creative ideas.

4.1.1.2 Application of scientific processes

Students should be able to

1. ask relevant questions, identify problems and formulate hypotheses for investigations;
2. select and apply facts and concepts learnt to solve problems;
3. plan scientific investigations individually and collaboratively with appropriate instruments and methods;
4. collect and analyze data, make further predictions, draw conclusions and present scientific information effectively.

Project work provides excellent opportunities for students to apply what they have learnt. Investigative projects, in particular, are suitable for assessing enquiry skills such as identifying problems, formulating hypotheses and designing strategies to solve problems scientifically and creatively.

4.1.1.3 Assessment of experimental skills

Students should be able to

1. handle apparatus and chemicals safely and properly;
2. carry out instructions for experiments;
3. observe and describe objects and experimental results accurately;
4. select appropriate apparatus and suggest experimental procedures.

The most suitable methods for assessing science skills are practical assessment. Students are required to perform several core practical tasks. They are expected to make use of their knowledge and understanding of science in performing these tasks. Through these practical tasks, students' practical, process and generic skills will be developed and assessed. These practical skills will also be assessed in Paper 3 and Paper 6 of the iAL curriculum.

4.1.1.4 Assessment of attitudes

Students should

1. develop curiosity and interest in science;
2. be aware of the importance of the safety of oneself and others in the laboratory and be committed to safe practices in daily life;
3. develop personal integrity through honest recording of experimental data;
4. develop an awareness of scientific advancement and its social, economic, environmental and technological implications;
5. be willing to communicate and comment on issues related to science and respect the decisions of others;
6. develop a positive attitude in enhancing personal and community health;
7. show concern for the care of the environment and a willingness to contribute to it.

Attitudes such as curiosity, perseverance, care and concern for living things, and cooperation with others are important in science learning. As these attitudes take time to develop, their assessment should take place over a period of time to show the progress that students have made. Some common means of assessing attitudes include observing behavior, asking students to write essays, and using questionnaires.

4.1.2 Weighting of component parts

Component	Weighting
Continuous assessments • Scientific investigations • Experimental skills • Quizzes and tests • Assignments • Preparation tasks before lesson	40%
Examinations	60%

4.1.3 Grading system

The International Advanced Level in Chemistry will be graded on a six-point scale A* to E. A* is usually awarded to the top achievers of grade A.

GradeA	• demonstrate comprehensive knowledge and understanding of facts, concepts and principles in the Chemistry curriculum • apply the concepts of chemistry to unfamiliar situations • analyze, synthesize and critically evaluate information from multiple perspectives and in an in-depth manner • effectively communicate ideas in a succinct, logical and coherent manner with accurate use of scientific terminology and in appropriate formats • design and conduct scientific investigations, evaluate procedures, handle and analyze data collected, and draw valid conclusions
Grade B	• demonstrate sound knowledge and understanding of facts, concepts and principles in the Chemistry curriculum • apply the concepts of chemistry to unfamiliar situations • analyze, synthesize and evaluate information from several perspectives • communicate ideas in a logical and coherent manner using scientific terminology and in appropriate formats • design and conduct scientific investigations, handle and interpret data collected, and draw conclusions
Grade C	• demonstrate adequate knowledge and understanding of facts, concepts and principles in the Chemistry curriculum • apply the concepts of chemistry to unfamiliar situations with guidance • construct relationships and analyze information • communicate ideas in a clear, structured manner using scientific terminology and in appropriate formats • design and conduct scientific investigations, handle and interpret data collected, and draw conclusions with guidance
Grade D	• demonstrate basic knowledge and understanding of facts, concepts and principles in the Chemistry curriculum • apply the concepts of chemistry to familiar situations • describe relationships and handle information • communicate ideas using appropriate scientific terms • conduct practical work by following instructions, handle and interpret data collected, and draw simple conclusions
Grade E	• recall elementary facts and principles in the Chemistry curriculum • apply the concepts of chemistry to simple and familiar situations • handle simple information presented in a straightforward manner • communicate simple ideas using scientific terms • conduct simple practical work by following instructions and collect the required

5 Role of parents at home and homework

Efficient time management is essential for students to be successful in the subject. Students are encouraged to prepare each lesson based on the guided task given and bring with them questions to be asked during the lesson to promote effective learning. Homework consolidates, reinforces, and strengthens concepts learnt in class and helps teachers assess the performance of students. Parents are encouraged to talk to their son or daughter about the work done in class and the current learning topics to have a better understanding of the learning situation in the subject. Zero marks will be given to homework in late submission.

6 Guidelines for using Artificial Intelligence (AI)

Guideline on AI-assisted Learning

Artificial intelligence (AI), including Generative AI, could serve as an effective tool for assisting science learning. This section provides examples of using AI to assist learning in science and general reminders.

Examples of AI-assisted learning in science

1. Research and organization of information
Information such as scientific concepts, real-life examples, and data, could be obtained from generative AI. AI could also be used to organize large amounts of information for clear presentation.

2. Feedback
Generative AI could provide feedback on student work based on given criteria to improve the quality of work and assess the accuracy.

3. Language support
By inputting the work in generative AI, the grammar and clarity of the work could be checked.

4. Exploration and brainstorming
Exploration of topics and generation of ideas for project work could be achieved using generative AI.

General reminders for using AI in science

1. Verification of information
Students should assess the accuracy of scientific concepts and the reliability of examples/data with their judgment and other sources. Information obtained from generative AI may not always be correct.

2. Learning effectiveness
There are multiple ways of learning. AI is not the only way for students to learn. Students should consider different learning styles and make good use of different learning strategies, instead of solely relying on AI. Moreover, information obtained from AI should be processed cognitively by students, instead of simply performing “copy and paste”.

3. Quality of prompts
Prompts inputted into generative AI should be specific. More details and conditions allow responses that better suit your needs to be generated.

Guideline on ethical use of AI (Important)

General guideline

Respect Intellectual Property
Students must observe copyright laws and understand the importance of giving proper credit to the original creators of any content they use or modify. When using AI-generated text or other content, students must properly **cite the source** and **acknowledge the use of the AI tool**.

Avoid Misinformation
Students should recognize the potential dangers of AI-generated content, including the spread of **misinformation**. Students should **cross-reference** AI-generated content with reliable sources and think critically about the information's validity.

Privacy and Security
Students must be aware of **privacy** and **security** concerns when using AI tools. Students need to protect their **personal information** and use secure platforms when accessing these tools. Students should be informed about the data collection and use practices of AI tool providers and be mindful of the potential risks associated with sharing personal data.

AI policy in science
Penalty will be given to students with inappropriate use of AI in their work including assignments, projects, etc.

- Students are suggested to keep the original work before being modified by AI. The original work may be requested to be submitted to verify the originality of the submitted work.
- Mark penalty could be given for work with content generated by AI without proper citation and acknowledgment. A zero mark could be given in serious cases. Follow-ups and further disciplinary actions could be taken.
- Students may be asked to redo and resubmit their work if the AI policy is violated.

Other Reminders

- Students should consult their subject teachers for anything uncertain about the use of AI in science subjects.