Chemistry

Introduction

1. Chemistry is one of the elective subjects offered in the Key Learning Area (KLA) of Science Education[1]. The new Chemistry Curriculum serves as a continuation of the Science (S1-3) Curriculum and builds on the strength of the current Chemistry curricula. It will provide a range of balanced learning experiences through which students can develop the necessary scientific knowledge and understanding, skills and processes, and values and attitudes embedded in the strand "The Material World" of science education and other related strands for personal development, and for contributing towards a scientific and technological world. The curriculum will prepare students for entering tertiary courses, vocation-related courses or the workforce in various fields related to chemistry.

Rationale

2. The emergence of a highly competitive and integrated economy, rapid scientific and technological innovations, and a growing knowledge base will continue to have a profound impact on our lives. In order to meet the challenges posed by these changes, Chemistry, like other science electives, will provide a platform for developing scientific literacy and for building up essential scientific knowledge and skills for life-long learning in science and technology.

3. Chemistry deals with the composition, structures, and properties of matter; and the interactions between different types of matter, and the relationship between matter and energy. Through the learning of chemistry, it is possible to acquire relevant conceptual and procedural knowledge. In addition, 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 to develop a holistic view of the relationships between science, technology and society.

4. The curriculum attempts to make the study of chemistry exciting and relevant. It is suggested to introduce the learning of chemistry in real life contexts. The adoption of diverse contexts, learning and teaching strategies, and assessment practices is intended to appeal to students of all abilities and aspirations, and to stimulate interest and motivation for learning among them. Together with other learning experiences, students are expected to

[1] Please refer to the appendix on p.225 for the overall curriculum framework of science education and the proposed elective subjects in the Key Learning Area of Science Education.

be able to apply knowledge of chemistry, to appreciate the relationship between chemistry and other disciplines, to be aware of the science-technology-society (STS) connections of contemporary issues, and to become responsible citizens.

Curriculum Aims

5. The overarching aim of the Chemistry Curriculum is to provide chemistry-related learning experiences for students to develop scientific literacy, so that they can participate actively in our rapidly changing knowledge-based society, prepare for further studies or careers in fields related to chemistry, and become life-long learners in science and technology.

The broad aims of the curriculum are to enable students to:

- develop interest and maintain a sense of wonder and curiosity in chemistry;
- construct and apply knowledge of chemistry, and appreciate the relationship between chemistry and other disciplines;
- appreciate and understand the evolutionary nature of science;
- develop skills for making scientific inquiries;
- develop the ability to think scientifically, critically and creatively, and solve problems individually and collaboratively in chemistry-related contexts;
- communicate ideas and views of science-related issues using the language of chemistry;
- make informed decisions and judgments on chemistry-related issues;
- develop open-mindedness, objectivity and pro-activeness; and
- be aware of the social, ethical, economic, environmental and technological implications of chemistry, and develop an attitude of responsible citizenship.

Curriculum Framework

(This part should be read in conjunction with the section "Curriculum Framework" of the Main Document. It should be noted that the curriculum framework suggested below is for initial consultation only. Feedback from the public will be taken into account and further details will be provided in the next stage of consultation.)

6. The learning targets of this curriculum are categorised into three domains: knowledge and understanding, skills and processes, and values and attitudes. Through the learning embodied in the Chemistry Curriculum, students will acquire relevant learning targets in various chemistry-related contexts.

Knowledge and Understanding

Students are expected to:

- ✧ understand phenomena, facts and patterns, principles, concepts, laws and theories in chemistry;
- ✧ learn chemical vocabulary, terminology and conventions;
- ✧ appreciate applications of chemistry in society and in everyday life; and
- ✧ develop an understanding of methods used in scientific investigation.

Skills and Processes

Students are expected to:

- ✧ develop scientific thinking and problem-solving skills;
- ✧ acquire an analytical mind to critically evaluate chemistry-related issues;
- ✧ communicate scientific ideas and values in meaningful and creative ways with appropriate use of symbols, formulae, equations and conventions;
- ✧ acquire practical skills such as manipulate apparatus and equipment, carry out given procedures, analyze and present data, draw conclusions and evaluate experimental procedures;
- ✧ plan and conduct scientific investigations individually and collaboratively with appropriate instruments and methods, collect quantitative and qualitative data with accuracy, analyze and present data, draw conclusions, and evaluate evidence and procedures; and
- ✧ develop study skills to improve the effectiveness and efficiency of learning; and develop abilities and habits that are essential to life-long learning.

Values and Attitudes

Students are expected to:

- ✧ develop curiosity and interest in making scientific investigation;
- ✧ develop personal integrity through objective observation and honest recording of experimental data; and be committed to safe practices when handling chemicals;
- ✧ be willing to communicate and make decisions on issues related to chemistry and demonstrate an open-minded attitude towards the views of others;
- ✧ be aware that chemistry is a developing science and has its limitations;
- ✧ appreciate the interrelationship of chemistry with other disciplines in providing societal and cultural values; and
- ✧ be aware of the impact of chemistry on social, economic, industrial, environmental and technological contexts.

7. The curriculum will consist of compulsory and elective parts. The compulsory part will cover a range of content that enables students to develop understanding of fundamental chemistry principles and concepts, and the scientific process skills. It is suggested to include topics such as "atomic structure", "bonding, structures and properties", "metals and non-metals", "periodicity", "mole and stoichiometry", "acids and bases", "electrochemistry", "chemistry of carbon compounds", "chemical energetics", "chemical kinetics", "chemical equilibrium" and "green chemistry".

8. To cater for the diverse interests, abilities and needs of students, an elective part will be included in the curriculum. The elective part aims to provide an in-depth treatment of some of the compulsory topics, or an extension of certain areas of study. Some possible choices are: "industrial chemistry", "material chemistry" and "analytical chemistry".

9. To facilitate the integration of knowledge and skills acquired, students are required to conduct an investigative study relevant to the curriculum. A proportion of total lesson time will be allocated to this study.

10. The suggested content and time allocation for the compulsory and elective parts are listed in the following tables.

I. Compulsory Part (Total 221 hours) Some possible topics are suggested as follows:		Suggested lesson time (hrs)
1. Planet earth	• The atmosphere • The ocean • Rocks and minerals	8
2. Microscopic world I	• Atomic structure • Periodic table • Metallic bonding and properties of metals • Ionic and covalent bonding • Dative covalent bond • Structures and properties of ionic and covalent substances	20
3. Metals	• Occurrence and extraction of metals • Reactivity of metals • Reacting masses • Corrosion of metals and their protection	20
4. Acids and bases	• Introduction to acids and alkalis • Indicators and pH • Strength of acids and alkalis • Neutralisation and salts • Concentration of solutions • Volumetric work involving acids and alkalis	25

I. Compulsory Part (Total 221 hours) Some possible topics are suggested as follows:		Suggested lesson time (hrs)
5. Fossil fuels and carbon compounds	• Fossil fuels and their uses • Functional groups and homologous series • Systematic nomenclature of carbon compounds • Alkanes and alkenes • Structural isomerism	20
6. Microscopic world II	• Electronic structure – shells and subshells • Shapes of simple molecules such as H_2O, NH_3, CH_4, BF_3 and CO_2 • Intermediate bond type – ionic bond with covalent character and polar covalent bond • Intermolecular forces – hydrogen bonding and van der Waals' forces • Structures and properties of modern materials like fullerenes	15
7. Redox reactions, chemical cells and electrolysis	• Chemical cells in daily life – primary and secondary cells • Fuel cells • Reactions in chemical cells • Redox reactions • Common oxidising agents and reducing agents • Electrolysis • Chlorine and hypochlorite	24
8. Chemical reactions and energy	• Energy changes in chemical reactions • Standard enthalpy changes • Hess's Law	8
9. Rate of reaction	• Rate of chemical reaction • Factors affecting rate of reaction – surface area, concentration, temperature and catalyst	8
10. Chemical equilibrium	• Dynamic equilibrium • Equilibrium constant (K_c) • The effect of changes of concentration, pressure and temperature on equilibrium	10
11. Chemistry of carbon compounds	• Stereoisomerism: geometrical isomers and enantiomers • Typical reactions of various functional groups (alkanes, alkenes, haloalkanes, alcohols, aldehydes and ketones, carboxylic acids, esters and amides) • Inter-conversions between the functional groups • Synthesis of important organic substances such as aspirin, dopamine and polyethylene terephthalate (PET) • Soaps and detergents	24

I. Compulsory Part (Total 221 hours) Some possible topics are suggested as follows:		Suggested lesson time (hrs)
12. Patterns in the chemical world	• Periodic variation in physical properties of the elements Li to Ar • Variations in acid-base properties of the oxides of the elements Na to Cl • General properties of transition metals	10
13. Chemical detective	• Application of appropriate tests to detect the presence of chemical species • Awareness of the uses of modern instruments in chemical analysis	8
14. Green chemistry	• Principles of green chemistry for promoting sustainable development • Green chemistry practices	4
15. Investigative study	• Design and conduct an investigation with a view to solving an authentic problem	17

II. Elective Part (Total 34 hours, any 2 out of 3) Some possible topics are suggested as follows:		Suggested lesson time (hrs)
1. Industrial chemistry	• Rate equation • Arrhenius equation • Catalysis • Chemical equilibrium involving gases • Important chemical processes as exemplified by Haber process and contact process	17
2. Material chemistry	• Preparation, structures and physical properties of polymers, including thermoplastics, thermosetting plastics and polymeric biomaterials • Account for differences between properties of metals and alloys such as hardness and conductivity • Types and applications of liquid crystals • Processing and applications of ceramics	17
3. Analytical chemistry	• Separation and purification methods such as chromatography and solvent extraction • Chemical aspects of forensic science • Instrumental analytical methods – colorimetry, infrared spectroscopy and mass spectrometry	17
	Total lesson time:	255

Learning and Teaching

11. The curriculum has an in-built flexibility to cater for the interests, abilities and needs of students. This flexibility also provides a means to bring about a balance between the quality and quantity of learning. Teachers should provide ample opportunities for students to engage in a variety of learning experiences, such as investigations, discussions, demonstrations, practical work, field studies, model-making, case-studies, questioning, oral reports, assignments, debates, information search and role-play. Teachers should give consideration to the range of experiences that would be most appropriate to their students. The context for learning should be made relevant to daily life, so that students will experience chemistry as interesting and important to them.

12. Practical work and investigations are essential components of the curriculum. They enable students to gain personal experience of science through hands-on activities, and to enhance the skills and thinking processes associated with the practice of science. Participation in these activities encourages students to bring scientific thinking to the processes of problem-solving, decision-making and evaluation of evidence. Engaging in scientific investigation enables students to gain an understanding of the nature of science and the limitations of scientific inquiry.

Assessment

(This part should be read in conjunction with the section "Assessment" of the Main Document.)

Aims of assessment

13. Assessment is an integral part of the learning and teaching cycle. Assessment is the practice of collecting evidence of student learning. Its aims are to improve learning and teaching as well as to recognise the achievement of students. Therefore, assessment design should be aligned with the learning targets, the curriculum design and the learning progression.

Internal Assessment

14. Internal assessment refers to the assessment practices that schools employ as part of the learning and teaching strategies during the three years of study in chemistry. These practices should be aligned with curriculum planning, teaching progression, student abilities and the local school contexts. Internal assessment includes both formative and summative assessment practices. The information collected will help to motivate and promote student learning. The information will also help teachers to find ways of promoting more effective

learning and teaching. A range of assessment practices, such as written tests, oral questioning, observation, project work, practical work and assignments, should be used to promote the attainment of various learning outcomes.

Public Assessment

15. Public assessment of the Chemistry subject leads to a qualification in the subject to be offered by the Hong Kong Examinations and Assessment Authority. Public assessment of the Chemistry subject will comprise two components: a Written Examination and School-based Assessment (SBA). The written examination will consist of various types of item to assess students' performance in a broad range of skills and abilities. Students will be assessed continuously through the SBA component. This will comprise a variety of assessment modes, such as practical work, investigations, assignments and oral reports.

16. In the public assessment, a standards-referenced approach will be adopted for grading and reporting student performance. The purpose of this approach is to recognise the learning outcomes that the students have attained in the subject at the end of the 3-year senior secondary education. Each student's performance will be matched against a set of performance standards, rather than compared to the performance of other students. Standards-referenced Assessment (SRA) makes the implicit standards explicit by providing specific indication of individual student performance. Descriptors will be provided for the set of standards at a later stage.

17. The proposed weighting of the SBA component will be 20-25% of the total weighting of the public assessment of new senior secondary Chemistry. The merits of adopting SBA are as follows:

(i) SBA provides a more valid assessment than an external examination on its own, since it can cover a more extensive range of learning outcomes, through flexibly employing a wider range of assessment practices that are not all possible in written examinations.

(ii) SBA enables the sustained work of students to be assessed. It provides a more comprehensive picture of student performance throughout the period of study rather than their performance in a one-off examination alone.

18. It should be noted that SBA is not an "add-on" element in the curriculum. Assessing student performance through practices such as class discussion and class observation is a normal in-class and out-of-class activity. The modes of SBA selected in the Chemistry will be appropriate to the learning objectives and processes to be assessed. The design and implementation of SBA should make reference to the nature of the subject and avoid unduly increasing the workload of both teachers and students.

Supporting Measures

19. A subject curriculum and assessment guide will be published to support learning and teaching. The Guide will provide stakeholders with information on the rationale, aims, curriculum framework, learning and teaching strategies and assessment. In addition, it is anticipated that quality textbooks and related learning and teaching materials, aligned with the rationale and the recommendations of the curriculum, will be available on the market.

20. Resource materials that facilitate learning will be developed by the Education and Manpower Bureau (EMB) to support the implementation of this curriculum. Tertiary institutions and professional organisations will be invited to contribute to the development of resource materials. Existing resource materials, such as "Inquiry-based Chemistry Experiments", "Chemistry Animations", "Reactions of Metals", "Exemplars of Learning Activities", "Resource Book for Sixth-form Practical Chemistry", published by the EMB and various working partners will be updated to meet with the latest curriculum development. Furthermore, schools are encouraged to develop their own learning and teaching materials to meet the needs of their students as necessary. Schools are also advised to adopt a wide variety of suitable learning resources such as school-based curriculum projects, useful information from the Internet, the media, relevant learning packages and educational software. Last but not the least, experiences from various collaborative research and development projects such as "Informed Decisions in Science Education", "Assessment for Learning in Science", "Infusing Process and Thinking Skills into Science lessons" and "Collaborative Development of Assessment Tasks and Assessment Criteria to Enhance Learning and Teaching in Science Curricula" are good sources of information for teachers.

21. To facilitate the implementation of the curriculum, professional development programmes will be organized for chemistry teachers. Listed below are the major domains of the professional development programmes to be provided.

- ✧ Understanding the rationale and the implementation of the Chemistry Curriculum;
- ✧ Sharing of learning and teaching strategies and good practices;
- ✧ Latest development in the field of chemistry (science update programmes);
- ✧ Curriculum management and leadership (curriculum leadership courses); and
- ✧ Internal assessment, School-based Assessment and Standards-referenced Assessment.

22. In addition, teacher networks and learning communities will be formed to facilitate reflection and discussion on various aspects related to the curriculum. Further information on support materials can be obtained from the CDI homepage: http://www.emb.gov.hk/cd.

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