MINISTRY OF EDUCATION MALAYSIA

Integrated Curriculum for Secondary Schools

Curriculum Specifications

CHEMISTRY
Form 4

Curriculum Development Centre
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THE NATIONAL PHILOSOPHY

Our nation, Malaysia, is dedicated to achieving a greater unity of all her people; maintaining a democratic way of life; creating a just society in which the wealth of the nation shall be equitably shared; ensuring a liberal approach to her rich and diverse cultural traditions; building a progressive society which shall be oriented towards modern science and technology.

We, the people of Malaysia, pledge our united efforts to attain these ends guided by the following principles:

- **BELIEF IN GOD**
- **LOYALTY TO KING AND COUNTRY**
- **SUPREMACY OF THE CONSTITUTION**
- **RULE OF LAW**
- **GOOD BEHAVIOUR AND MORALITY**

NATIONAL PHILOSOPHY OF EDUCATION

Education in Malaysia is an on-going effort towards developing the potential of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious based on a firm belief in and devotion to God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards and who are responsible and capable of achieving a high level of personal well being as well as being able to contribute to the harmony and betterment of the family, society and the nation at large.

NATIONAL SCIENCE EDUCATION PHILOSOPHY

In consonance with the National Education Philosophy,
science education in Malaysia nurtures
a Science and Technology Culture by focusing
on the development of individuals who are competitive,
dynamic, robust and resilient and able
to master scientific knowledge and technological competency.

PREFACE

The aspiration of the nation to become an industrialised society depends on science and technology. It is envisaged that success in providing quality science education to Malaysians from an early age will serve to spearhead the nation into becoming a knowledge society and a competitive player in the global arena. Towards this end, the Malaysian education system is giving greater emphasis to science and mathematics education.

The Chemistry curriculum has been designed not only to provide opportunities for students to acquire science knowledge and skills, develop thinking skills and thinking strategies, and to apply this knowledge and skills in everyday life, but also to inculcate in them noble values and the spirit of patriotism. It is hoped that the educational process en route to achieving these aims would produce well-balanced citizens capable of contributing to the harmony and prosperity of the nation and its people.

The Chemistry curriculum aims at producing active learners. To this end, students are given ample opportunities to engage in scientific investigations through hands-on activities and experimentations. The inquiry approach, incorporating thinking skills, thinking strategies and thoughtful learning, should be emphasised throughout the teaching-learning process. The content and contexts suggested are chosen based on their relevance and appeal to students so that their interest in the subject is enhanced.

In a recent development, the Government has made a decision to introduce English as the medium of instruction in the teaching and learning of science and mathematics. This measure will enable students to keep abreast of developments in science and technology in contemporary society by enhancing their capability and know-how to tap the diverse sources of information on science written in the English language. At the same time, this move would also provide opportunities for students to use the English language and hence, increase their proficiency in the language. Thus, in implementing the science curriculum, attention is given to developing students' ability to use English for study and communication, especially in the early years of learning.

The development of this curriculum and the preparation of the corresponding Curriculum Specifications have been the work of many individuals over a period of time. To all those who have contributed in one way or another to this effort, may I, on behalf of the Ministry of Education, express my sincere gratitude and thanks for the time and labour expended.

(MAHZAN BIN BAKAR *SMP, AMP*)
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INTRODUCTION

As articulated in the National Education Policy, education in Malaysia is an on-going effort towards developing the potential of individuals in a holistic and integrated manner to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious. The primary and secondary school science curriculum is developed with the aim of producing such individuals.

As a nation that is progressing towards a developed nation status, Malaysia needs to create a society that is scientifically oriented, progressive, knowledgeable, having a high capacity for change, forward-looking, innovative and a contributor to scientific and technological developments in the future. In line with this, there is a need to produce citizens who are creative, critical, inquisitive, open-minded and competent in science and technology.

The Malaysian science curriculum comprises three core science subjects and four elective science subjects. The core subjects are Science at primary school level, Science at lower secondary level and Science at upper secondary level. Elective science subjects are offered at the upper secondary level and consist of Biology, Chemistry, Physics, and Additional Science.

The core science subjects for the primary and lower secondary levels are designed to provide students with basic science knowledge, prepare students to be literate in science, and
enable students to continue their science education at the upper secondary level. Core Science at the upper secondary level is designed to produce students who are literate in science, innovative, and able to apply scientific knowledge in decision-making and problem solving in everyday life.

The elective science subjects prepare students who are more scientifically inclined to pursue the study of science at post-secondary level. This group of students would take up careers in the field of science and technology and play a leading role in this field for national development.

For every science subject, the curriculum for the year is articulated in two documents: the syllabus and the curriculum specifications. The syllabus presents the aims, objectives and the outline of the curriculum content for a period of 2 years for elective science subjects and 5 years for core science subjects. The curriculum specifications provide the details of the curriculum which includes the aims and objectives of the curriculum, brief descriptions on thinking skills and thinking strategies, scientific skills, scientific attitudes and noble values, teaching and learning strategies, and curriculum content. The curriculum content provides the learning objectives, suggested learning activities, the intended learning outcomes, and vocabulary.

AIMS

The aims of the chemistry curriculum for secondary school are to provide students with the knowledge and skills in chemistry and technology and enable them to solve problems and make decisions in everyday life based on scientific attitudes and noble values.

Students who have followed the secondary science curriculum will have the foundation in science to enable them to pursue formal and informal further education in chemistry and technology.

The curriculum also aims to develop a concerned, dynamic and progressive society with a science and technology culture that values nature and works towards the preservation and conservation of the environment.

OBJECTIVES

The chemistry curriculum for secondary school enables students to:

1. Acquire knowledge in science and technology in the context of natural phenomena and everyday life experiences.

2. Understand developments in the field of science and technology.

3. Acquire scientific and thinking skills.

4. Apply knowledge and skills in a creative and critical manner for problem solving and decision-making.

5. Face challenges in the scientific and technological world and be willing to contribute towards the development of science and technology.

6. Evaluate science- and technology-related information wisely and effectively.

7. Practise and internalise scientific attitudes and good moral values.

8. Realise the importance of inter-dependence among living things and the management of nature for survival of mankind.

9. Appreciate the contributions of science and technology towards national development and the well-being of mankind.

10. Realise that scientific discoveries are the result of human endeavour to the best of his or her intellectual and mental capabilities to understand natural phenomena for the betterment of mankind.

11. Create awareness on the need to love and care for the environment and play an active role in its preservation and conservation.

SCIENTIFIC SKILLS

Science emphasises inquiry and problem solving. In inquiry and problem solving processes, scientific and thinking skills are utilised. Scientific skills are important in any scientific investigation such as conducting experiments and carrying out projects.

Scientific skills encompass science process skills and manipulative skills.

Science Process Skills

Science process skills enable students to formulate their questions and find out the answers systematically.

Descriptions of the science process skills are as follows:

Observing	Using the sense of hearing, touch, smell, taste and sight to collect information about an object or a phenomenon.
Classifying	Using observations to group objects or events according to similarities or differences.
Measuring and Using Numbers	Making quantitative observations using numbers and tools with standardised units. Measuring makes observation more accurate.
Inferring	Using past experiences or previously collected data to draw conclusions and make explanations of events.
Predicting	Stating the outcome of a future event based on prior knowledge gained through experiences or collected data.
Communicating	Using words or graphic symbols such as tables, graphs, figures or models to describe an action, object or event.
Interpreting Data	Giving rational explanations about an object, event or pattern derived from collected data.
Defining Operationally	Defining concepts by describing what must be done and what should be observed.
Controlling Variables	Identifying the fixed variable, manipulated variable, and responding variable in an investigation. The manipulated variable is changed to observe its relationship with the responding variable. At the same time, the fixed variable is kept constant.
Hypothesising	Making a general statement about the relationship between a manipulated variable and a responding variable in order to explain an event or observation. This statement can be tested to determine its validity.
Experimenting	Planning and conducting activities to test a certain hypothesis. These activities include collecting, analysing and interpreting data and making conclusions.

Manipulative Skills

Manipulative skills in scientific investigation are psychomotor skills that enable students to:

- use and handle science apparatus and laboratory substances correctly.
- handle specimens correctly and carefully.
- draw specimens, apparatus and laboratory substances accurately.
- clean science apparatus correctly, and
- store science apparatus and laboratory substances correctly and safely.

THINKING SKILLS

Thinking is a mental process that requires an individual to integrate knowledge, skills and attitude in an effort to understand the environment.

One of the objectives of the national education system is to enhance the thinking ability of students. This objective can be achieved through a curriculum that emphasises thoughtful learning. Teaching and learning that emphasises thinking skills is a foundation for thoughtful learning.

Thoughtful learning is achieved if students are actively involved in the teaching and learning process. Activities should be organised to provide opportunities for students to apply thinking skills in conceptualisation, problem solving and decision-making.

Thinking skills can be categorised into critical thinking skills and creative thinking skills. A person who thinks critically always evaluates an idea in a systematic manner before accepting it. A person who thinks creatively has a high level of imagination, is able to generate original and innovative ideas, and modify ideas and products.

Thinking strategies are higher order thinking processes that involve various steps. Each step involves various critical and creative thinking skills. The ability to formulate thinking strategies is the ultimate aim of introducing thinking activities in the teaching and learning process.

Critical Thinking Skills

A brief description of each critical thinking skill is as follows:

Attributing	Identifying criteria such as characteristics, features, qualities and elements of a concept or an object.
Comparing and Contrasting	Finding similarities and differences based on criteria such as characteristics, features, qualities and elements of a concept or event.
Grouping and Classifying	Separating and grouping objects or phenomena into categories based on certain criteria such as common characteristics or features.
Sequencing	Arranging objects and information in order based on the quality or quantity of common characteristics or features such as size, time, shape or number.
Prioritising	Arranging objects and information in order based on their importance or priority.
Analysing	Examining information in detail by breaking it down into smaller parts to find implicit meaning and relationships.
Detecting Bias	Identifying views or opinions that have the tendency to support or oppose something in an unfair or misleading way.

Evaluating	Making judgements on the quality or value of something based on valid reasons or evidence.
Making Conclusions	Making a statement about the outcome of an investigation that is based on a hypothesis.

Creative Thinking Skills

A brief description of each creative thinking skill is as follows:

Generating Ideas	Producing or giving ideas in a discussion.
Relating	Making connections in a certain situation to determine a structure or pattern of relationship.
Making Inferences	Using past experiences or previously collected data to draw conclusions and make explanations of events.
Predicting	Stating the outcome of a future event based on prior knowledge gained through experiences or collected data.
Making Generalisations	Making a general conclusion about a group based on observations made on, or some information from, samples of the group.
Visualising	Recalling or forming mental images about a particular idea, concept, situation or vision.
Synthesising	Combining separate elements or parts to form a general picture in various forms such as writing, drawing or artefact.
Making Hypotheses	Making a general statement on the relationship between manipulated variables and responding variables in order to explain a certain thing or happening. This statement is thought to be true and can be tested to determine its validity.
Making Analogies	Understanding a certain abstract or complex concept by relating it to a simpler or concrete concept with similar characteristics.
Inventing	Producing something new or adapting something already in existence to overcome problems in a systematic manner.

Thinking Strategy

Description of each thinking strategy is as follows:

Conceptualising	Making generalisations based on inter-related and common characteristics in order to construct meaning, concept or model.
Making Decisions	Selecting the best solution from various alternatives based on specific criteria to achieve a specific aim.

Problem Solving Finding solutions to challenging or unfamiliar situations or unanticipated difficulties in a systematic manner.

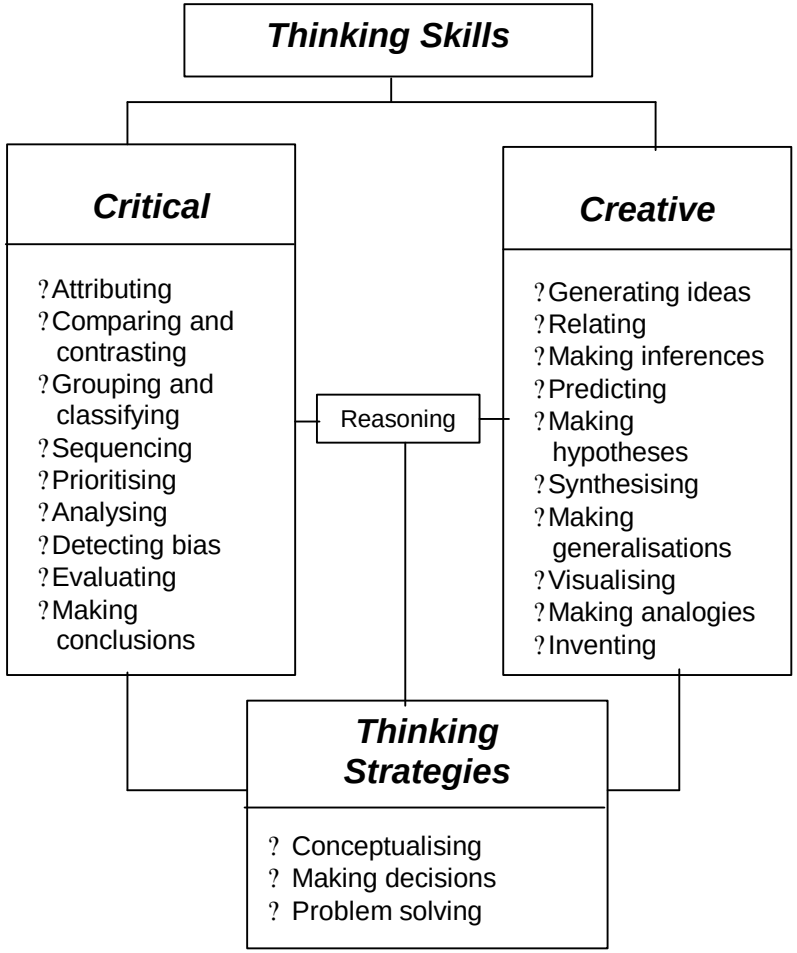
Besides the above thinking skills and thinking strategies, another skill emphasised is reasoning. Reasoning is a skill used in making logical, just and rational judgements. Mastering of critical and creative thinking skills and thinking strategies is made simpler if an individual is able to reason in an inductive and deductive manner. Figure 1 gives a general picture of thinking skills and thinking strategies.

Mastering of thinking skills and thinking strategies (TSTS) through the teaching and learning of science can be developed through the following phases:

1. Introducing TSTS.
2. Practising TSTS with teacher's guidance.
3. Practising TSTS without teacher's guidance.
4. Applying TSTS in new situations with teacher's guidance.
5. Applying TSTS together with other skills to accomplish thinking tasks.

Further information about phases of implementing TSTS can be found in the guidebook *"Buku Panduan Penerapan Kemahiran Berfikir dan Strategi Berfikir dalam Pengajaran dan Pembelajaran Sains"* (Curriculum Development Centre, 1999).

Figure 1 : TSTS Model in Science



Relationship between Thinking Skills and Science Process Skills

Science process skills are skills that are required in the process of finding solutions to a problem or making decisions in a systematic manner. It is a mental process that promotes critical, creative, analytical and systematic thinking. Mastering of science process skills and the possession of suitable attitudes and knowledge enable students to think effectively.

The mastering of science process skills involves the mastering of the relevant thinking skills. The thinking skills that are related to a particular science process skill are as follows:

Science Process Skills	Thinking Skills
Observing	Attributing Comparing and contrasting Relating
Classifying	Attributing Comparing and contrasting Grouping and classifying
Measuring and Using Numbers	Relating Comparing and contrasting
Making Inferences	Relating Comparing and contrasting Analysing Making inferences
Predicting	Relating Visualising
Using Space-Time Relationship	Sequencing Prioritising
Interpreting data	Comparing and contrasting Analysing Detecting bias Making conclusions Generalising Evaluating
Defining operationally	Relating Making analogy Visualising Analysing
Controlling variables	Attributing Comparing and contrasting Relating Analysing
Making hypothesis	Attributing Relating Comparing and contrasting Generating ideas Making hypothesis Predicting Synthesising
Experimenting	All thinking skills
Communicating	All thinking skills

Teaching and Learning based on Thinking Skills and Scientific Skills

This science curriculum emphasises thoughtful learning based on thinking skills and scientific skills. Mastery of thinking skills and scientific skills are integrated with the acquisition of knowledge in the intended learning outcomes. Thus, in teaching and learning, teachers need to emphasise the mastery of skills together with the acquisition of knowledge and the inculcation of noble values and scientific attitudes.

The following is an example and explanation of a learning outcome based on thinking skills and scientific skills.

Example*:*

Learning Outcome:	Compare and contrast metallic elements and non-metallic elements.
Thinking Skills:	Comparing and contrasting

Explanation:

To achieve the above learning outcome, knowledge of the characteristics and uses of metals and non-metals in everyday life are learned through comparing and contrasting. The mastery of the skill of comparing and contrasting is as important as the knowledge about the elements of metal and the elements of non-metal.

SCIENTIFIC ATTITUDES AND NOBLE VALUES

Science learning experiences can be used as a means to inculcate scientific attitudes and noble values in students. These attitudes and values encompass the following:

- Having an interest and curiosity towards the environment.
- Being honest and accurate in recording and validating data.
- Being diligent and persevering.
- Being responsible about the safety of oneself, others, and the environment.
- Realising that science is a means to understand nature.
- Appreciating and practising clean and healthy living.
- Appreciating the balance of nature.
- Being respectful and well-mannered.
- Appreciating the contribution of science and technology.
- Being thankful to God.
- Having critical and analytical thinking.
- Being flexible and open-minded.
- Being kind-hearted and caring.
- Being objective.
- Being systematic.
- Being cooperative.
- Being fair and just.
- Daring to try.
- Thinking rationally.
- Being confident and independent.

The inculcation of scientific attitudes and noble values generally occurs through the following stages:

- Being aware of the importance and the need for scientific attitudes and noble values.
- Giving emphasis to these attitudes and values.
- Practising and internalising these scientific attitudes and noble values.

When planning teaching and learning activities, teachers need to give due consideration to the above stages to ensure the continuous and effective inculcation of scientific attitudes and values. For example, during science practical work, the teacher should remind pupils and ensure that they carry out experiments in a careful, cooperative and honest manner.

Proper planning is required for effective inculcation of scientific attitudes and noble values during science lessons. Before the first lesson related to a learning objective, teachers should examine all related learning outcomes and suggested teaching-learning activities that provide opportunities for the inculcation of scientific attitudes and noble values.

The following is an example of a learning outcome pertaining to the inculcation of scientific attitudes and values.

Example*:*

Year:	Form 5
Learning Area:	1. Rate of Reaction
Learning Objective:	1.4 Practising scientific knowledge to enhance quality of life
Learning Outcome:	A student is able to apply knowledge on factors affecting the rate of reaction in everyday activities, and adopt problem solving approaches and make rational decisions based on research.
Suggested Learning Activities	Carry out some daily activities related to factors affecting the rate of reaction. Collect and interpret data on scientists' contribution in enhancing the quality of life. Carry out problem solving activities involving rate of reaction in the field of science and technology through experiment and research.
Scientific attitudes and noble values	Appreciating the contribution of science and technology. Being thankful to God. Having critical and analytical thinking. Being honest and accurate in recording and validating data

Inculcating Patriotism

The science curriculum provides an opportunity for the development and strengthening of patriotism among students. For example, in learning about the earth's resources, the richness and variety of living things and the development of science and technology in the country, students will appreciate the diversity of natural and human resources of the country and deepen their love for the country.

TEACHING AND LEARNING STRATEGIES

Teaching and learning strategies in the science curriculum emphasise thoughtful learning. Thoughtful learning is a process that helps students acquire knowledge and master skills that will help them develop their minds to the optimum level. Thoughtful learning can occur through various learning approaches such as inquiry, constructivism, contextual learning, and mastery learning. Learning activities should therefore be geared towards activating students' critical and creative thinking skills and not be confined to routine or rote learning. Students should be made aware of the thinking skills and thinking strategies that they use in their learning. They should be challenged with higher order questions and problems and be required to solve problems utilising their creativity and critical thinking. The teaching and learning process should enable students to acquire knowledge, master skills and develop scientific attitudes and noble values in an integrated manner.

Teaching and Learning Approaches in Science

Inquiry-Discovery

Inquiry-discovery emphasises learning through experiences. Inquiry generally means to find information, to question and to investigate a phenomenon that occurs in the environment. Discovery is the main characteristic of inquiry. Learning through discovery occurs when the main concepts and principles of science are investigated and discovered by students themselves. Through activities such as experiments, students investigate a phenomenon and draw conclusions by themselves. Teachers then lead students to understand the science concepts through the results of the inquiry.

Thinking skills and scientific skills are thus developed further during the inquiry process. However, the inquiry approach may not be suitable for all teaching and learning situations. Sometimes, it may be more appropriate for teachers to present concepts and principles directly to students.

Constructivism

Constructivism suggests that students learn about something when they construct their own understanding. The important attributes of constructivism are as follows:

- Taking into account students' prior knowledge.
- Learning occurring as a result of students' own effort.
- Learning occurring when students restructure their existing ideas by relating new ideas to old ones.
- Providing opportunities to cooperate, sharing ideas and experiences, and reflecting on their learning.

Science, Technology and Society

Meaningful learning occurs if students can relate their learning with their daily experiences. Meaningful learning occurs in learning approaches such as contextual learning and Science, Technology and Society (STS).

Learning themes and learning objectives that carry elements of STS are incorporated into the curriculum. STS approach suggests that science learning takes place through investigation and discussion based on science and technology issues in society. In the STS approach, knowledge in science and technology is to be learned with the application of the principles of science and technology and their impact on society.

Contextual Learning

Contextual learning is an approach that associates learning with daily experiences of students. In this way, students are able to appreciate the relevance of science learning to their lives. In contextual learning, students learn through investigations as in the inquiry-discovery approach.

Mastery Learning

Mastery learning is an approach that ensures all students are able to acquire and master the intended learning objectives. This approach is based on the principle that students are able to learn if they are given adequate opportunities. Students should be allowed to learn at their own pace, with the incorporation of remedial and enrichment activities as part of the teaching-learning process.

Teaching and Learning Methods

Teaching and learning approaches can be implemented through various methods such as experiments, discussions, simulations, projects, and visits. In this curriculum, the teaching-learning methods suggested are stated under the column "Suggested Learning Activities." However, teachers can modify the suggested activities when the need arises.

The use of a variety of teaching and learning methods can enhance students' interest in science. Science lessons that are not interesting will not motivate students to learn and subsequently will affect their performance. The choice of teaching methods should be based on the curriculum content, students' abilities, students' repertoire of intelligences, and the availability of resources and infrastructure. Besides playing the role of knowledge presenters and experts, teachers need to act as facilitators in the process of teaching and learning. Teachers need to be aware of the multiple intelligences that exist among students. Different teaching and learning activities should be planned to cater for students with different learning styles and intelligences.

The following are brief descriptions of some teaching and learning methods.

Experiment

An experiment is a method commonly used in science lessons. In experiments, students test hypotheses through investigations to discover specific science concepts and principles. Conducting an experiment involves thinking skills, scientific skills, and manipulative skills.

Usually, an experiment involves the following steps:

- ✍ Identifying a problem.
- ✍ Making a hypothesis.
- ✍ Planning the experiment
  - controlling variables.
  - determining the equipment and materials needed.
  - determining the procedure of the experiment and the method of data collection and analysis.
- ✍ Conducting the experiment.
- ✍ Collecting data.
- ✍ Analysing data.
- ✍ Interpreting data.
- ✍ Making conclusions.
- ✍ Writing a report.

In the implementation of this curriculum, besides guiding students to do an experiment, where appropriate, teachers should provide students with the opportunities to design their own experiments. This involves students drawing up plans as to how to conduct experiments, how to measure and analyse data, and how to present the outcomes of their experiment.

Discussion

A discussion is an activity in which students exchange questions and opinions based on valid reasons. Discussions can be conducted before**,** during or after an activity. Teachers should play the role of a facilitator and lead a discussion by asking questions that stimulate thinking and getting students to express themselves.

Simulation

In simulation, an activity that resembles the actual situation is carried out**.** Examples of simulation are role-play, games and the use of models. In role-play, students play out a particular role based on certain pre-determined conditions. Games require procedures that need to be followed. Students play games in order to learn a particular principle or to understand the process of decision-making. Models are used to represent objects or actual situations so that students can visualise the said objects or situations and thus understand the concepts and principles to be learned.

Project

A project is a learning activity that is generally undertaken by an individual or a group of students to achieve a certain learning objective. A project generally requires several lessons to complete. The outcome of the project either in the form of a report, an artefact or in other forms needs to be presented to the teacher and other students. Project work promotes the development of problem-solving skills, time management skills, and independent learning.

Visits and Use of External Resources

The learning of science is not limited to activities carried out in the school compound. Learning of science can be enhanced through the use of external resources such as zoos, museums, science centres, research institutes, mangrove swamps, and factories. Visits to these places make the learning of science more interesting, meaningful and effective. To optimise learning opportunities, visits need to be carefully planned. Students may be involved in the planning process and specific educational tasks should be assigned during the visit. No educational visit is complete without a post-visit discussion.

Use of Technology

Technology is a powerful tool that has great potential in enhancing the learning of science. Through the use of technology such as television, radio, video, computer, and Internet, the teaching and learning of science can be made more interesting and effective.

Computer simulation and animation are effective tools for the teaching and learning of abstract or difficult science concepts.

Computer simulation and animation can be presented through courseware or Web page. Application tools such, as word processors, graphic presentation software and electronic spreadsheets are valuable tools for the analysis and presentation of data.

The use of other tools such as data loggers and computer interfacing in experiments and projects also enhance the effectiveness of teaching and learning of science.

CONTENT ORGANISATION

The science curriculum is organised around themes. Each theme consists of various learning areas**,** each of which consists of a number of learning objectives. A learning objective has one or more learning outcomes.

Learning outcomes are written based on the hierarchy of the cognitive and affective domains. Levels in the cognitive domain are: knowledge, understanding, application, analysis, synthesis and evaluation. Levels in the affective domain are: to be aware of, to be in awe, to be appreciative, to be thankful, to love, to practise, and to internalise. Where possible, learning outcomes relating to the affective domain are explicitly stated. The inculcation of scientific attitudes and noble values should be integrated into every learning activity. This ensures a more spontaneous and natural inculcation of attitudes and values. Learning areas in the psychomotor domain are implicit in the learning activities.

Learning outcomes are written in the form of measurable behavioural terms. In general, the learning outcomes for a particular learning objective are organised in order of complexity. However, in the process of teaching and learning, learning activities should be planned in a holistic and integrated manner that enables the achievement of multiple learning outcomes according to needs and context. Teachers should avoid employing a teaching strategy that tries to achieve each learning outcome separately according to the order stated in the curriculum specifications.

The Suggested Learning Activities provide information on the scope and dimension of learning outcomes. The learning activities stated under the column Suggested Learning Activities are given with the intention of providing some guidance as to how learning outcomes can be achieved. A suggested activity may cover one or more learning outcomes. At the same time, more than one activity may be suggested for a particular learning outcome. Teachers may modify the suggested activity to suit the ability and style of learning of their students. Teachers are encouraged to design other innovative and effective learning activities to enhance the learning of science.

THEME : INTRODUCING CHEMISTRY

LEARNING AREA : 1. INTRODUCTION TO CHEMISTRY **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
1.1 Understanding chemistry and its importance	Collect and interpret the meaning of the word 'chemistry'. Discuss some examples of common chemicals used in daily life such as sodium chloride, calcium carbonate and acetic acid. Discuss the uses of these chemicals in daily life. View a video or computer courseware on the following: a. careers that need the knowledge of chemistry, b. chemical-based industries in Malaysia and its contribution to the development of the country. Attend talks on chemical-based industries in Malaysia and their contribution to the development of the country.	A student is able to: ? explain the meaning of chemistry, ? list some common chemicals used in daily life, ? state the uses of common chemicals in daily life, ? list examples of occupations that require the knowledge of chemistry, ? list chemical-based industries in Malaysia, ? describe the contribution of chemical-based industries towards the development of the country.		chemicals- *bahan kimia* chemical-based industry - *industri berasaskan kimia*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
1.2 Synthesising scientific method	Observe a situation and identify all variables. Suggest a question suitable for a scientific investigation. Carry out an activity to: a. observe a situation. b. identify all variables, c. suggest a question, d. form a hypothesis, e. select suitable apparatus, f. list down work procedures. Carry out an experiment and: a. collect and tabulate data, b. present data in a suitable form, c. interpret the data and draw conclusions, d. write a complete report.	A student is able to: ? identify variables in a given situation, ? identify the relationship between two variables to form a hypothesis, ? design and carry out a simple experiment to test the hypothesis, ? record and present data in a suitable form, ? interpret data to draw a conclusion, ? write a report of the investigation.	Students have knowledge of scientific method in Form 1, 2 and 3. Scientific skills are applied throughout.	solubility - *keterlarutan*
1.3 Incorporate scientific attitudes and values in conducting scientific investigations	View videos or read passages about scientific investigations. Students discuss and identify scientific attitudes and values practised by researchers and scientists in the videos or passages. Students discuss and justify the scientific attitudes and values that should be practised during scientific investigations.	A student is able to: ? identify scientific attitudes and values practised by scientists in carrying out investigations, ? practise scientific attitudes and values in conducting scientific investigations.	Throughout the course, attention should also be given to identifying and practising scientific attitudes and values.	

THEME : MATTER AROUND US

LEARNING AREA : 2. THE STRUCTURE OF THE ATOM **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
2.1 Analysing matter	Discuss and explain the particulate nature of matter. Use models or view computer simulation to discuss the following: a. the kinetic theory of matter, b. the meaning of atoms, molecules and ions. Conduct an activity to investigate diffusion of particles in solid, liquid and gas. Investigate the change in the state of matter based on the kinetic theory of matter through simulation or computer animation. Conduct an activity to determine the melting and freezing points of ethanamide or naphthalene. Plot and interpret the heating and the cooling curves of ethanamide or naphthalene.	A student is able to: ? describe the particulate nature of matter, ? state the kinetic theory of matter, ? define atoms, molecules and ions, ? relate the change in the state of matter to the change in heat, ? relate the change in heat to the change in kinetic energy of particles, ? explain the inter-conversion of the states of matter in terms of kinetic theory of matter.	Students have acquired prior knowledge of elements, compounds and mixtures in Form 2. Ethanamide is also known as acetamide.	collision-*perlanggaran* diffusion - *peresapan* melting point-*takat lebur* freezing point- *takat beku* simulation-*simulasi* inter-conversion-*perubahan keadaan*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
2.2 Synthesising atomic structure	Discuss the development of atomic models proposed by scientists namely Dalton, Thomson, Rutherford, Chadwick and Bohr. Use models or computer simulation to illustrate the structure of an atom as containing protons and neutrons in the nucleus and electrons arranged in shells. Conduct activities to determine the proton number, nucleon number and the number of protons, electrons and neutrons of an atom. Use a table to compare and contrast the relative mass and the relative charge of the protons, electrons and neutrons. Investigate the proton and nucleon numbers of different elements. Discuss : a. the relationship between proton number and nucleon number, b. to make generalisation that each element has a different proton number.	A student is able to: ? describe the development of atomic model, ? state the main subatomic particles of an atom, ? compare and contrast the relative mass and the relative charge of the protons, electrons and neutrons, ? define proton number, ? define nucleon number, ? determine the proton number, ? determine the nucleon number, ? relate the proton number to the nucleon number, ? relate the proton number to the type of element, ? write the symbol of elements, ? determine the number of neutrons, protons and electrons from the proton number and the nucleon number and vice versa, ? construct the atomic structure.	Dates and how models are developed are not needed. Proton number is also known as atomic number. Nucleon number is also known as mass number.	make generalisation - *mengitlak*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Carry out an activity to write: a. the symbols of elements, b. the standard representation for an atom of any element. $^{A}_{Z}X$ where: **X** = element A = nucleon number Z = proton number Construct models or use computer simulation to show the atomic structure.			
2.3 Understanding isotopes and assessing their importance	Collect and interpret information on: a. the meaning of isotope, b. isotopes of hydrogen, oxygen, carbon, chlorine and bromine. Conduct activities to determine the number of subatomic particles of isotopes from their proton numbers and their nucleon numbers. Gather information from the internet or from printed materials and discuss the uses of isotope.	A student is able to: ? state the meaning of isotope, ? list examples of elements with isotopes, ? determine the number of subatomic particles of isotopes, ? justify the uses of isotope in daily life.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
2.4 Understanding the electronic structure of an atom	Study electron arrangements of various atoms and identify their valence electrons. Discuss the meaning of valence electrons using illustrations. Conduct activities to: a. illustrate electron arrangements of elements with proton numbers 1 to 20, b. write electron arrangements of elements with proton numbers 1 to 20.	A student is able to: ? describe electron arrangements of elements with proton numbers 1 to 20, ? draw electron arrangement of an atom in an element, ? state the meaning of valence electrons, ? determine the number of valence electrons from the electron arrangement of an atom.		
2.5 Appreciate the orderliness and uniqueness of the atomic structure	Discuss the contributions of scientists towards the development of ideas on the atomic structure. Conduct a story-telling competition on the historical development of the atomic structure with emphasis on the creativity of scientists.	A student is able to: ? describe the contributions of scientists towards the understanding of the atomic structure, ? describe the creative and conscientious efforts of scientists to form a complete picture of matter.		Gratefulness – *kesyukuran*

THEME : MATTER AROUND US

LEARNING AREA : 2. CHEMICAL FORMULAE AND EQUATIONS **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
3.1 Understanding and applying the concepts of relative atomic mass and relative molecular mass	Collect and interpret data concerning relative atomic mass and relative molecular mass based on carbon-12 scale. Discuss the use of carbon-12 scale as a standard for determining relative atomic mass and relative molecular mass. Investigate the concepts of relative atomic mass and relative molecular mass using analogy or computer animation. Carry out a quiz to calculate the relative molecular mass of substances based on the given chemical formulae, for example HCl, CO_2, Na_2CO_3, $Al(NO_3)_3$, $CuSO_4.5H_2O$	A student is able to: ? state the meaning of relative atomic mass based on carbon-12 scale, ? state the meaning of relative molecular mass based on carbon-12 scale, ? state why carbon-12 is used as a standard for determining relative atomic mass and relative molecular mass, ? calculate the relative molecular mass of substances.	Relative formula mass is introduced as the relative mass for ionic substances.	
3.2 Analysing the relationship between the number of moles with the number of particles	Study the mole concept using analogy or computer simulation. Collect and interpret data on Avogadro constant. Discuss the relationship between the number of particles in one mole of a substance with the Avogadro constant.	A student is able to: ? define a mole as the amount of matter that contains as many particles as the number of atoms in 12 g of ^{12}C, ? state the meaning of Avogadro constant, ? relate the number of particles in one mole of a substance with	^{12}C can also be represented as $^{12}_{6}C$ or C-12 Avogadro constant is also known as Avogadro number.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Carry out problem solving activities to convert the number of moles to the number of particles for a given substance and vice versa.	the Avogadro constant, ? solve numerical problems to convert the number of moles to the number of particles of a given substance and vice versa.		
3.3 Analysing the relationship between the number of moles of a substance with its mass	Discuss the meaning of molar mass. Using analogy or computer simulation, discuss to relate: a. molar mass with the Avogadro constant, b. molar mass of a substance with its relative atomic mass or relative molecular mass. Carry out problem solving activities to convert the number of moles of a given substance to its mass and vice versa.	A student is able to: ? state the meaning of molar mass, ? relate molar mass to the Avogadro constant, ? relate molar mass of a substance to its relative atomic mass or relative molecular mass, ? solve numerical problems to convert the number of moles of a given substance to its mass and vice versa.	Chemical formulae of substances are given for calculation.	
3.4 Analysing the relationship between the number of moles of a gas with its volume	Collect and interpret data on molar volume of a gas. Using computer simulation or graphic representation, discuss: a. the relationship between molar volume and Avogadro constant, b. to make generalization on the molar volume of a gas at STP or room conditions.	A student is able to: ? state the meaning of molar volume of a gas, ? relate molar volume of a gas to the Avogadro constant, ? make generalization on the molar volume of a gas at a given temperature and pressure, ? calculate the volume of gases at STP or room conditions from	STP – Standard Temperature and Pressure	STP – *suhu dan tekanan piawai*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Carry out an activity to calculate the volume of gases at STP or room conditions from the number of moles and vice versa. Construct a mind map to show the relationship between number of particles, number of moles, mass of substances and volume of gases at STP and room conditions. Carry out problem solving activities involving number of particles, number of moles, mass of a substance and volume of gases at STP or room conditions.	the number of moles and vice versa, ? solve numerical problems involving number of particles, number of moles, mass of substances and volume of gases at STP or room conditions.		
3.5 Synthesising chemical formulae	Collect and interpret data on chemical formula, empirical formula and molecular formula. Conduct an activity to: a. determine the empirical formula of copper(II) oxide using computer simulation, b. determine the empirical formula of magnesium oxide, c. compare and contrast empirical formula with molecular formula. Carry out problem solving activities	A student is able to: ? state the meaning of chemical formula, ? state the meaning of empirical formula, ? state the meaning of molecular formula, ? determine empirical and molecular formulae of substances, ? compare and contrast empirical formula with molecular formula, ? solve numerical problems involving empirical and	The use of symbols and chemical formulae should be widely encouraged and not restricted to writing chemical equations only.	Ionic formula – *formula ion*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	involving empirical and molecular formulae. Carry out exercises and quizzes in writing ionic formulae. Conduct activities to: a. construct chemical formulae of compounds from a given ionic formula, b. state names of chemical compounds using IUPAC nomenclature.	molecular formulae, ? write ionic formulae of ions, ? construct chemical formulae of ionic compounds, ? state names of chemical compounds using IUPAC nomenclature.	IUPAC – International Union of Pure and Applied Chemistry.	
3.6 Interpreting chemical equations	Discuss: a. the meaning of chemical equation, b. the reactants and products in a chemical equation. Construct balanced chemical equations for the following reactions: a. heating of copper(II) carbonate, $CuCO_3$, b. formation of ammonium chloride, NH_4Cl, c. precipitation of lead(II) iodide, PbI_2.	A student is able to: ? state the meaning of chemical equation, ? identify the reactants and products of a chemical equation, ? write and balance chemical equations ? interpret chemical equations quantitatively and qualitatively, ? solve numerical problems using chemical equations.	A computer spreadsheet can be used for balancing chemical equation exercises.	precipitation - *pemendakan*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Carry out the following activities: a. write and balance chemical equations, b. interpret chemical equations quantitatively and qualitatively, c. solve numerical problems using chemical equations (stoichiometry).			
3.7 Practising scientific attitudes and values in investigating matter	Discuss the contributions of scientists for their research on relative atomic mass, relative molecular mass, mole concept, formulae and chemical equations. Discuss to justify the need for scientists to practise scientific attitudes and positive values in doing their research on atomic structures, formulae and chemical equations. Discuss the role of chemical symbols, formulae and equations as tools of communication in chemistry.	A student is able to: ? identify positive scientific attitudes and values practised by scientists in doing research on mole concept, chemical formulae and chemical equations, ? justify the need to practise positive scientific attitudes and good values in doing research on atomic structures, chemical formulae and chemical equations, ? use symbols, chemical formulae and equations for easy and systematic communication in the field of chemistry.		

THEME : MATTER AROUND US

LEARNING AREA : 3. PERIODIC TABLE OF ELEMENTS **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
4.1 Analysing the Periodic Table of Elements	Collect information on the contributions of various scientists towards the development of the Periodic Table. Study the arrangement of elements in the Periodic Table from the following aspects: a. group and period, b. proton number, c. electron arrangement. Carry out an activity to relate the electron arrangement of an element to its group and period. Discuss the advantages of grouping elements in the Periodic Table. Conduct activities to predict the group and period of an element based on its electron arrangement.	A student is able to: ? describe the contributions of scientists in the historical development of the Periodic Table, ? identify groups and periods in the Periodic Table, ? state the basic principle of arranging the elements in the Periodic Table from their proton numbers, ? relate the electron arrangement of an element to its group and period, ? explain the advantages of grouping elements in the Periodic Table, ? predict the group and the period of an element based on its electron arrangement.	Include scientists like Lavoisier, Dobereiner, Newlands, Meyer, Mendeleev and Mosely.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
4.2 Analysing Group 18 elements	Use a table to list all the elements in Group 18. Describe the physical properties such as the physical state, density and boiling point of Group 18 elements. Discuss: a. changes in the physical properties of Group 18 elements, b. the inert nature of Group 18 elements. Discuss the relationship between the electron arrangement and the inert nature of Group 18 elements. Use diagrams or computer simulations to illustrate the duplet and octet electron arrangement of Group 18 elements to explain their stability. Gather information on the reasons for the uses of Group 18 elements.	A student is able to: ? list all Group 18 elements, ? state in general the physical properties of Group 18 elements, ? describe the changes in the physical properties of Group 18 elements, ? describe the inert nature of elements of Group 18, ? relate the inert nature of Group 18 elements to their electron arrangements, ? relate the duplet and octet electron arrangements of Group 18 elements to their stability, ? describe uses of Group 18 elements in daily life.	The elements in Group 18 can also be referred to as noble gases or inert gases. Students are encouraged to use multimedia materials.	Inert – *lengai*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
4.3 Analysing Group 1 elements	Gather information and discuss: a. Group 1 elements, b. general physical properties of lithium, sodium and potassium, c. changes in the physical properties from lithium to potassium with respect to hardness, density and melting point, d. chemical properties of lithium, sodium and potassium, e. the similarities in chemical properties of lithium, sodium and potassium, f. the relationship between the chemical properties of Group 1 elements and their electron arrangements. Carry out experiments to investigate the reactions of lithium, sodium and potassium with water and oxygen. Study the reactions of lithium, sodium and potassium with chlorine and bromine through computer simulation. Discuss changes in the reactivity of Group 1 elements down the group. Predict physical and chemical properties of Group 1 elements other than lithium, sodium and potassium.	A student is able to: ? list all Group 1 elements. ? state the general physical properties of lithium, sodium and potassium, ? describe changes in the physical properties from lithium to potassium, ? list the chemical properties of lithium, sodium and potassium, ? describe the similarities in chemical properties of lithium, sodium and potassium, ? relate the chemical properties of Group 1 elements to their electron arrangements, ? describe changes in reactivity of Group 1 elements down the group, ? predict physical and chemical properties of other elements in Group 1, ? state the safety precautions when handling Group 1 elements.	Teachers are encouraged to use demonstration for activities involving sodium and potassium.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Watch multimedia materials on the safety precautions when handling Group 1 elements.			
4.4 Analysing Group 17 elements	Gather information and discuss on: a. Group 17 elements, b. physical properties of chlorine, bromine and iodine with respect to their colour, density and boiling point, c. changes in the physical properties from chlorine to iodine, d. describe the chemical properties of chlorine, bromine and iodine, e. the similarities in chemical properties of chlorine, bromine and iodine, f. the relationship between the chemical properties of Group 17 elements with their electron arrangements. Carry out experiments to investigate the reactions of chlorine, bromine and iodine with: a. water, b. metals such as iron, c. sodium hydroxide. Discuss changes in the reactivity of Group 17 elements down the group.	A student is able to: ? list all Group 17 elements, ? state the general physical properties of chlorine, bromine and iodine, ? describe changes in the physical properties from chlorine to iodine, ? list the chemical properties of chlorine, bromine and iodine, ? describe the similarities in chemical properties of chlorine, bromine and iodine, ? relate the chemical properties of Group 17 elements with their electron arrangements, ? describe changes in reactivity of Group 17 elements down the group, ? predict physical and chemical properties of other elements in Group 17, ? state the safety precautions when handling Group 17 elements.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Predict physical and chemical properties of Group 17 elements other than chlorine, bromine and iodine. Watch multimedia materials on the safety precautions when handling Group 17 elements.			
4.5 Analysing elements in a period	Collect and interpret data on the properties of elements in Period 3 such as: a. proton number, b. electron arrangement, c. size of atom, d. electronegativity, e. physical state. Discuss changes in the properties of elements across Period 3. Carry out experiments to study the oxides of elements in Period 3 and relate them to their metallic properties. Discuss in small groups and make a presentation on the changes of properties of oxides of elements across Period 3. Discuss and predict changes in the properties of elements in Period 2.	A student is able to: ? list all elements in Period 3, ? write electron arrangements of all elements in Period 3, ? describe changes in the properties of elements across Period 3, ? state changes in the properties of the oxides of elements across Period 3, ? predict changes in the properties of elements across Period 2, ? describe uses of semi-metals.	Semi-metals are also known as metalloids.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Collect and interpret data on uses of semi-metals i.e. silicon and germanium in the microelectronic industry.			
4.6 Understanding transition elements	Carry out an activity to identify the positions of transition elements in the Periodic Table. Collect and interpret data on properties of transition elements with respect to melting points, density, variable oxidation numbers and ability to form coloured compounds. Observe the colour of: a. a few compounds of transition elements, b. products of the reaction between aqueous solution of compounds of transition elements with sodium hydroxide solution, NaOH, and ammonia solution, NH_3(aq). Observe the colour of precious stones and identify the presence of transition elements. Give examples on the use of transition elements as catalysts in industries.	A student is able to: ? identify the positions of transition elements in the Periodic Table, ? give examples of transition elements, ? describe properties of transition elements, ? state uses of transition elements in industries.	Oxidation number is synonymous with oxidation state. Chemical equations are not required.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
4.7 Appreciating the existence of elements and their compounds	Gather information on efforts of scientists in discovering the properties of elements and make a multimedia presentation. Discuss in a forum about life without various elements and compounds. Carry out projects to collect specimens or pictures of various types of rocks. Discuss and practise ways to handle chemicals safely and to avoid their wastage.	A student is able to: ? describe efforts of scientists in discovering the properties of elements, ? describe what life would be without diverse elements and compounds, ? identify different colours in compounds of transition elements found naturally, ? handle chemicals wisely.		

THEME : MATTER AROUND US

LEARNING AREA : 4. CHEMICAL BONDS **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
5.1 Understanding formation of compounds	Collect and interpret data on the existence of various naturally occurring compounds for example, water, H_2O, carbon dioxide, CO_2, and minerals to introduce the concept of chemical bonds. Discuss: a. the stability of inert gases with respect to the electron arrangement, b. conditions for the formation of chemical bonds, c. types of chemical bonds.	A student is able to: ? explain the stability of inert gases, ? explain conditions for the formation of chemical bonds, ? state types of chemical bonds.		
5.2 Synthesising ideas on formation of ionic bond	Use computer simulation to explain formation of ions and electron arrangement of ions. Conduct an activity to prepare ionic compounds for example, magnesium oxide, MgO, sodium chloride, NaCl and iron(III) chloride, $FeCl_3$. Carry out an activity to illustrate formation of ionic bond through models, diagrams or computer simulation. Use computer simulation to illustrate the existence of electrostatic force between ions of opposite charges in ionic bond.	A student is able to: ? explain formation of ions, ? write electron arrangements for the ions formed, ? explain formation of ionic bond, ? illustrate electron arrangement of an ionic bond, ? illustrate formation of ionic bond.	Ionic bond is synonymous with electrovalent bond.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
5.3 Synthesising ideas on formation of covalent bond	Collect and interpret data on the meaning of covalent bond. Use models and computer simulation to illustrate formation of: a. single bond in hydrogen, H_2, chlorine, Cl_2, hydrogen chloride, HCl, water, H_2O, methane, CH_4, ammonia, NH_3, tetrachloromethane, CCl_4, b. double bond in oxygen, O_2, carbon dioxide, CO_2, c. triple bond in nitrogen, N_2. Draw diagrams showing electron arrangements for the formation of covalent bond including Lewis structure. Discuss and construct a mind map to compare the formation of covalent bond with ionic bond.	A student is able to: ? state the meaning of covalent bond, ? explain formation of covalent bond, ? illustrate formation of a covalent bond by drawing electron arrangement, ? illustrate formation of covalent bond, ? compare and contrast formation of ionic and covalent bonds.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
5.4 Analysing properties of ionic and covalent compounds	Collect and interpret data on properties of ionic and covalent compounds. Work in groups to carry out an activity to compare the following properties of ionic and covalent compounds: a. melting and boiling points, b. electrical conductivities, c. solubilities in water and organic solvents. Discuss: a. differences in electrical conductivities of ionic and covalent compounds due to the presence of ions, b. differences in the melting and boiling points of ionic and covalent compounds. Gather information on uses of covalent compounds as solvents in daily life.	A student is able to: ? list properties of ionic compounds, ? list properties of covalent compounds, ? explain differences in the electrical conductivity of ionic and covalent compounds, ? describe differences in melting and boiling points of ionic and covalent compounds, ? compare and contrast the solubility of ionic and covalent compounds, ? state uses of covalent compounds as solvents.		Solvent - *pelarut*

THEME : INTERACTION BETWEEN CHEMICALS

LEARNING AREA : 1. ELECTROCHEMISTRY **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
6.1 Understanding properties of electrolytes and non-electrolytes	Conduct activities to classify chemicals into electrolytes and non-electrolytes. Discuss: a. the meaning of electrolyte, b. the relationship between the presence of freely moving ions and electrical conductivity.	A student is able to: ? state the meaning of electrolyte, ? classify substances into electrolytes and non-electrolytes, ? relate the presence of freely moving ions to electrical conductivity.	Students have basic knowledge that electrical circuit can be built using solutions and electrolysis of water.	
6.2 Analysing electrolysis of molten compounds	Discuss: a. electrolysis process, b. structure of electrolytic cell. Use computer simulation to: a. identify cations and anions in a molten compound, b. illustrate to show the existence of ions held in a lattice in solid state but move freely in molten state. Conduct an activity to investigate the electrolysis of molten lead(II) bromide, $PbBr_2$ to: a. identify cations and anions, b. describe the electrolysis process, c. write half-equations for the discharge of ions at anode and cathode. Collect and interpret data on electrolysis	A student is able to: ? describe electrolysis, ? describe electrolytic cell, ? identify cations and anions in a molten compound, ? describe evidence for the existence of ions held in a lattice in solid state but move freely in molten state, ? describe electrolysis of a molten compound, ? write half-equations for the discharge of ions at anode and cathode, ? predict products of the electrolysis of molten compounds.	The term and skill in writing half-equation or half-reaction is new to students.	molten – *leburan* half-equation - *setengah persamaan* half-reaction - *setengah tindak balas*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	of molten ionic compounds with very high melting points, for example sodium chloride, NaCl and lead(II) oxide, PbO. Predict products from the electrolysis of other molten compounds.			
6.3 Analysing the electrolysis of aqueous solutions	Conduct an activity to investigate the electrolysis of copper(II) sulphate solution and dilute sulphuric acid using carbon electrodes to: a. identify cations and anions in the aqueous solutions, b. describe the electrolysis of the aqueous solutions, c. write half equations for the discharge of ions at the anode and the cathode. Conduct experiments to investigate factors determining selective discharge of ions at electrodes based on: a. positions of ions in electrochemical series, b. concentration of ions in a solution, c. types of electrodes. Use computer simulation to explain factors affecting electrolysis of an aqueous solution.	A student is able to: ? identify cations and anions in an aqueous solution, ? describe the electrolysis of an aqueous solution, ? explain using examples factors affecting electrolysis of an aqueous solution, ? write half equations for the discharge of ions at the anode and the cathode, ? predict the products of electrolysis of aqueous solutions.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Predict the products of electrolysis of aqueous solutions and write their half equations.			
6.4 Evaluating electrolysis in industry	Conduct experiments to study the purification and electroplating of metals. Using computer simulation, study and discuss: a. extraction of aluminium from aluminium oxide, b. purification of copper, c. electroplating of metals. Carry out activities to write chemical equations for electrolysis in industries. Collect data and discuss the benefits and harmful effects of electrolysis in industries.	A student is able to: ? state uses of electrolysis in industries, ? explain the extraction, purification and electroplating of metals involving electrolysis in industries, ? write chemical equations to represent the electrolysis process in industries, ? justify uses of electrolysis in industries, ? describe the problem of pollution from electrolysis in industry.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
6.5 Analysing voltaic cell	Study the structure of a voltaic cell such as a simple voltaic cell and Daniell cell. Conduct an experiment to show the production of electricity from chemical reactions in a simple voltaic cell. Carry out activities on a simple voltaic cell and a Daniell cell to explain the reactions in each cell. Collect data and discuss the advantages and disadvantages of various voltaic cells including dry cell, lead-acid accumulator, mercury cell, alkaline cell and nickel cadmium cell. Discuss and compare an electrolytic cell with a voltaic cell.	A student is able to: ? describe the structure of a simple voltaic cell and Daniell cell, ? explain the production of electricity from a simple voltaic cell, ? explain the reactions in a simple voltaic cell and Daniell cell, ? compare and contrast the advantages and disadvantages of various voltaic cells, ? describe the differences between electrolytic and voltaic cells.	A voltaic cell is also called galvanic cell. Mention new cells such as lithium ion, nickel hydride and polymeric cells.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
6.6 Synthesising electrochemical series	Carry out an experiment to construct the electrochemical series based on: a. potential difference between two metals, b. the ability of a metal to displace another metal from its salt solution. Discuss uses of the electrochemical series to determine: a. cell terminal, b. standard cell voltage, c. the ability of a metal to displace another metal from its salt solution. Carry out experiments to confirm the predictions on the metal displacement reaction. Carry out an activity to write the chemical equations for metal displacement reactions.	A student is able to: ? describe the principles used in constructing the electrochemical series, ? construct the electrochemical series, ? explain the importance of electrochemical series, ? predict the ability of a metal to displace another metal from its salt solution, ? write the chemical equations for metal displacement reactions.		displacement reaction – *tindak balas penyesaran*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
6.7 Develop awareness and responsible practices when handling chemicals used in electrochemical industries	Discuss the importance of electrochemical industries in our daily life. Collect data and discuss the problems on pollution caused by the industrial processes involving electrochemical industries. Hold a forum to discuss the importance of waste disposal from electrochemical industries in a safe and orderly manner. Show a video on the importance of recycling and systematic disposal of used batteries in a safe and orderly manner. Practise recycling used batteries.	A student is able to: ? justify the fact that electrochemical industries can improve the quality of life, ? describe the problem of pollution caused by the industrial processes involving electrolysis, ? justify the need to dispose of waste from electrochemical industries in a safe and orderly manner, ? practise safe and systematic disposal of used batteries.		

THEME : INTERACTION BETWEEN CHEMICALS

LEARNING AREA : 2. ACIDS AND BASES **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
7.1 Analysing characteristics and properties of acids and bases	Discuss: a. the concept of acid, base and alkali in terms of the ions they contained or produced in aqueous solutions, b. uses of acids, bases and alkalis in daily life. Carry out an experiment to show that the presence of water is essential for the formation of hydrogen ions that causes acidity. Carry out an experiment to show that the presence of water is essential for the formation of hydroxide ions that causes alkalinity. Watch computer simulation on the formation of hydroxonium ions and hydroxide ions in the presence of water. Conduct activities to study chemical properties of acids and alkalis from the following reactions: a. acids with bases, b. acids with metals, c. acids with metallic carbonates. Write equations for the respective reactions.	A student is able to: ? state the meaning of acid, base and alkali, ? state uses of acids, bases and alkalis in daily life, ? explain the role of water in the formation of hydrogen ions to show the properties of acids, ? explain the role of water in the formation of hydroxide ions to show the properties of alkalis, ? describe chemical properties of acids and alkalis.	The formation of hydroxonium ion, H_30^+, is introduced. Monoprotic and diprotic acid is introduced.	monoprotic acid – *asid monobes* diprotic acid – *asid dwibes*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
7.2 Synthesising the concepts of strong acids, weak acids, strong alkalis and weak alkalis	Carry out an activity using pH scale to measure the pH of solutions used in daily life such as soap solution, carbonated water, tap water or fruit juice. Carry out an activity to measure the pH value of a few solutions with the same concentration. For example, hydrochloric acid, ethanoic acid, ammonia and sodium hydroxide with the use of indicators, pH meter or computer interface. Based on the data obtained from the above activity, discuss the relationship between: a. pH values and acidity or alkalinity of a substance, b. concentration of hydrogen ions and the pH values, c. concentration of hydroxide ions and the pH values, d. strong acids and their degree of dissociation, e. weak acids and their degree of dissociation, f. strong alkalis and their degree of dissociation, g. weak alkalis and their degree of dissociation.	A student is able to: ? state the use of a pH scale, ? relate pH value with acidic or alkaline properties of a substance, ? relate concentration of hydrogen ions with pH value, ? relate concentration of hydroxide ions with pH value, ? relate strong or weak acid with degree of dissociation, ? relate strong or weak alkali with degree of dissociation, ? conceptualise qualitatively strong and weak acids, ? conceptualise qualitatively strong and weak alkalis.	The formula $pH = -\log [H^+]$ is not required. Dissociation is also known as ionisation.	dissociation – *penceraian* ionisation - *pengionan*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Use computer simulation to show the degree of dissociation of strong and weak acids as well as strong and weak alkalis. Build a mind map on strong acids, weak acids, strong alkalis and weak alkalis.			
7.3 Analysing concentration of acids and alkalis	Discuss: a. the meaning of concentration, b. the meaning of molarity, c. the relationship between the number of moles with the molarity and the volume of a solution, d. methods for preparing standard solutions. Solve numerical problems involving conversion of concentration units from g dm^{-3} to mol dm^{-3} and vice versa. Prepare a standard solution of sodium hydroxide, NaOH or potassium hydroxide, KOH. Prepare a solution with specified concentration from the prepared standard solution through dilution. Carry out an experiment to investigate	A student is able to: ? state the meaning of concentration, ? state the meaning of molarity, ? state the relationship between the number of moles with molarity and volume of a solution, ? describe methods for preparing standard solutions, ? describe the preparation of a solution with a specified concentration using dilution method, ? relate pH value with molarity of acid and alkali, ? solve numerical problems involving molarity of acids and alkalis.	The use of pH meter is recommended. Salt solutions can be included in the discussion. Molarity or molar concentration. Sodium hydroxide is not stable and absorbs moisture, thus the concentration is only approximate. Oxalic acid, $H_2C_2O_4.2H_2O$ or sodium carbonate, Na_2CO_3 is	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	the relationship between pH values with the molarity of a few diluted solutions of an acid and an alkali. Solve numerical problems on the molarity of acids and alkalis.		recommended as a primary standard solution.	
7.4 Analysing neutralisation	Collect and interpret data on neutralisation and its application in daily life. Carry out activities to write equations for neutralisation reactions. Carry out acid-base titrations and determine the end point using indicators or computer interface. Carry out problem solving activities involving neutralisation reactions to calculate either concentration or volume of solutions.	A student is able to: ? explain the meaning of neutralisation, ? explain the application of neutralisation in daily life, ? write equations for neutralisation reactions, ? describe acid-base titration, ? determine the end point of titration during neutralisation, ? solve numerical problems involving neutralisation reactions to calculate either concentration or volume of solutions.	Neutralise soil using lime or ammonia, use of anti-acid. Teacher should emphasise on using correct techniques.	

THEME : INTERACTION BETWEEN CHEMICALS

LEARNING AREA : 3. SALTS **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
8.1 Synthesising salts	Collect and interpret data on: a. naturally existing salts, b. the meaning of salt, c. uses of salts in agriculture, medicinal field, preparation and preservation of food. Carry out experiments to study the solubilities of nitrate, sulphate, carbonate and chloride salts. Prepare soluble salts by reacting: a. acid with alkali, b. acid with metallic oxide, c. acid with metal, d. acid with metallic carbonate. Carry out an activity to purify soluble salts by recrystallisation. Discuss the need to purify salts. Observe to identify physical characteristics of crystals such as copper(II) sulphate, $CuSO_4$, sodium chloride, NaCl, potassium chromate(VI), K_2CrO_4, and potassium dichromate, $K_2Cr_2O_7$.	A student is able to: ? state examples of salts used in daily life, ? explain the meaning of salt ? identify soluble and insoluble salts, ? describe the preparation of soluble salts, ? describe the purification of soluble salts by recrystallisation, ? list physical characteristics of crystals, ? describe the preparation of insoluble salts, ? write chemical and ionic equations for reactions used in the preparation of salts, ? design an activity to prepare a specified salt, ? construct ionic equations through the continuous variation method, ? solve problems involving calculation of quantities of reactants or products in stoichiometric reactions.	The soluble salts prepared are purified by recrystalisation. Use prepared crystals of salts.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Prepare insoluble salts such as lead(II) iodide, PbI_2, lead(II) chromate(VI), $PbCrO_4$, and barium sulphate, $BaSO_4$, through precipitation reactions. Carry out activities to write chemical and ionic equations for preparation of soluble and insoluble salts. Construct a flow chart to select suitable methods for preparation of salts. Plan and carry out an activity to prepare a specified salt. Carry out an experiment to construct ionic equations through continuous variation method. Calculate quantities of reactants or products in stoichiometric reactions.		Use worksheets or quizzes	precipitation reaction – *tindak balas pemendakan*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
8.2 Synthesising qualitative analysis of salts	Discuss the meaning of qualitative analysis. Study and make inferences on the colour and the solubility of various salts in water. Watch multimedia presentation on methods used for identifying gases. Observe and carry out chemical tests to identify oxygen, O_2, hydrogen, H_2, carbon dioxide, CO_2, ammonia, NH_3, chlorine, Cl_2, hydrogen chloride, HCl, sulphur dioxide, SO_2, and nitrogen dioxide, NO_2, gases. Carry out tests to study the action of heat on carbonate and nitrate salts. Observe changes in colour and evolution of gases when the salts are heated. Carry out tests to confirm the presence of carbonate, sulphate, chloride and nitrate ions in aqueous solutions. Carry out tests to identify the presence of Cu^{2+}, Mg^{2+}, Al^{3+}, Fe^{2+}, Fe^{3+}, Pb^{2+}, Zn^{2+}, NH_4^+, Ca^{2+} ions in aqueous solution using sodium hydroxide solution, NaOH, and ammonia solution, NH_3 (aq).	A student is able to: ? state the meaning of qualitative analysis, ? make inferences on salts based on their colour and solubility in water, ? describe tests for the identification of gases, ? describe the action of heat on salts, ? describe the tests for anions, ? state observation of reaction of cations with sodium hydroxide solution and ammonia solution, ? describe confirmatory tests for Fe^{2+}, Fe^{3+}, Pb^{2+} and NH_4^+, ? plan qualitative analysis to identify salts.	Chemical tests for O_2, H_2, CO_2, NH_3 and HCl are confirmatory tests. Action of heat on sulphate and chloride salts may be mentioned.	

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
	Carry out tests to confirm the presence of Fe^{2+}, Fe^{3+}, Pb^{2+} and NH_4^+ ions in aqueous solution. Construct a flow chart on the qualitative analysis of salts. Plan and carry out tests to identify anions and cations in unknown salts.			
8.3 Practising to be systematic and meticulous when carrying out activities	Carry out activities using correct techniques during titration, preparation of standard solutions and preparation of salts and crystals. Plan and carry out an experiment, make observations, record and analyse data systematically and carefully.	A student is able to: ? carry out activities using the correct techniques during preparation of salts and crystals.	Activities are integrated in the topic where applicable.	

THEME : PRODUCTION AND MANAGEMENT OF MANUFACTURED CHEMICALS

LEARNING AREA : 1. MANUFACTURED SUBSTANCES IN INDUSTRY **Chemistry - Form 4**

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
9.1 Understanding the manufacture of sulphuric acid	Discuss uses of sulphuric acid in daily life such as in the making of paints, detergents, fertilizers and accumulators. Collect and interpret data on the manufacture of sulphuric acid. Construct a flow chart to show the stages in the manufacture of sulphuric acid as in the contact process. Gather information and write an essay on how sulphur dioxide, SO_2, causes environmental pollution.	A student is able to: ? list uses of sulphuric acid, ? explain industrial process in the manufacture of sulphuric acid, ? explain that sulphur dioxide causes environmental pollution.		
9.2 Synthesising the manufacture of ammonia and its salts	Discuss uses of ammonia in daily life, e.g. in the manufacture of fertilizers and nitric acid. Carry out an activity to investigate properties of ammonia. Collect data from various sources and construct a flow chart to show the stages in the manufacture of ammonia as in the Haber process. Design an activity to prepare an ammonium fertilizer, for example ammonium sulphate, $(NH_4)_2SO_4$.	A student is able to: ? list uses of ammonia, ? state the properties of ammonia, ? explain the industrial process in the manufacture of ammonia, ? design an activity to prepare ammonium fertilizer.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
9.3 Understanding alloys	Look at some examples of pure metals and materials made of alloys in daily life. List and discuss their properties. Carry out an activity to compare the strength and hardness of alloys with that of their pure metals. Study the arrangement of atoms in metals and alloys through computer simulation. Work in groups to discuss: a. the meaning of alloy, b. the purpose of making alloys such as duralumin, brass, steel, stainless steel, bronze and pewter, c. compositions, properties and uses of alloys. Carry out experiments to compare the rate of corrosion of iron, steel and stainless steel. Study various local products made from alloys.	A student is able to: ? relate the arrangement of atoms in metals to their ductile and malleable properties, ? state the meaning of alloy, ? state the aim of making alloys, ? list examples of alloys, ? list compositions and properties of alloys, ? relate the arrangement of atoms in alloys to their strength and hardness, ? relate properties of alloys to their uses.	Properties include conductivity, ductility, malleability and lustre. Discuss the making of alloys, for example steel and pewter as an enrichment exercise.	ductile – *mulur* malleable – *boleh tempa / bentuk* lustre – *kilau / relap*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
9.4 Evaluating uses of synthetic polymers	Discuss the meaning of polymers. Observe exhibits of materials made of polymers and classify them into naturally occurring polymers and synthetic polymers. Identify the monomers in synthetic polymers using models or computer simulation. Collect information on the quantity and types of household synthetic polymers disposed of over a certain period of time. Discuss the environmental pollution resulting from the disposal of synthetic polymers. Hold a debate on uses and the environmental effects of non-biodegradable synthetic polymers in daily life.	A student is able to: ? state the meaning of polymers, ? list naturally occurring polymers, ? list synthetic polymers and their uses, ? identify the monomers in the synthetic polymers, ? justify uses of synthetic polymers in daily life.	Natural polymers to be discussed are rubber, cellulose and starch. Synthetic polymers to be discussed are PVC, polythene, polypropene, perspex, nylon and terylene. Recycling as a disposal method can be discussed. Uses of biodegradable polymers can be discussed.	biodegradable – *terbiodegradasi* non-biodegradable – *tidak terbiodegradasi*

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
9.5 Applying uses of glass and ceramics	Collect and interpret data on types, composition, properties and uses of glass and ceramics. Prepare a folio incorporating video clips and pictures on uses of glass and ceramics that have been improved for a specific purpose, e.g. photo chromic glass and conducting glass.	A student is able to: ? list uses of glass, ? list uses of ceramics, ? list types of glass and their properties, ? state properties of ceramics.	Glass types include soda-lime glass, fused glass, borosilicate glass and lead crystal glass.	
9.6 Evaluating uses of composite materials	Watch a multimedia presentation and prepare a folio on: a. the meaning of composite materials, b. a list of composite materials including reinforced concrete, specific super conductor, fibre optic, fibre glass and photo chromic glass, c. components of composite materials, d. uses of composite materials. Compare the superior properties of composite materials to their original component through computer simulation. Discuss and justify the uses of composite materials. Watch the production of composite materials in factories.	A student is able to: ? describe needs to produce new materials for specific purposes, ? state the meaning of composite materials, ? list examples of composite materials and their components, ? compare and contrast properties of composite materials with those of their original component, ? justify uses of composite materials, ? generate ideas to produce advanced materials to fulfil specific needs.		

Learning Objectives	Suggested Learning Activities	Learning Outcomes	Notes	Vocabulary
9.7 Appreciating various synthetic industrial materials	Discuss the importance of synthetic materials in daily life. Hold a forum to discuss the importance of doing research and development for the well being of mankind continuously. Watch a multimedia presentation or computer simulation on pollution caused by the disposal of synthetic materials.	A student is able to: ? justify the importance of doing research and development continuously, ? act responsibly when handling synthetic materials and their wastes, ? describe the importance of synthetic materials in daily life.		

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