KEMENTERIAN
PENDIDIKAN
MALAYSIA

KURIKULUM STANDARD SEKOLAH MENENGAH

Kimia

Dokumen Standard Kurikulum dan Pentaksiran

Tingkatan 4 & 5

(EDISI BAHASA INGGERIS)

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Form 4 & 5

(Edisi Bahasa Inggeris)

Bahagian Pembangunan Kurikulum

SEPTEMBER 2018

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CONTENT

RUKUN NEGARA

BAHAWASANYA Negara kita Malaysia mendukung cita-cita hendak:
Mencapai perpaduan yang lebih erat dalam kalangan seluruh masyarakatnya;
Memelihara satu cara hidup demokratik;
Mencipta satu masyarakat yang adil di mana kemakmuran negara
akan dapat dinikmati bersama secara adil dan saksama;
Menjamin satu cara yang liberal terhadap tradisi-tradisi
kebudayaannya yang kaya dan berbagai corak;
Membina satu masyarakat progresif yang akan menggunakan
sains dan teknologi moden;

MAKA KAMI, rakyat Malaysia, berikrar akan menumpukan seluruh tenaga dan usaha kami untuk mencapai cita-cita tersebut berdasarkan atas prinsip-prinsip yang berikut:

KEPERCAYAAN KEPADA TUHAN
KESETIAAN KEPADA RAJA DAN NEGARA
KELUHURAN PERLEMBAGAAN
KEDAULATAN UNDANG-UNDANG
KESOPANAN DAN KESUSILAAN

FALSAFAH PENDIDIKAN KEBANGSAAN

“Pendidikan di Malaysia adalah suatu usaha berterusan ke arah lebih memperkembangkan potensi individu secara menyeluruh dan bersepadu untuk melahirkan insan yang seimbang dan harmonis dari segi intelek, rohani, emosi dan jasmani, berdasarkan kepercayaan dan kepatuhan kepada Tuhan. Usaha ini adalah bertujuan untuk melahirkan warganegara Malaysia yang berilmu pengetahuan, berketerampilan, berakhlak mulia, bertanggungjawab dan berkeupayaan mencapai kesejahteraan diri serta memberikan sumbangan terhadap keharmonian dan kemakmuran keluarga, masyarakat dan negara”

Sumber: Akta Pendidikan 1996 (Akta 550)

DEFINISI KURIKULUM KEBANGSAAN

3. Kurikulum Kebangsaan

(1) Kurikulum Kebangsaan ialah suatu program pendidikan yang termasuk kurikulum dan kegiatan kokurikulum yang merangkumi semua pengetahuan, kemahiran, norma, nilai, unsur kebudayaan dan kepercayaan untuk membantu perkembangan seseorang murid dengan sepenuhnya dari segi jasmani, rohani, mental dan emosi serta untuk menanam dan mempertingkatkan nilai moral yang diingini dan untuk menyampaikan pengetahuan.

Sumber: Peraturan-Peraturan Pendidikan (Kurikulum Kebangsaan) 1997
[PU(A)531/97.]

FALSAFAH PENDIDIKAN SAINS KEBANGSAAN

Selaras dengan Falsafah Pendidikan Kebangsaan, pendidikan sains di Malaysia memupuk budaya Sains dan Teknologi dengan memberi tumpuan kepada perkembangan individu yang kompetitif, dinamik, tangkas dan berdaya tahan serta dapat menguasai ilmu sains dan keterampilan teknologi.

Sumber: Kementerian Sains, Teknologi dan Inovasi (MOSTI)

KATA PENGANTAR

Kurikulum Standard Sekolah Menengah (KSSM) yang dilaksanakan secara berperingkat mulai tahun 2017 akan menggantikan Kurikulum Bersepadu Sekolah Menengah (KBSM) yang mula dilaksanakan pada tahun 1989. KSSM digubal bagi memenuhi keperluan dasar baharu di bawah Pelan Pembangunan Pendidikan Malaysia (PPPM) 2013-2025 agar kualiti kurikulum yang dilaksanakan di sekolah menengah setanding dengan standard antarabangsa. Kurikulum berasaskan standard yang menjadi amalan antarabangsa telah dijelmakan dalam KSSM menerusi penggubalan Dokumen Standard Kurikulum dan Pentaksiran (DSKP) untuk semua mata pelajaran yang mengandungi Standard Kandungan, Standard Pembelajaran dan Standard Prestasi.

Usaha memasukkan standard pentaksiran di dalam dokumen kurikulum telah mengubah lanskap sejarah sejak Kurikulum Kebangsaan dilaksanakan di bawah Sistem Pendidikan Kebangsaan. Menerusinya murid dapat ditaksir secara berterusan untuk mengenal pasti tahap penguasaannya dalam sesuatu mata pelajaran, serta membolehkan guru membuat tindakan susulan bagi mempertingkatkan pencapaian murid.

DSKP yang dihasilkan juga telah menyepadukan enam tunjang Kerangka KSSM, mengintegrasikan pengetahuan, kemahiran dan nilai, serta memasukkan secara eksplisit Kemahiran Abad Ke-21 dan Kemahiran Berfikir Aras Tinggi (KBAT). Penyepaduan tersebut dilakukan untuk melahirkan insan seimbang dan harmonis dari segi intelek, rohani, emosi dan jasmani sebagaimana tuntutan Falsafah Pendidikan Kebangsaan.

Bagi menjayakan pelaksanaan KSSM, pengajaran dan pembelajaran guru perlu memberi penekanan kepada KBAT dengan memberi fokus kepada pendekatan Pembelajaran Berasaskan Inkuiri dan Pembelajaran Berasaskan Projek, supaya murid dapat menguasai kemahiran yang diperlukan dalam abad ke-21.

Kementerian Pendidikan Malaysia merakamkan setinggi-tinggi penghargaan dan ucapan terima kasih kepada semua pihak yang terlibat dalam penggubalan KSSM. Semoga pelaksanaan KSSM akan mencapai hasrat dan matlamat Sistem Pendidikan Kebangsaan.

SHAZALI BIN AHMAD
Pengarah
Bahagian Pembangunan Kurikulum
Kementerian Pendidikan Malaysia

INTRODUCTION

As articulated in the National Education Philosophy, education in Malaysia is an on-going effort towards nurturing the potential of individuals in a holistic and integrated manner, to develop individuals who are intellectually, spiritually, emotionally and physically balanced. The primary and secondary school curriculum standard and assessment for sciences are developed with the aim of fostering such individuals.

Moving towards a developed nation, Malaysia should create a scientific, progressive, inventive and visionary community as well as benefiting the latest technologies. This community must be able to contribute to the advancement of science and the sustainability of technological civilisation. To achieve this, we need to develop critical, creative, innovative and competent citizens who practice the culture of Science, Technology, Engineering and Mathematics (STEM).

The national science curriculum encompasses core science and elective science subjects. The core science subject is being offered in primary, lower secondary and upper secondary schools, while the eective sciences are being offered in upper secondary schools such as are Biology, Physics, Chemistry and Additional Science.

Secondary core science subject is designed to develop science literacy and high order thinking skills as well as the ability to apply science knowledge, in decision-making and solving real-life problems among pupils.

Elective science subjects are aspired to sharpen and reinforce pupil's knowledge and skills in STEM. These subjects enable pupils to pursue high education with lifelong learning skills. These pupils are anticipated to pursue career in STEM and be able to actively participate in community development and nation-building.

Pupils taking KSSM Chemistry will have the knowledge and skills to enable them to solve problems and make decisions in everyday life related to Chemistry based on scientific attitudes and values. They will also be able to further their studies and undertake chemistry related career. KSSM Chemistry intends to develop individuals who are dynamic, viable, fair, practice STEM culture and responsible towards community and environment.

AIMS

KSSM Chemistry aims to develop science-literate pupils through learning experiences in understanding the chemistry related concepts, developing skills, using various strategies and applying the knowledge and skills based on scientific attitudes and values as well as understanding the impact of science and technological developments in society. These pupils can communicate, make decisions based on scientific evidences, and able to further their education and careers in the STEM field.

OBJECTIVES

The KSSM Chemistry enables pupils to achieve the following objectives:

1. Strengthen interest and passion for chemistry.
2. Reinforce and enrich scientific knowledge, skills, attitudes and values in chemistry through scientific investigation.
3. Enhance the ability to think logically, rationally, critically and creatively through processes of understanding and applying chemistry in decision-making and problems solving.
4. Acknowledge that the knowledge of chemistry is temporary and evolving.
5. Practise the usage of chemistry language and symbols and equip pupils with skills in delivering phyiscs related ideas in the relevant context.
6. Develop mindset about chemical concepts, theories and laws, open-mindedness, objectiveness and proactiveness.
7. Realize social, economic, environmental and technological implications in chemistry and caring for the environment and society.
8. Appreciate chemistry and its application in helping to explain phenomena and solve real worls problems.

KSSM FRAMEWORK

KSSM Chemistry is built based on six pillars, which are Communication; Spiritual, Attitude and Value; Humanity; Personal Development; Chemistry Development and Aesthetic; and Science and Technology. The six pillars are the main domain that support each other and are integrated with critical, creative and innovative thinking.

This integration aimed at developing human capital who is knowledgeable, competent, creative, critical, innovative and embraces noble values based on religion as illustrated in Figure 1.

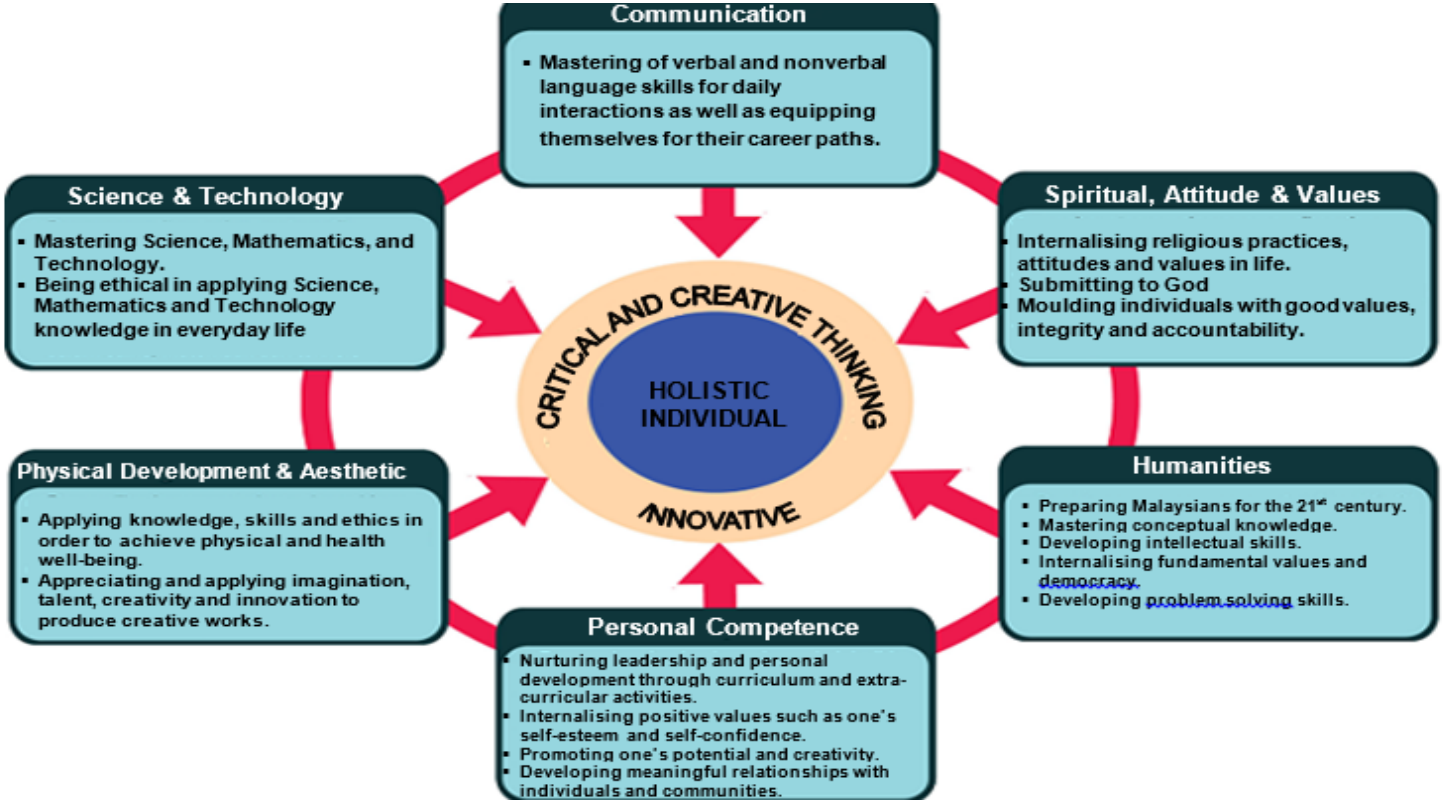


Figure 1: KSSM Framework

FOCUS

KSSM Chemistry focuses on thoughtful learning based on the three domains, which are knowledge, skills and values. The development of these domains will be experienced by pupils through inquiry method in order to nurture thoughtful science individual (Figure 2). The inquiry approach includes pupil-centred learning, constructivism, contextual learning, problem-based learning, mastery learning as well as related strategies and methods.

The curriculum also aims to prepare pupils to face rapid technological development and various challenges of the 21st century like The Industrial Revolution 4.0. The group of pupils that have gone through this curriculum will be the STEM human resource who will be able to contribute towards national development.

Thoughtful Science Learners

According to Kamus Dewan (4th Edition), 'fikrah' or in English language 'thoughtful' means the ability to think and reflect. In the context of science curriculum, thoughtful science refers to the quality desired to be produced by the National Science Education System. Thoughtful science learners are those who can understand scientific ideas and are able to communicate in scientific language; can evaluate and apply scientific knowledge and skills in science and technology contextually, responsibly and ethically. Thoughtful science also intends to produce creative and critical individuals that can communicate and collaborate to face the challenges of the 21st century demands, in which the country's progress is highly dependent upon the capacity and quality of its human resources.

Thoughtful Learning

Thoughtful learning is a process of acquiring and mastering skills and knowledge which can develop pupils mind to optimum level.

Thoughtful science can be achieved through thoughtful learning when pupils are actively engaged in the teaching and learning processes (T&L). In this process, the thoughtful learning activities designed by teachers are to dig the pupils' minds and encourage them to think, to conceptualize, solve problems and make wise decisions. Hence, thinking skills should be practised and cultured among pupils.

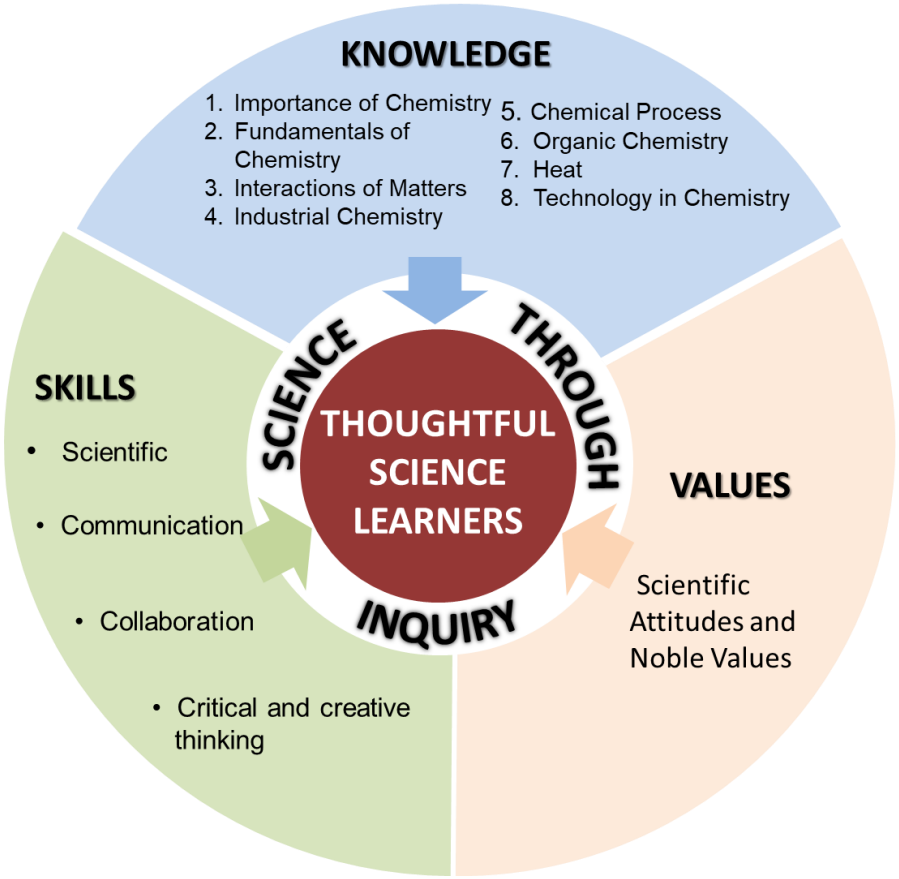


Figure 2: The Conceptual Framework for Chemistry Curriculum

Critical Thinking Skills

Critical thinking skills is the ability to evaluate an idea in a logical and rational manner to make reasonable judgement with justifications and reliable evidences.

A brief description of each critical thinking skills is as in Table 1:

Table 1: Critical Thinking Skills

CRITICAL THINKING SKILLS	DESCRIPTION
Attributing	Identifying 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 objects or events.
Grouping and Classifying	Separating and grouping objects or phenomena into groups 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.

CRITICAL THINKING SKILLS	DESCRIPTION
Prioritising	Arranging objects or information in order based on their importance or urgency.
Analysing	Processing information by breaking it down into smaller parts in order to deeply and thoroughly understand them in details and their interrelationship.
Detecting Bias	Identify/ Investigate views or opinions that have the tendency to support or oppose something.
Evaluating	Assessing considerations and decisions using knowledge, experiences, skills, values and giving justification.
Making Conclusion	Making a statement about the outcomes of an investigation based on a hypothesis.

Creative Thinking Skills

Creative thinking skill is the ability to produce or create something new and valuable by using genuine imaginative skill and unconventional thinking. A brief description of each creative thinking skill is as in Table 2.

Table 2: Creative Thinking Skills

CREATIVE THINKING SKILLS	DESCRIPTION
Generating Ideas	Prompting thoughts or opinions related to something.
Relating	Making connections in certain situations or events to find relationship between a structure or pattern.
Making Inference	Making initial conclusion and explaining an event using data collection and past experiences.

CREATIVE THINKING SKILLS	DESCRIPTION
Predicting	Forecasting an event based on observations and previous experiences or collected data.
Making Generalisation	Making general statement about certain matter from a group of observations on samples or some information from that group.
Visualising	Forming perception or making mental images about a particular idea, concept, situation or vision.
Synthesising	Combining separate elements to produce an overall picture in the form of writing, drawing or artefact.
Developing Hypothesis	Making a general statement about the relationship between the manipulated variable and responding variable to explain an observation or event. This statement or conjencture can be tested to determine its validity.
Developing Analogy	Forming an understanding about a complex or abstract concept by relating it to simple or concrete concept with similar characteristics.
Inventing	Producing something new or modifying something which is already in existence to overcome problems in a systematic manner.

Thinking Strategy

Thinking strategy is structured and focused high-level thinking which involves critical and creative thinking and reasoning skills in every steps taken to achieve the intended goal or solution to a problem. Description of each thinking strategy is as in Table 3.

Table 3: Thinking Strategy

THINKING STRATEGY	DESCRIPTION
Conceptualising	Making generalisations towards building a meaning, concept or model based on inter-related specific common characteristics.
Making Decision	Selecting the best solution from several alternatives based on specific criteria to achieve the intended aims.
Problem Solving	Finding the right solutions in a systematic manner for situations that are uncertain or challenging or unanticipated difficulties.

Table 3 shows an overall picture of the thinking skills and thinking strategies. Further information on thinking skills and thinking strategies(TSTS) can be found in *Buku Panduan Penerapan Kemahiran Berfikir dan Strategi Berfikir dalam Pengajaran dan Pembelajaran Sains (Curriculum Development Centre, 1999).*

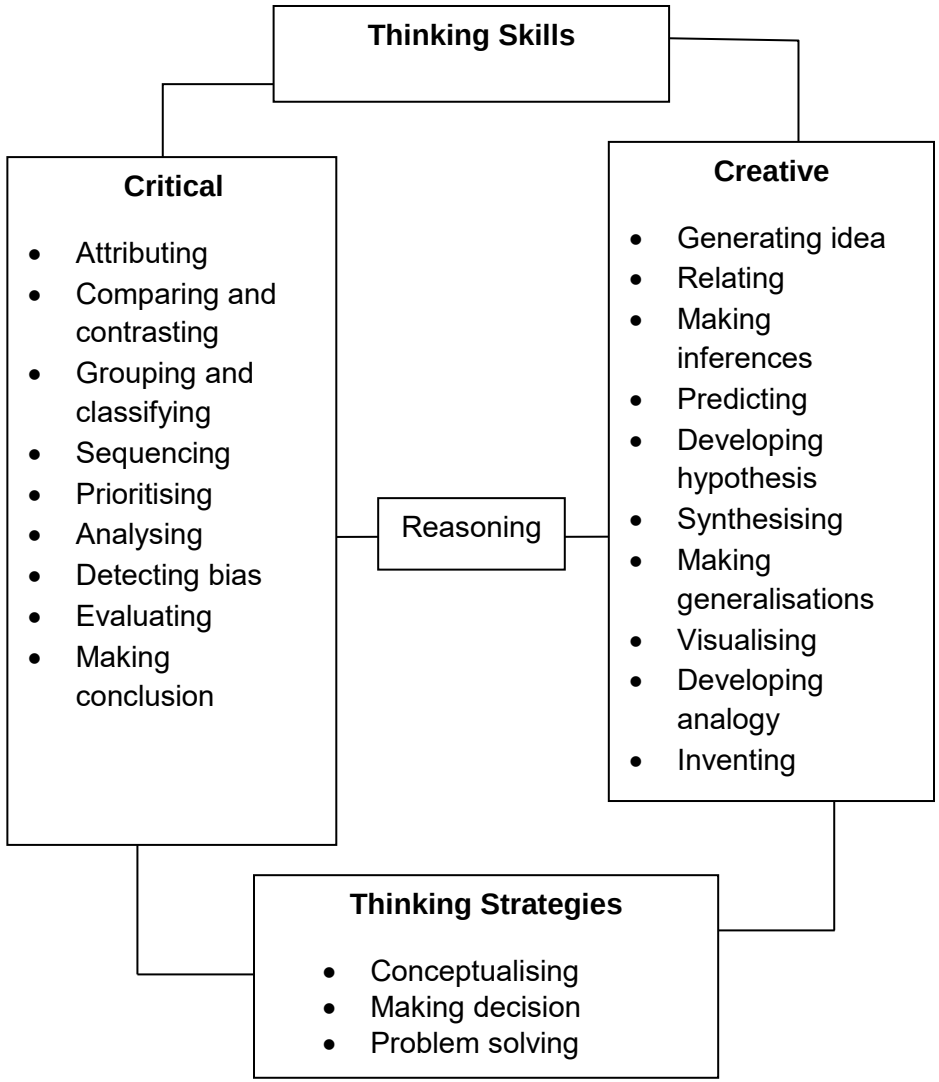


Figure 3: TSTS Model in KSSM Chemistry

Scientific Skills

KSSM Chemistry emphasizes on inquiry and problem solving. In the process of inquiry and solving problem, scientific skills and thinking skills are used. Scientific skills are important skills used during scientific activities such as conducting experiments and projects.

Scientific skills consist of science process skills and manipulative skills.

Science Process Skills

Science Process Skills (SPS) are skills required in the process of finding solutions to a problem or making decisions in a systematic manner. SPS are mental processes which promote critical, creative, analytical and systematic thinking. Mastery of SPS together with attitude and appropriate knowledge to guarantee the ability of pupils to think effectively. Thus, good command of SPS with positive attitude and sound knowledge will ensure effective thinking among pupils. Table 4 describes each of the SPS.

Table 4: Science Process Skills

SCIENCE PROCESS SKILLS	DESCRIPTION
Observing	Using the senses of sight, hearing, touch, taste or smell to gather information about objects and phenomena.
Classifying	Using observations to group objects or phenomena according to similarities and differences.
Measuring and Using Numbers	Making quantitative observations using numbers and tools with standard units to ensure an accurate measurement.
Inferring	Using collected data or past experiences to draw conclusions and make explanations of events.
Predicting	Making forecast about future events based on observations and previous experiences or collected data.

SCIENCE PROCESS SKILLS	DESCRIPTIONS
Communicating	Using words or graphic symbols such as tables, graphs, diagrams or models to explain actions, objects or events.
Using Space-Time Relationship	Describing changes in parameter such as location, direction, shape, size, volume, weight or mass with time.
Interpreting Data	Giving rational explanations about an object, event or pattern derived from collected data.
Defining Operationally	Giving meaning to a concept by describing what must be done and what should be observed.
Controlling Variables	Managing manipulated variable, responding variable and fixed variable. In a scientific investigation, the manipulated variable is changed to observe its relationship with the responding variable. At the same time, the other variables are kept the same.
Hypothesising	Making a general statement about the relationship between the manipulated and responding variable to explain an observation or event. This statement or conjecture can be tested to determine its validity.
Experimenting	Planning and conducting an investigation under controlled conditions to test a hypothesis, collecting and interpreting data until a conclusion can be obtained.

<u>Manipulative Skills</u>

Manipulative skills are psychomotor skills that enable pupils to carry out practical works in science. It involves the development of hand-eye coordination. These manipulative skills are:

- Use and handle science apparatus and substances correctly.
- Handle specimens correctly and carefully.
- Draw specimens, apparatus and substances accurately
- Clean science apparatus correctly
- Store science apparatus and substances correctly and safely.

Relationship between Science Process Skills and Thinking Skills

Accomplishment in Science Process Skills require pupils to master the related thinking skills. Table 5 shows these relationships.

Table 5: Relationship between Science Process Skills and Thinking Skills

SCIENCE PROCESS SKILLS	DESCRIPTION
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 conclusion Making Generalisation Evaluating
Defining operationally	Relating Developing analogy Visualising Analysing

SCIENCE PROCESS SKILLS	DESCRIPTION
Controlling variables	Attributing Comparing and contrasting Relating Analysing
Hypothesising	Attributing Relating Comparing and contrasting Generating ideas Developing hypothesis Predicting Synthesising
Experimenting	All thinking skills
Communication	All thinking skills

Teaching and Learning based on Thinking Skills and Scientific Skills

KSSM Chemistry emphasizes thoughtful learning based on thinking skills and scientific skills. In this curriculum, the intended Learning Standard (LS) is written by integrating the aspired knowledge and skills for pupils to acquire and master. Teachers should emphasize on the acquisition and proficiency of pupils' knowledge and skills along with attitudes and scientific values in T&L.

The embedding of SPS in KSSM Chemistry has somewhat fulfills the aspirations of 21st century education and indirectly encourages and uplifts the development of pupils' high order thinking skills.

Science Process Skills Standard

The Science Process Skills Standard is a general recommended and specific accomplishment which must be met by pupils in each level of schooling. Each statement refers to the minimum standard of pupils' achievement based on schooling levels and cognitive development.

The science process skills at level 1 and 2 stated in the Learning Standard which must mastered as a basis for further study at the secondary level as shown in Table 6.

Table 6: Science Process Skills Standard

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
1	**Observing**	• Use sensory organs involved to make observation about phenomena or changes that occur.	• Use sensory organs to make observation qualitatively and quantitatively with appropriate tools to describe the phenomena or changes that occur.	• Make relevant and precise observation qualitatively and quantitatively to identify trends or sequences on objects or phenomena. • Use correct tools skillfully to make observations.	• Make observation qualitatively and quantitatively to make generalization based on trends or sequences. • Present advance findings analytically.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
2	**Classifying**	• Collect/segregate evidences/data/objects /phenomena based on observed characteristics.	• Compare/identify the similarities and differences based on given categories based on common characteristics.	• Compare/identify the similarities and differences to determine the criteria of category for evidence/ data/ objects/ studied phenomena	• Identify characteristics used to segregate, choose and explain in detail about objects or the studied phenomena.
3	**Measuring and Using Numbers**	• Measure using correct tools and standard units.	• Measure using correct techniques, tools with standard units.	• Measure using correct techniques and tools with standard units and record systematically and completely. • Convert basic quantity units correctly. • Use correct derived units.	• Show ways to measure using tools and standard units with correct techniques and record in tables systematically and completely. • Use complex derived units correctly.
4	**Inferring**	• State a reasonable explanation for an observation.	• Make reasonable pre-assumption for an observation using the	• Make more than one reasonable early conclusions for an	• Generate multiple possibilities to explain a complex situation.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
			information given.	incident or an observation using information given.	• Explain the relation and trends between manipulated and responding variables in an investigation.
5	**Predicting**	• Describe a possibility for an incident or data.	• Make a reasonable prediction about an incident based on observations, past experiences or data.	• Perform simple development or trend analysis based on obtained data to predict the future of an object or phenomena.	• Perform simple development or trend analysis based on obtained data to predict the future of an object or phenomena. • Test the prediction made.
6	**Communicating**	• Record ideas or information in any form.	• Record and present ideas and information systematically in suitable form.	• Present experimental findings and observation data in various form such as simple graphics, pictures or tables.	• Present experimental findings and observation data in various complex form using graphics, pictures or tables to show the relationship between the associated patterns.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
7	**Using Space Time Relationship**	(Not stated explicitly in the Learning Standard)	• Arrange a phenomenon or incident chronologically.	• Arrange a phenomenon or incident chronologically. • Interpret and explain the meaning of mathematical relations.	• Use, analyze and interpret numbers and numerical relationship efficiently when solving problems and conducting investigations.
8	**Interpreting Data**		• Choose relevant ideas about objects, incidents or patterns in data to come up with an explanation.	• Give rational explanations by interpolating and extrapolating the collected data.	• Analyze data and suggest ways to improve. • Detect and explain anomaly in collected sets of data.
9	**Defining Operationally**		• Describes an interpretation by stating what is being done and observed in a specific aspects of a situation.	• Describes the most appropriate interpretation of a concept by stating what is being done and observed in a situation.	• Describe the interpretation made about the selection of tools or methods of what is being observed.
10	**Controlling Variables**	(Not stated explicitly in the Learning Standard)	• Determine the responding and constant variables	• Determine all types of variable, which are responding variables,	• Change the fixed variable to the manipulated variable

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
			after the manipulated variable is determined in an investigation.	manipulated variables and fixed variables.	and state the new responding variable.
11	**Hypothesising**		• Make a general statement that can be tested about the relationship between the variables in an investigation.	• Make a relationship between the manipulated variable and the responding variable to build a hypothesis which can be tested.	• Explain an expected result from the designed scientific investigation.
12	**Experimenting**		• Carry out experiment, collect data, interpret data and make conclusions to test the hypothesis and write report.	• Carry out experiment, build hypothesis, design methods and determine appropriate apparatus, collect data, analyse, summarise and write report.	• Trigger new question and plan an experiment to test new hypothesis from the question.

Scientific Attitudes And Noble Values

Science learning experiences can inculcate scientific attitudes and noble values in pupils. These attitudes and values are instilled through the following:

1. Interest and curious about the environment.
   - Seek information from teachers, friends or other people.
   - Do own reading.
   - Collect materials or specimens for research purposes.
   - Carry out own research.

2. Honest and accurate in recording and validating data.
   - Describe and record real observations.
   - Record information objectively (not affected by feelings of illusions)
   - Explain information rationally.
   - Cite the sources of used information.

3. Flexible and open-minded.
   - Accept others' opinions.
   - Agree tp cogent evidence.
   - Be open-mided.

4. Diligent and persistent when carrying out a task.
   - Preservere and determined.
   - Ready to repeat experiments.
   - Do the task wholeheartedly.
   - Ready to accept critics and challanges.
   - Strive to overcome problems and challenges.

5. Systematic, confident and ethical.
   - Conduct activities orderly and timely.
   - Arrange tools and materials in order.
   - Optimistic about the task.
   - Brave and ready to venture something new.
   - Dare to defend something done.

6. Collaborate.
   - Help friends and teachers.
   - Carry out activities and experiments together.
   - Selflessness.
   - Fair and equitable.

7. Be responsible for the safety of oneself, others, and the environment.
    - Take care of oneself and friends' safety.
    - Preserve and conserve the environment.

8. Compasionate.
    - Love all living things.
    - Be prudent and respectful.

9. Appreciate the contributions of science and technology.
    - Use the creation of science and technology wisely.
    - Utilise public facilities created by science and technology responsibly.

10. Thankful to God.
    - Always be satisfied with the gift of God.
    - Use the gift of God wisely.
    - Be thankful to God.

11. Appreciate and practise clean and healthy living.
    - Maintain cleanliness and good health.
    - Always be conscious of personal hygiene and clean environment.

12. Realise that science as a means to understand nature.
    - Express how science is used to solve problems.
    - State the implications of using science to solve a problem or issue.
    - Communicate through correct scientific language.

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

- Aware and understand the importance and the need of scientific attitudes and noble values.
- Focus on these attitudes and noble values.
- Internalise and practise these scientific attitudes and noble values.

Sound lesson plan is required for effective inculcation of scientific attitudes and noble values during teaching and learning. Thus, before planning each lesson, teachers should examine the Learning Standard, including Performance Standard fto foster scientific attitudes and noble values in the lesson.

21st CENTURY SKILLS

One of the aspirations in KSSM is to develop pupils with 21st century skills, while focusing on thinking skills as well as life and career skills strongly rooted in noble values and practices. 21st century skills aim to prepare pupils with the characteristics specified in Table 7: Pupils' Profile. These features enable them to compete globally. Achieving CS and LS in KSSM Chemistry contributes to the acquisition of 21st century skills among pupils.

Table 7: Pupils' Profile

PUPILS' PROFILE	DESCRIPTION
Resilient	Able to face and overcome difficulties and challenges with wisdom, confidence, tolerance and empathy.
Communicator	Able to voice out and express their thoughts, ideas and information confidently and creatively in verbal and written, using multi-media and technology.
Thinker	Able to think critically, creatively and innovatively; solve complex problems and make ethical decisions. Think about learning and about being learners themselves. Generate questions and are receptive towards perspective, values and individual traditions and society. Confident and creative in handling new learning areas.
Team Player	Cooperate effectively and harmoniously with others. Share collective responsibility while respecting and appreciating the contributions of each member in the team. Acquire interpersonal skills through collaborative activities, which in turn mould pupils into better leaders and team members.
Curious	Develop natural curiosity to explore strategies and new ideas. Learn skills that are needed to carry out inquiry and research, as well as display

PUPILS' PROFILE	DESCRIPTION
	independent learning traits. Enjoy continuous life-long learning experiences.
Principled	Honest and have integrity, equity with just and respect for individuals, groups and community. Responsible for their actions, and as well as the consequences.
Informative	Knowledgeable, have wide, deep and balanced understanding across various disciplines. Explore and gain knowledge on local and global issues effectively and efficiently. Understand ethical issues/ laws related to the information gained.
Caring/ Concern	Show empathy, compassion and respect towards the needs and feelings of others. Committed to serve the society and ensure sustainability of the environments.
Patriotic	Portray love, support and respect towards the country.

HIGHER ORDER THINKING SKILLS

Higher Order Thinking Skills (HOTS) is explicitly stated in the curriculum to encourage teachers to incorporate them in teaching and learning, hence stimulating structured and focused thinking among pupils. Descriptions of the focused four levels of HOTS are shown in Table 8.

Table 8: Thinking Levels in HOTS

THINKING LEVEL	DESCRIPTIONS
Applying	Using knowledge, skills and values to take actions in different situations.
Analysing	Breaking down information into smaller parts to enhance understanding and make relationship between the parts.
Evaluating	Making considerations and decisions using knowledge, skills, values and experiences as well as justifications.
Creating	Generating ideas, products or methods and innovatively.

HOTS are the ability to apply knowledge, skills and values in reasoning and reflecting to solve problems, make decisions, to innovate and create something. HOTS include critical thinking, creative thinking, reasoning and thinking strategy.

Critical thinking skill is the ability to evaluate an idea in a logical and rational manner to make a reasonable judgement with justifications and reliable evidences.

Creative thinking skill is the ability to produce or create something new and valuable by using genuine imaginative skill and unconventional thinking.

Reasoning skill is the ability of an individual to consider and evaluate logically and rationally.

Thinking strategy is a way of thinking that is structured and focused to solve problems.

HOTS can be applied in classrooms through activities in the form of reasoning, inquiry learning, problem solving and projects. Teachers and pupils need to use thinking tools such as thinking maps and mind maps, including high level questioning to stimulate thinking processes among pupils.

TEACHING AND LEARNING STRATEGIES

Teaching and learning strategies in KSSM Chemistry emphasise on thoughtful learning. Thoughtful learning is a process that helps pupils acquire knowledge and master skills which assist them to develop their minds to optimum level. Thoughtful learning can take place through various learning approaches such as inquiry, constructivism, science, technology and society, contextual learning and mastery learning space. Learning activities should therefore be geared towards activating pupils' critical and creative thinking skills and not be confined to routine methods. Pupils should be made explicitly aware of the thinking skills and thinking strategies which are employed in their learning.

More higher order questions and problems posed to pupils encourages them to enhance their critical and creative thinking skills. Pupils actively involved in the teaching and learning where the acquisition of knowledge, mastery of skills and inculcation of scientific attitudes and noble values are integrated.

The learning approaches that can be applied by teachers in the classroom are as follows:

Inquiry Approach

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

Constructivism

Constructivism is a learning theory which suggests that learners construct their own knowledge and understanding of the world through experiences and reflecting on those experiences. The important elements of constructivisme are:

- Teachers have to consider pupils' prior knowledge.
- Learning is the result from pupils' own effort.
- Learning occurs when pupils restructure their ideas through relating original ideas to new ones.
- Pupils have the opportunities to cooperate, share ideas and experiences and reflect on their learning.

Contextual Learning

Contextual learning is a method of instruction that enables pupils to apply new knowledge and skills to real-life situations. In this context pupils do not just obtain knowledge theoretically, but allowing pupils to make connections and make relevance of science learning with their lives. A contextual approach is used when pupils learn through investigation similar to inquiry approach.

Mastery Learning

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

Problem/ Project Based Learning

Problem/ project based learning (PBL) is a student-centered pedagogy where pupils learn through prompting solving issues/ problems. The issues or problems are provided by teachers. Teachers can provide issues, problems or projects from various sources such as newspapers, magazines, journals, books, textbooks, and cartoons, videos, television, films and others to suit the teaching and learning.

Real world and relevant problem or project is used as a platform to encourage pupils to the intended the concepts and principles. PBL promotes the development of critical thinking skills, problem solving abilities, and communication skills.

PBL provides students the opportunity to work in a team, collaborate on inquiring and evaluating research materials, analysing data, justifying and making decision, and nurturing life-long learning among pupils.

For effective PBL, the provided issue of problem should;

- encourage pupils to understand the concept clearly an deeply.
- Require pupils to justify and support their decisions.
- meet the intended and previous related content/ learning standards.
- Be suitable to the capabilities of the pupils to ensure they can work together to complete the task.
- Be open and captivating enough to motivate and enhance pupils' interest.

STEM APPROACH

STEM approach is the teaching and learning (T&L) method which applies integrated knowledge, skills and values of STEM through inquiry, problem solving or project in the context of daily life, environmentand, as well as local and global community, as shown in Diagram 4.

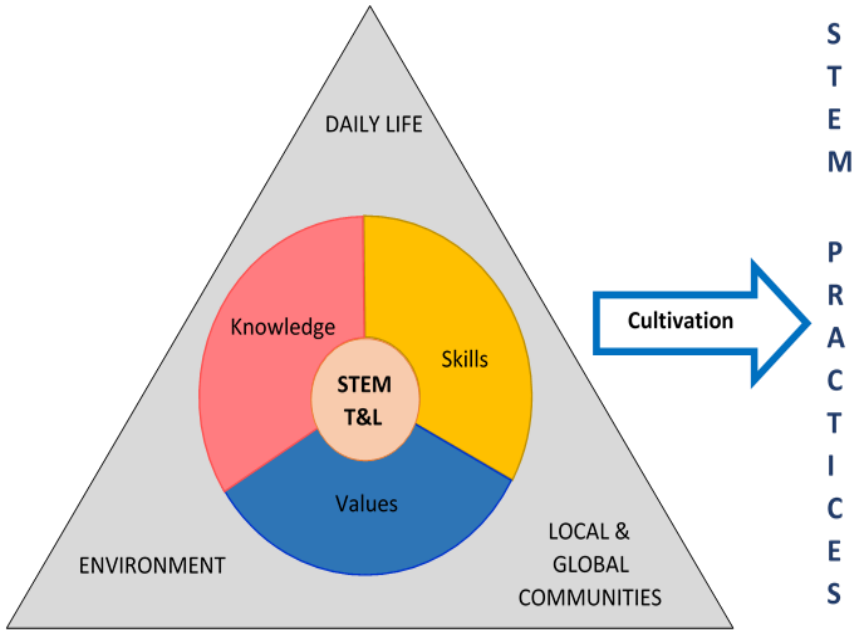


Diagram 4: STEM Teaching and Learning Approach

STEM T&L which is contextual and authentic can encourage in depth learning amongst pupils. Pupils can work in groups or individually based on the nature of the T&L activities. The STEM practices that are encouraged during STEM T&L are as follows:

1. Questioning and identifying problems,
2. Developing and using models,
3. Planning and carrying out investigations,
4. Analyzing and interpreting data,
5. Using mathematical thinking and computational thinking,
6. Developing explanations and designing solutions,
7. Engaging in debates and discussion based on evidence, and
8. Acquiring information, evaluating and communicating about the information.

Computational thinking is a cognitive process involved in formulating problems and solutions which can be represented in a form that can be effectively executed by humans and/ or computers. Computational thinking helps pupils to solve complex problems easily through organizing, analysing and presenting data or ideas in a logical and systematic way.

Varied T&L activties can elevate pupils' interest towards science. Interesting science lessons will motivate pupils to study which will then show favourable influence on their performance. The T&L activities should correspond to the intended curriculum content, pupils' ability and multiple intelligences, as well as resources and facilities available.

Some T&L activities encouraged in science are as follows:

Scientific Investigation/ Experiment

A scientific investigation/ experiment is commonly used in science lessons. The hypothesis is tested by pupils through an investigation to discover certain scientific concepts of principle. Carrying out scientific investigation/ experiment encourages pupils to cultivate thnking skills, science process skills and manipulative skills.

In general, the procedures to conduct a scientific investigation/ experiment are shown in Diagram 5.

With the introduction of KSSM Chemistry, pupils are given the opportunity to design scientific investigation/ experiments beside the usual teacher-guided scientific investigations/ experiments. Pupils are expected to plan and design the experiment, collect and analyse data, interpret and display results, and finally share and present their report and findings.

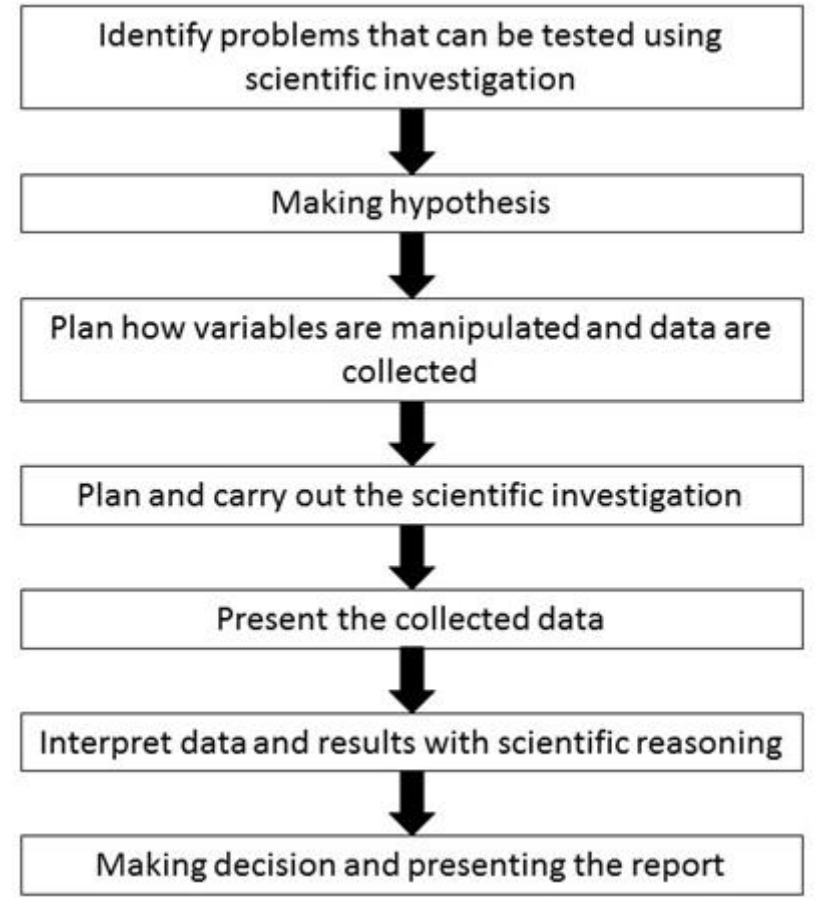


Diagram 5: Steps to carry out a scientific investigation/ experiment

Simulation

Simulation is an activity that imitates the real situation. Simulations can be carried out through role-play, games or using model. In role-playing, pupil act out a particular role spontaneously based on a certain pre-determined conditions. Whereas in gaming, pupils is required to follow procedures. Pupil plays games in order to learn a particular principle or to understand the process of decision making. While in modelling, an object/ replica is used to represent the real thing/ process. Pupils will be able to visualise the actual situation, thus understand the concepts and principles to be learned.

Project

Activities carried out by individuals or groups of students to achieve certain goals. Project takes a long time and usually reach out with the formal learning time. Pupils' reports, artifacts or other forms of project outcomes need to be presented to teachers and fellow pupils. Project work promotes problem solving skills, time management skills and self-study.

Visits and Use of External Resources

Science learning is not limited to schools only. Science learning can take place at the zoos, museums, science centers, research institutes, mangrove swamps and factories too. Visits to such places can make learning more effective, fun and meaningful. Learning through visits can be impacted by careful planning. To optimise learning, students must carry out activities or perform assignments during the visit and held discussion after the visit.

The Use of Technology

Technology is a highly effective and powerful tool to increase interest in science learning. Through the use of technologies such as television, radio, video, computers and the internet, science T&L can be more exciting and effective. Animation and computer simulation can be used as an effective tool to learn difficult and abstract science concepts. Computer simulations and animation can also be displayed in the form of coursewareor through website. Software applications such as word processors, graphic presentation software and electronic spreadsheets are valuable tools that can be employed to analyse and present data.

The use of other technologies such as data loggers and computerized user interface in experiments and projects can be of effective assistants in science teaching and learning.

Good management of activities and two-ways interactions between teacher-pupils and pupils-pupils during T&L further liberate their thinking skills to a higher level.

ELEMENTS ACROSS THE CURRICULUM

Elements Across Curriculum is a set of value-added elements applied in the teaching and learning process other than those specified in the standard content. The application of these elements is aimed at strengthening the human capital skills and competency besides preparing pupils for the challenges of the present and the future. The elements are explained below:

1. Language

- Using correct instruction language in all subjects.
- Emphasising promunication correct sentences structure, grammar and terminologies in T&L in order to assist pupils to communicate effectively and organise their thoughts clearly and systematically.

2. Environmental Sustainability Awareness

- Developing awareness, nurturing the love and care for the environment through teaching and learning.
- Promoting knowledge and awareness on the importance of the environmental ethics and sustainability for pupils to appriciate.

3. Noble Values

- Instilling noble values in all subjects to ensure that pupils are aware of their importance and gradually practice them.
- Practising noble values which encompass the aspects of spirituality, humanity and citizenship in relation to pupils' daily life.

4. Science and Technology

- Raising the pupils' interest in the science and technology to improve scientific and technological literacy.
- Using technology in teaching and learning can contribute and assist efficient and effective learning.
- Integration of science and technology in the teaching and learning enhances knowledge, skills and values in all subjects for examples:
  (i) knowledge of science and technology principles, concepts and facts related to science and technology;
  (ii) Process skills (process of thought and specific manipulative skills);
  (iii) Scientific attitudes and values
  (iv) Technological knowledge and skills.

5. Patriotism

- Nurturing patriotism in all subjects, extracurricular activities and community services,
- Developing the spirit of love for the country as well as encouraging the feelings of 'truly proud to be Malaysians' amongst pupils.

6. Creativity and Innovation

- Giving time and opportunity in all subjects for pupils to be creative and innovative through extracting and generating or creating new/ original ideas.

- Exploiting and fostering pupils' creativity and innovativeness to see and realise their full potential.
- Integrating elements of creativity and innovation in teaching and learning to ensure human capital meet the challenges of 21st Century.

7. Entrepreneurship

- Incorporating the characteristics and practices of enterpreneurship, gradually shaping a culture amongst pupils,
- Fostering entrepreneured characteristics through activities which promote diligence, honesty, trustworthiness and responsibility as well as developing creative and innovative mindset to drive ideas into the economy.

8. Information and Communication Technology (ICT)

- Incorperating information and communication technology (ICT) in the lessons to ensure pupils have the ability to apply and strengthen their basic knowledge and skills in ICT,
- Uitilizing ICT to motivate pupils to be creative, stimulates interesting and fun T&L and improve the quality of learning,
- Integrating ICT in teaching appropriate topics to further enhance pupils' understanding of the content subject.

9. Global Sustainability

- Discussing Global Sustainability directly or indirectly in related subjects, prompt and develop sustainable thinking (responsive towards the environment, being responsible, creative and resourceful) with the concept of living within global resources without damaging its present or future environment,
- Educating global sustainability prepares pupils to face challenges on complex interconnected global issues.

10. Financial Education

- Incorporating Financial Education to build future generations who are financial literate, capable of making wise financial decisions and practise ethical financial management and skills.
- Exploring financial management and skills directly or indirectly in T&L through topics related to finance e.g simple and compound interest, foreign exchange, budgeting credit-debit, saving and financial safety.
- Simulating financial management activities to prepare pupils with knowledge, skills and values which are relevant and useful to their living.

CLASSROOM ASSESSMENT

Classroom Assessment is the process of obtaining information on student development planned, implemented and reported by the teacher concerned. This process is ongoing to enable teachers to determine the Student Mastery Level.

Classroom Assesment can be implemented by teachers formatively and summatively. Assessment is formatively implemented at the same time with the T&L process, while summative assessments are implemented at the end of a learning unit, term, semester or year. Teachers should plan, construct valuation items or instruments, administer, examine, record and report levels of mastery based on DSKP.

In order to ensure that assessments help to improve the ability and mastery of the pupils, the teacher should implement the assessments that have the following characteristics:

- Use various assessment methods such as observation, oral and writing.
- Use various assessment strategies that can be implemented by teachers and pupils.
- Take into consideration the various levels of knowledge and skills learned.
- Allow pupils to show various learning capabilities.
- Assess the pupil's mastery level on Learning Standard and Performance Standards.
- Follow up actions for recovery and consolidation purposes.

Performance Standard of KSSM Chemistry

Classroom Assesment for KSSM Chemistry is evaluated from three main domains which are knowledge, skills and affective domains (for nobles values).

Knowledge and science process skills integrated in learning area are assessed based on the stated Performance Standards (PS). PS aims to gauge the achievement of students mastering the specific knowledge, skills and values. Assessment of scientific skills can be carried out continuously, periodically or in clusters throughout the year. Therefore, it is important for teachers to use professional judgment in determining the pupils' performance levels. There are 6 performance levels with their general descriptors shown in Table 9.

Table 9 : General Descriptors of Performance Level in Science subjects for KSSM Chemistry

PERFORMANCE LEVEL	DESCRIPTORS
1	Recall knowledge and basic skills of science.
2	Understand the knowledge and skills of science and explain the understanding.
3	Apply knowledge and science skills to carry out simple tasks.
4	Analyze information about knowledge and science skills in the context of problem solving.
5	Evaluate to make judgement about the science knowledge and skills in context problem solving and decision-making to carrying out a task.
6	Invent by applying the knowledge and skills in context problem solving and decision-making or carrying out an assignment in a new situation creatively and innovatively, giving due consideration to the social values/ economy/ culture of the community.

Teachers can refer to **Appendix** to view the relationship between the key verbs of each Performance Level in Performance Standards and verbs in the Learning Standard with examples of student activity that can be implemented.

All the investigations/ experiments/ activities listed in each theme in Table 10 are **COMPULSORY**. Investigations / experiments / activities are conducted using inquiry approach.

Table 10: List of Investigations/ Experiments/ Activities in each Theme

THEME	EXPERIMENTS	
IMPORTANCE OF CHEMISTRY	1.2.2	Investigate the effect of temperature on the solubility of salt in water using a suitable scientific method.
FUNDAMENTALS OF CHEMISTRY	2.1.3	Determine the melting and freezing points of napthalene through activity.
	3.3.2	Determine the empirical formula of magnesium oxide (MgO) through an activity.
	3.3.3	Determine the empirical formula of copper(II) oxide (CuO) through an activity.

THEME	EXPERIMENTS
	4.4.2 Investigate through experiment the chemical properties of Group 1 elements with: (i) water (ii) oxygen gas (iii) chlorine
	4.6.2 Conduct an experiment to observe changes in the properties of the oxides of elements across Period 3.
	5.7.1 Compare the properties of ionic and covalent compounds through experiment.
INTERACTIONS OF MATTER	6.1.3 Investigate the role of water in showing acidic and alkaline properties through experiment
	6.2.3 Investigate the relationship between pH value and the concentration of hydrogen and hydroxide ions through experiment

THEME	EXPERIMENTS
	6.4.1 Formulate the chemical properties of acids by carrying out the following reactions: (i) Acids and bases (ii) Acids and reactive metals (iii) Acid and metal carbonates
	6.4.2 Formulate the chemical properties of alkalis by carrying out the following reactions: (i) Alkalis and acids (ii) Alkalis and metal ions (iii) Alkali and ammonium salts
	6.6.2 Describe and carry out the preparation of a standard solution: (i) from a solid substance (ii) through dilution of an aqueous solution.
	6.7.2 Determine the concentration of an unknown solution using titration method.
	6.9.1 Test the solubility of salt in water and classify them into soluble and insoluble salts through experiment.

THEME	EXPERIMENTS
	6.9.2 Describe the preparation of a soluble salt through activity.
	6.9.3 Describe the preparation of an insoluble salt through activity.
	6.9.4 Construct an ionic equation using the continuous variation method through experiment.
	6.10.2 Investigate the effect of heat on salts through experiment.
	6.11.1 Identify the anion and cation present in a salt through experiment.
	7.1.3 Identify changes which can be observed and measured during chemical reactions through activity; (i) zinc and acids (ii) potassium iodide and lead(II) nitrate solutions

THEME	EXPERIMENTS
	7.2.1 Investigate factors affecting the rate of reactions through experiment, based on: (i) size of reactants, (ii) concentration, (iii) temperature, and (iv) use of catalyst.
INDUSTRIAL CHEMISTRY	8.1.2 Compare the properties of an alloy with its pure metal through experiment
CHEMICAL PROCESS	9.1.1 Carry out activities to study the transfer of electrons at a distance.
	9.1.2 Carry out activities to study the conversion of Fe^{2+} ion to Fe^{3+} ion and vice versa.
	9.1.3 Carry out activities to study the following redox reactions: (i) displacement of metal from its salt solution. (ii) displacement of halogen from its halide solution.

THEME	EXPERIMENTS
	9.3.1 Carry out an investigation activity by constructing a simple voltaic cell and Daniell cell to: i) identify the anode and cathode for different pairs of electrodes ii) determine the voltage.
	9.4.2 Carry out an activity to study electrolysis in molten lead(II) bromide.
	9.4.3 Carry out an experiment to study electrolysis of the following: (i) dilute sulphuric acid (H_2SO_4) and copper(II) sulphate solution ($CuSO_4$) using carbon electrode. (ii) concentrated and dilute hydrochloric acid using carbon electrode. (iii) copper(II) sulphate solution ($CuSO_4$) using copper electrode and carbon electrode

THEME	EXPERIMENTS
	9.4.5 Purify copper and electroplate a metal object with copper through electrolysis.
	9.6.1 Experiment to study how reaction of metal corrosion can occur on copper and iron.
	9.6.2 Carry out an experiment to study the effects of other metals in contact with iron towards rusting of iron.
ORGANIC CHEMISTRY	i) Carry out a laboratory activity to compare alkane (saturated hydrocarbon) and alkene (unsaturated hydrocarbon) based on: • combustion (sootiness) • chemical reaction with bromine water and acidified potassium manganate(VII) solution

THEME	EXPERIMENTS
	ii) Carry out an activity to prepare ethanol through fermentation process. iii) Carry out a laboratory activity to study dehydration and oxidation of ethanol. iv) Carry out an activity to study the chemical properties of carboxylic acid.
	10.3.2 Carry out a laboratory activity to prepare various esters.
HEAT	11.1.1 Study types of reaction based on heat change and the changes in the thermometer reading through the activity of dissolving the following substances in water: (i) sodium hydroxide (NaOH), (ii) anhydrous calcium chloride ($CaCl_2$), (iii) ammonium nitrate (NH_4NO_3), (iv) sodium thiosulphate ($Na_2S_2O_3$).

THEME	EXPERIMENTS
	11.2.1 Determine heat of precipitation through activity.
	11.2.2 i) Determine heat of displacement through activity. ii) Comparing heat of displacement of metal from its salt solution by metals of different electropositivity.
	11.2.3 Carry out an experiment to compare heat of neutralisation for reactions between: (i) hydrochloric acid (HCl) and sodium hydroxide solution (NaOH), (ii) ethanoic acid (CH_3COOH) and sodium hydroxide solution (NaOH), (iii) hydrochloric acid (HCl) and aqueous ammonia (NH_3), (iv) ethanoic acid (CH_3COOH) and aqueous ammonia (NH_3).

THEME	EXPERIMENTS
	11.2.4 Carry out an experiment to compare heat of combustion for methanol (CH_3OH), ethanol (C_2H_5OH), propanol (C_3H_7OH) and butanol (C_4H_9OH).
TECHNOLOGY IN CHEMISTRY FIELD	12.1.2 Carry out an activity to produce nylon and study the properties of nylon through the reaction between 1,6-hexanediamine and decanedioyl dichloride.
	12.2.2 i) Conduct an experiment to investigate latex coagulation and methods in preventing coagulation. ii) Carry out an activity to produce latex products.
	12.2.3 Carry out an activity to produce vulcanised rubber.
	12.2.4 Study the elasticity of vulcanised rubber and unvulcanised rubber through experiments.
	13.2.2 Study the elasticity of vulcanised rubber and unvulcanised rubber through experiments.
	13.2.3 Design an experiment to study the effectiveness of cleansing actions of soap and detergent.

Reporting on scientific skills assessments is done twice a year. Table 11 can be used as guidance on making professional judgment for the reporting.

Table 11: General Descriptions of Performance Level in Scientific Skills for KSSM Chemistry

PERFORMANCE LEVEL	DESCRIPTORS
1	• Poorly planned scientific investigation. • Inappropriate materials and apparatus used in the scientific investigation. • No data collected and recorded. • No or unclear explanation of the scientific investigation.
2	• Plan the correct strategy and procedure in the scientific investigation with guidance. • Use suitable material and apparatus. • Collect and record incomplete or irrelevant data. • Make an interpretation and conclusion not based on the collected data.

PERFORMANCE LEVEL	DESCRIPTORS
3	• Plan and carry out the correct strategy and procedure in the scientific investigation with guidance. • Use correct material and apparatus. • Collect and record relevant data. • Organize data in numerical or visual form with some error. • Make an interpretation and conclusion based on the collected data. • Write an incomplete scientific investigation report.
4	• Plan and carry out the correct strategy and procedure in the scientific investigation. • Handle and use the correct material and apparatus to get an accurate result. • Collect relevant data and record in a suitable format. • Organize the data in the numerical or visual form with no error.

PERFORMANCE LEVEL	DESCRIPTORS
	• Interpret the data and make an accurate conclusion based on the aim of the scientific investigation. • Write a complete report on the scientific investigation
5	• Carry out a scientific investigation and writing a complete report. • Collect, organize and present data in numerical or visual form well. • Interpret data and make conclusions accurately with scientific reasoning. • Identify the trend, pattern and relevant data.
6	• Justify the outcome of the scientific investigation relating to theory, principle and law of science in the reporting. • Evaluate and suggest ways to improve to the scientific investigation methods and further inquiry investigation if needed. • Discuss the validity of the data and suggest ways to improve the method of data collection.

Assessment of scientific attitudes and values can be implemented throughout the year. Table 12 can be used as guide for teachers in making a professional judgment.

Table 12: General Interpretation of the Performance Level in Scientific Attitudes and Values of KSSM Chemistry

PERFORMANCE LEVEL	DESCRIPTORS
1	Pupil is **not able** to: • state how science is used to solve problems. • state the implication of using science to solve problems or certain issues. • use scientific language to communicate • document the source of information used.
2	Pupil **is less able** to: • state how science is used to solve problems. • state the implication of using science to solve problems or certain issues. • use scientific language to communicate • document the source of information used.
3	Pupil **is able** to: • state how science is used to solve problems. • state the implication of using science to solve problems or certain issues. • use limited scientific language to communicate. • document a few sources of information used.
4	Pupil **is able** to: • determine how science is used to solve problems or certain issues. • determine the implication of using science to solve problems or certain issues. • always use sufficient scientific language to communicate. • document parts of the sources of information used.
5	Pupil **is able** to: • Summarise how science is used to solve specific problems or issues.

PERFORMANCE LEVEL	DESCRIPTORS
	• Summarise the implications of a particular problem or issue. • Always use scientific language to communicate well. • Document almost all sources of information used.
6	Pupil **is able** to: • Summarise how science is used to solve problems or certain issues. • Discuss and analyse the implication of using science to solve problems or certain issues. • Consistently use the correct scientific language to communicate clearly and accurately. • Document all the sources of information. • Become a role model to other pupils.

Overall Performance Level

Overall Performance Level of KSSM Chemistry is to be determined at the end of each year. This Overall Performance Level includes aspects of knowledge, skills and values. Teachers need to assess pupils collectively and holistically by looking at all aspects of the learning process. Teachers' professional judgment should be employed in all assessment processes, particularly in determining the overall performance level. Professional judgments can be made based on knowledge and experience of teachers, teacher-pupil interactions, and discussions with committee members of relevant departments. Table 13 shows the overall performance level descriptors of KSSM Chemistry.

Table 13: Descriptors of the overall performance level of KSSM Chemistry

PERFORMANCE LEVEL	DESCRIPTORS
1 (Know)	Pupils know basic knowledge, skills or values in Chemistry.
2 (Know and understand)	Pupils know and understand basic knowledge, skills and values in Chemistry.
3 (Know, understand and do)	Pupils know, understand and apply basic knowledge, skills and values in Chemistry.
4 (Know, understand and carry out in a civilised manner)	Pupils know, understand and apply knowledge, skills and values in a competent mannerly procedure in Chemistry.
5 (Know, understand and do with commendable praise)	Pupils know, understand and apply knowledge, skills and values in new situations with excellent commendable procedure in Chemistry.
6 (Know, understand and carry out in an exemplary manner)	Pupils know, understand and apply knowledge, skills and values in new situations with exceptional exemplary procedure in Chemistry.

CONTENT ORGANISATION

KSSM Form 4 Chemistry consists of four themes namely The Importance of Chemistry, Fundamentals of Chemistry, Interaction Between Matter and Industrial Chemistry whereas in Form 5 another four themes are implemented namely Chemical Processes, Organic Chemistry, Heat and Technology in Chemistry. Each theme is divided into several learning areas as shown in Table 14.

Table 14: Themes and Learning Areas in Chemistry

FORM	THEME	LEARNING AREA	
4	The Importance of Chemistry	1.0	Introduction to Chemistry
	Fundamentals of Chemistry	2.0	Matter and Structure of Atom
		3.0	Mole, Chemical Formula and Equation
		4.0	The Periodic Table of Elements
		5.0	Chemical Bonds
	Interaction between Matter	6.0	Acids, Bases and Salts
		7.0	Rate of Reaction
	Industrial Chemistry	8.0	Manufactured Substances in Industries
5	Chemical Processes	9.0	Redox Equilibrium
	Organic Chemistry	10.0	Carbon Compound
	Heat	11.0	Thermochemistry
	Technology in Chemistry	12.0	Polymer
		13.0	Consumer and Industrial Chemistry

The recommended minimum teaching hours for KSSM Chemistry is 96 hours per year as stipulated in *Surat Pekeliling Ikhtisas Kementerian Pendidikan Malaysia Bilangan 9 Tahun 2016.*

The Learning Area in each theme describes the span of development, knowledge, skills and values through its Content Standard and Learning Standard. The Content Standard has one or more Learning Standards which collectively form a concept or idea based on the Learning Area.

T&L needs to be holistic and integrated in order to deliver the scientific concept or principle from a few Learning Standards to suit pupils' ability. Teachers need to examine Content Standards, Learning Standards and Standard Performance during the

intended T&L activities. Teachers need to prepare activities which would actively prompt pupils to exercise their analytical, critical, innovative and creative thinking.

The application of technology in activity, investigation or experimental-based T&L will promote and strengthen pupils' understanding.

KSSM Chemistry focuses on the mastery of knowledge, skills and values that are appropriate to the pupils' development. Each Learning Area contains Content Standard, Learning Standard and Standard Performance as described in Table 15.

The Remarks column gives additional information to the Content Standard and Learning Standard. It also includes suggestions on activities to be performed and/ or notes related to Learning Standard and sometimes limitations to the Learning Standard.

Table 15: Interpretation of Content Standard, Learning Standard and Performance Standard

CONTENT STANDARD	LEARNING STANDARD	PERFORMANCE STANDARD
Specific statements about what pupils should know and can do during the schooling period encompassing the knowledge, skills and values.	A predetermined criteria or indicator of the quality in learning and achievement that can be measured for each content standard.	A set of general criteria which reflects the levels of pupils' achievement that they should show as a sign that a certain topic has been mastered by pupils.

In providing learning environments and activities which are suitable and relevant to the pupils' abilities and interests, teachers need to use their creativity and wisdom. The list of proposed activities is not absolute. Teachers are advised to use various resources such as books and the internet in providing T&L activities suitable to their pupils' ability and interest.

Content Standard,
Learning Standard
and Performance Standard
Form Four

THEME

THE IMPORTANCE OF CHEMISTRY

LEARNING AREA

1.0 INTRODUCTION TO CHEMISTRY

Theme 1: **THE IMPORTANCE OF CHEMISTRY**

This theme introduces pupils to the meaning of chemistry, its importance, careers in the field of chemistry dan chemicals in daily life. In addition the application of scientific skills and problem-solving method in chemistry are also establised and strengthen.

Learning Area: **1.0 Introduction to Chemistry**

1.1 Development in chemistry field and its importance in daily life

1.2 Scientific investigation in chemistry

1.3 Usage, management and handling of apparatus and materials

1.0 INTRODUCTION TO CHEMISTRY

CONTENT STANDARD	LEARNING STANDARD	REMARKS
1.1 Development in chemistry field and its importance in daily life	1.1.1 State the meaning of chemistry. 1.1.2 State examples of chemicals commonly used in daily life. 1.1.3 Generate ideas on the development of chemistry field and the contributions of chemical technology towards mankind. 1.1.4 State examples of careers related to chemistry field.	**Note:** Various types of commonly used chemicals in food, medicine, agriculture and industry. Example of careers and the uses of chemical technology in fields like cosmetology, pharmacology, biotechnology, nanotechnology and green technology. **Suggested activity:** Narrate the meaning of chemistry based on pupils' understanding. Gather and interpret data on the origin of the word chemistry and its meaning. Gather information and design poster/ multimedia presentation/ conduct exhibitions on the contributions of chemists, development of chemical technology and careers in the field of chemistry as well as chemicals in daily life. Carry out role playing activities about careers in the latest field of chemistry.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
1.2 Scientific investigation in chemistry	Pupils are able to: 1.2.1 Design an experiment to test a hypothesis. 1.2.2 Investigate through experiment the effect of temperature on the solubility of salt in water using a scientific method.	**Note**: Pupils have prior knowledge on steps in scientific investigations in Form 1. Analysing findings and presenting data in a suitable form need to be emphasised. Suitable science process skills must be strenghtened.
1.3 Usage, management and handling of apparatus and materials	Pupils are able to: 1.3.1 Explain the types and functions of self protective equipment and safety in the laboratory. 1.3.2 Demonstrate methods of managing and handling apparatus and materials. 1.3.3 Communicate about emergency management procedure in laboratory.	**Note:** Pupils have prior knowledge on the rules and safety measures in the laboratory in Form 1. Types of self protective equipment and laboratory safety such as gloves, laboratory coat and shoes, eyewasher, face mask, safety goggles, handwasher, fume chamber, safety shower, fire extinguisher and others. Accidents involving chemical spillage and mercury poisoning should be emphasised. Meaning of mercury poisoning, its symptoms and treatment.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Carry out an activity on how to use and handle apparatus and materials correctly. For example, when carrying out distillation, titration, filtration, collection of gases, testing of gases, electrolysis, heating of solids and weighing of solids. Discussion on methods of storage and disposal of waste products (chemicals, glass, rubber), chemical with pH < 5 and pH > 9, organic solvents, hydrocarbons (grease, oil, oil paint), hydrogen peroxide, toxic materials, heavy metals, volatile and reactive substances.

PERFORMANCE STANDARD

INTRODUCTION TO CHEMISTRY

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills in chemistry, scientific investigation, usage, management and handling of apparatus and materials.
2	**Understand** and explain the importance of chemistry, scientific investigation, usage, management and handling of apparatus and materials.
3	**Apply** knowledge on chemistry, scientific investigations, usage, management and handling of apparatus and materials to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on chemistry, scientific investigation, usage, management and handling of apparatus and materials in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on chemistry, scientific investigation, usage, management and handling of apparatus and materials in the context of problem solving and decision-making in carrying out a task.
6	**Invent** by applying the knowledge on chemistry, scientific investigation, management and handling of apparatus and materials in the context of **problem solving and decision-making** or while carrying out an activity/ task in new situations creatively and innovatively; giving due considerations to the social/ economic/ cultural values of the community.

THEME

FUNDAMENTALS OF CHEMISTRY

LEARNING AREA

2.0 MATTER AND ATOMIC STRUCTURE

3.0 THE MOLE CONCEPT, CHEMICAL FORMULA AND EQUATION

4.0 THE PERIODIC TABLE OF ELEMENTS

5.0 CHEMICAL BOND

Theme 2: **FUNDAMENTALS OF CHEMISTRY**

This theme aims to introduce chemistry from the microscopic aspect which includes particles, the mole concept, formula and chemical equations. This knowledge is important in the quantitative and qualitative analysis of a reaction. The Periodic Table of Elements and chemical bonds are also emphasised to understand the fundamentals of chemistry.

Learning area:

2.0 Matter and the Atomic Structure

- 2.1 Basic concepts of matter
- 2.2 The development of the atomic model
- 2.3 Atomic structure
- 2.4 Isotopes and its uses

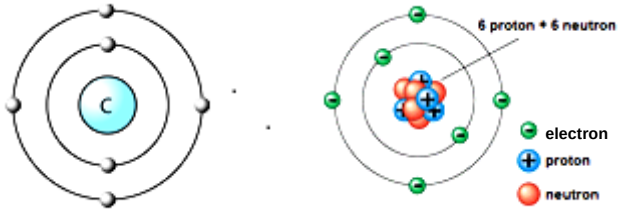
3.0 The Mole Concept, Chemical Formula and Equation

- 3.1 Relative atomic mass and relative molecular mass
- 3.2 Mole concept
- 3.3 Chemical formula
- 3.4 Chemical equation

2.0 MATTER AND ATOMIC STRUCTURE

CONTENT STANDARD	LEARNING STANDARD	REMARKS
2.1 Basic concepts of matter	Pupils are able to: 2.1.1 Describe matter briefly. 2.1.2 Explain the changes in the states of matter. 2.1.3 Determine the melting point and freezing point of naphthalene through activity.	**Note:** Pupils have prior knowledge on Particle Theory of Matter and Kinetic Theory of Matter in Form 1. Explain matter and the changes that take place in kinetic energy, arrangement of particles and forces of attraction between particles when there is a change in state of matter. State the type of particles found in matter. **Suggested activity**: Carry out an activity to determine the melting point and freezing point of naphthalene. Pupils should be able to: (i) Plot heating and cooling curves (ii) Determine the melting point and freezing point (iii) Interpret the heating and cooling curves

CONTENT STANDARD	LEARNING STANDARD	REMARKS
2.2 The development of the atomic model	Pupils are able to: 2.2.1 State the subatomic particles in atoms of various elements. 2.2.2 Compare and contrast the relative mass and relative charge of proton, electron and neutron. 2.2.3 Sequence the atomic structure models based on Atomic Models of Dalton, Thomson, Rutherford, Bohr and Chadwick.	**Note:** Pupils have prior knowledge about atom, atomic structure, molecule and subatomic particles such as proton, electron and neutron in Form 1. **Suggested activity:** View a video on subatomic particles. Gather information and conduct simulation/ story telling/ acting/ present or understand the article on the development models of atomic structure.
2.3 Atomic structure	Pupils are able to: 2.3.1 Define proton number and nucleon number. 2.3.2 Determine the nucleon number, proton number and number of electrons in an atom. 2.3.3 Write the standard representation of an atom.	**Note:** Writing of standard representation of an atom in the form ${}^{A}_{Z}X$. Comparison of the number of protons, neutrons and electrons in an atom and its ion. **Suggested Activity:** Carry out a group activity to determine the number of neutrons, protons and electrons from its proton number and nucleon number and vice versa.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	2.3.4 Construct an atomic structure diagram and electron arrangement.	Example of the atomic structure diagram and electron arrangement of carbon.  Electron arrangement Atomic structure **Suggested activity:** Use a model or simulation to illustrate the atomic structure showing the protons and neutrons in the nucleus and the electrons in the shell. Carry out an activity to write the electron arrangement and draw the atomic structure for the first 20 elements in The Periodic Table of Elements to show the position of subatomic particles.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
2.4 Isotopes and its usage	Pupils are able to: 2.4.1 Deduce the meaning of isotopes. 2.4. 2 Calculate the relative atomic mass of isotopes. 2.4.3 Justify the uses of isotopes in various fields.	**Note:** The natural abundance of isotope is the percentage of isotopes in a sample of an element that exists naturally. Example : Chlorine gas has two isotopes, ^{35}Cl and ^{37}Cl have a natural abundance of 75% and 25% respectively. ^{35}Cl can be represented as $^{35}_{17}\mathbf{Cl}$ or **Cl-35**. The formula to calculate relative atomic mass from the natural abundance of an element containing isotopes: $\frac{\Sigma(\%\ \text{isotope}\ \times\ \text{mass of isotope})}{100}$ Usage of isotopes in medicine, agriculture, nuclear, archeology, industry and engineering. **Suggested activity:** Carry out a forum or debate on issues regarding isotopes. Gathering information on examples of isotopes and its uses, via interactive media.

PERFORMANCE STANDARD

MATTER AND THE ATOMIC STRUCTURE

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills on matter and the atomic structure.
2	**Understand** and explain matter and the atomic structure.
3	**Apply** knowledge on matter and the atomic structure to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on matter and atomic structure in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on matter and atomic structure in the context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying the knowledge on matter and atomic structure in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations creatively and innovatively; giving due considerations to the social/ economic/ cultural values of the community.

3.0 THE MOLE CONCEPT, CHEMICAL FORMULA AND EQUATION

CONTENT STANDARD	LEARNING STANDARD	REMARKS
3.1 Relative atomic mass and relative molecular mass	Pupils are able to: 3.1.1 Conceptualise relative atomic mass and relative molecular mass based on the carbon-12 scale. 3.1.2 Calculate relative molecular mass and relative formula mass.	**Note :** The relative formula mass is introduced as the relative mass of an ionic compound**.** **Suggested activity:** Discuss why carbon-12 is used as a standard to determine the relative atomic mass and the relative molecular mass. View a video or carry out an activity on relative mass. Carry out an activity to calculate the relative mass through games.
3.2 Mole concept	Pupils are able to: 3.2.1 Define mole. 3.2.2 Interrelate the Avogadro constant, N_A, the number of particles and the number of moles.	**Note:** The mole, symbol mol, is the SI unit of amount of substance. One mole contains exactly 6.02214076 x 10^{23} elementary entities. This number is the fixed numerical value of the Avogadro constant, N_A, when expressed in mol^{-1}, and is called the Avogadro number.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	3.2.3 State the meaning of molar mass. 3.2.4 Interrelate the molar mass, mass and the number of moles. 3.2.5 State the meaning of molar volume. 3.2.6 Interrelate the molar volume, volume of gas and the number of moles. 3.2.7 Solve numerical problems involving the number of particles, number of moles, mass of the substance and volume of gases.	**Note:** STP is the abbreviation for standard temperature and pressure. **Suggested activity:** Construct a chart to show the relationship between the number of particles, the number of moles, mass of the substance and the volume of gas at STP and room conditions. Carry out activities to solve numerical problems involving number of particles, number of moles, the mass of the substance and the volume of gas at STP or room conditions.
3.3 Chemical formula	Pupils are able to: 3.3.1 State the meaning of chemical formula, empirical formula and molecular formula. 3.3.2 Determine the empirical formula of magnesium oxide (MgO) through an activity. 3.3.3 Determine the empirical formula of copper(II) oxide (CuO) through an activity.	**Note:** Writing the physical states of matter of substances in a chemical equation is encouraged. Constructing chemical formulae of compounds and naming them according to IUPAC nomenclature. IUPAC- International Union of Pure and Applied Chemistry. Differences between empirical formula and molecular formula should be emphasised.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	3.3.4 Solve numerical problems involving empirical formula and molecular formula. 3.3.5 Construct chemical formulae of compounds.	**Suggested activity:** Collect and interpret data regarding chemical formulae, empirical formulae and molecular formulae. Use computer simulation or video to show how to determine the empirical formula of copper(II) oxide using combustion tube.
3.4 Chemical equation	Pupils are able to: 3.4.1 Write balanced chemical equations. 3.4.2 Interpret chemical equations qualitatively and quantitatively. 3.4.3 Solve stoichiometry numerical problems.	**Suggested activity:** Carry out group activities to construct balanced chemical equations for the following reactions: (i) Decomposition of copper(II) carbonate ($CuCO_3$). (ii) Formation of ammonium chloride (NH_4Cl). (iii) Precipitation of lead(II) iodide (PbI_2). Interpret the chemical equations above qualitatively and quantitatively.

PERFORMANCE STANDARD

THE MOLE CONCEPT, FORMULA AND CHEMICAL EQUATION

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills on mole concept, chemical formulae and equations.
2	**Understand** and explain the mole concept, chemical formulae and equations.
3	**Apply** knowledge on mole concept, chemical formulae and equations to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on mole, chemical formulae and equations in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on mole concept, chemical formulae and equations in the context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying the knowledge on mole concept, chemical formulae and equations in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations creatively and innovatively; giving due considerations to the social/ economic/ cultural values of the community.

4.0 THE PERIODIC TABLE OF ELEMENTS

CONTENT STANDARD	LEARNING STANDARD	REMARKS
4.1 Development of Periodic Table of Elements	Pupils are able to: 4.1.1 Describe the historical development of the Periodic Table of Elements. 4.1.2 Deduce the basic principle of arrangement of elements in the Periodic Table of Elements.	**Note:** Scientists involved in the historical development of the Periodic Table of Elements are Lavoisier, Dobereiner, Newlands, Meyer, Mendeleev and Moseley. The latest developments on the Periodic Table of Elements are explored. **Suggested activity:** Design a chart/ multimedia presentation on the historical development of the Periodic Table of Elements based on the increase in proton number. Discuss the importance of the classification of elements based on prepared stimuli. Examples of stimuli are charts, tables, diagrams, comics and articles.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
4.2 The arrangement of elements in the modern Periodic Table of Elements	Pupils are able to: 4.2.1 Describe briefly the modern Periodic Table of Elements. 4.2.2 Generalise the relationship between the proton number and the position of elements in the Periodic Table of Elements.	**Note:** Pupils have prior knowledge on the position of metals, non-metals and noble gases in The Periodic Table of Elements in Form 1. The arrangement of elements in the Periodic Table of Elements is viewed from the following aspects: (i) Group and Period (ii) proton number (iii) electron arrangement. The number of valence electrons from the proton number of an element is used to determine the position of the element in the Periodic Table of Elements. **Suggested activity:** Carry out an activity to predict the Group and the Period of an element based on its electron arrangement.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
4.3 Elements in Group 18	Pupils are able to: 4.3.1 Relate the inert nature of Group 18 elements to its stability. 4.3.2 Generalise the changes in physical properties of elements when going down Group 18. 4.3.3 Describe briefly the uses of Group 18 elements in daily life.	**Suggested activity:** Carry out an activity to relate the inert nature of Group 18 elements to their stability based on duplet and octet electron arrangement. View a video to summarise the uses of Group 18 in daily life. Build a model to compare the physical properties and their changes when going down Group 18.
4.4 Elements in Group 1	Pupils are able to: 4.4.1 Generalise the changes in physical properties of elements when going down Group 1. 4.4.2 Investigate through experiment the chemical properties of Group 1 elements with: (i) water (ii) oxygen gas (iii) chlorine 4.4.3 Generalise the changes in the reactivity of elements when going down Group 1. 4.4.4 Reason out the physical and chemical properties of the other elements in Group 1.	**Note:** Group 1 elements used in experiments are lithium, sodium and potassium only. Attention: It is suggested that experiment 4.4.2 (i) is to be demonstrated by the teacher because the reaction between Group 1 elements and water is highly reactive. The changes in reactivity of elements going down Group 1 can be summarised from observations in experiments 4.4.2 (i), (ii) and (iii).

CONTENT STANDARD	LEARNING STANDARD	REMARKS
4.5 Elements in Group 17	Pupils are able to: 4.5.1 Generalise the changes in the physical properties of elements when going down Group 17. 4.5.2 Summarise the chemical properties of Group 17 elements. 4.5.3 Generalise the changes in the reactivity of elements when going down Group 17. 4.5.4 Reason out the physical and chemical properties of other elements in Group 17.	**Suggested activity:** View a video showing the reaction of chlorine, bromine and iodine with: (i) water (ii) metals like iron (iii) alkalis like sodium hydroxide View a video showing safety measures when handling elements of Group 17.
4.6 Elements in Period 3	Pupils are able to: 4.6.1 Describe the trends in physical properties of elements across Period 3. 4.6.2 Conduct an experiment to observe changes in the properties of the oxides of elements across Period 3. 4.6.3 Describe briefly the uses of semi-metals.	**Note:** The trend in physical properties of elements in Period 3 from the following aspects: (i) atomic size (ii) electronegativity (iii) physical state Semi-metals are also known as metalloid. **Suggested activity:** Discuss in groups to predict the changes in properties of elements in Period 2. Gather information and discuss the usage of semi-metals like silicon and germanium in microelectronic industry.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
4.7 Transition elements	Pupils are able to: 4.7.1 Determine the position of transition elements in the Periodic Table of Elements. 4.7.2 Explain the special characteristics of a few transition elements with examples. 4.7.3 List the uses of transition elements in industry.	**Note:** Special characteristics of transition elements are: act as catalyst, have more than one oxidation number, have the ability to form coloured compounds and complex ions. Oxidation number is the same as oxidation state. Chemical equations are not required. **Suggested activity:** Carry out a PBL activity related to the special characteristics of transition elements in the form of problem solving. Prepare a scrap book/ brochure/ foldable/ poster to state the uses of some transition elements in various industries.

PERFORMANCE STANDARD

THE PERIODIC TABLE OF ELEMENTS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills about the Periodic Table of Elements.
2	**Understand** and explain the Periodic Table of Elements.
3	**Apply** knowledge about Periodic Table of Elements and its concept to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge about Periodic Table of Elements in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge about Periodic Table of Elements in the context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying the knowledge about Periodic Table of Elements in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations in a creatively and innovatively; giving due considerations to the social/ economic/ cultural values of the community.

5.0 CHEMICAL BOND

CONTENT STANDARD	LEARNING STANDARD	REMARKS
5.1 Basics of compound formation	Pupils are able to: 5.1.1 Explain the basics of compound formation.	**Note:** The following need to be emphasised: (i) the relationship between the duplet or octet electron arrangement and the stability of Group 18 elements. (ii) prerequisite for the formation of chemical bonds. (iii) examples of chemical bonds like ionic and covalent bonds. The basis of formation of chemical bonds in compounds is through the transfer and sharing of electrons. **Suggested activity:** Carry out an act/ simulation/ view a video on the formation of compounds through the transfer or sharing of electrons to achieve a stable octet or duplet electron arrangement.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
5.2 Ionic bond	Pupils are able to: 5.2.1 Explain with examples the formation of ionic bond.	**Note:** The following need to be emphasised: (i) write half equation to explain the formation of positive ions from metal atoms and negative ions from non-metal atoms. (ii) electron arrangement for the ions formed. (iii) illustrate the electron arrangement to show the transfer of electrons for the formation of ionic bonds. **Suggested activity:** Carry out an activity to explain the formation of ionic bond in magnesium oxide (MgO), sodium chloride (NaCl) and sodium oxide (Na_2O).

CONTENT STANDARD	LEARNING STANDARD	REMARKS
5.3 Covalent bond	Pupils are able to: 5.3.1 Explain with examples the formation of covalent bond. 5.3.2 Compare ionic bonds and covalent bonds.	**Note:** To show the formation of covalent bonds using the electron arrangement diagram and Lewis structure. **Suggested activity:** Build a model or carry out a simulation to illustrate and describe the formation of: (i) single bond in hydrogen gas (H_2) and hydrogen chloride (HCl), (ii) double bond in oxygen (O_2) and carbon dioxide (CO_2) and (iii) triple bond in nitrogen (N_2).
5.4 Hydrogen bond	Pupils are able to: 5.4.1 Explain with examples the formation of a hydrogen bond. 5.4.2 Explain the effect of the hydrogen bond on the physical properties of substances.	**Note:** The hydrogen bond is an interaction or a force of attraction between the hydrogen atom and an atom with high electronegativity like N, O and F. **Suggested activity:** Discuss the hydrogen bonding in HF, NH_3 and H_2O.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Explain the examples of the role of hydrogen bond in daily life. (i) Moistened hair sticks together due to the presence of hydrogen bond. (ii) Papers can be separated from sticking together by using wet fingertips. Discuss the solubility in water and the boiling points of covalent compounds like NH_3, HCl and C_2H_5OH.
5.5 Dative bond	Pupils are able to: 5.5.1 Explain with examples the formation of dative bond.	**Note:** Dative or coordinate bond is a type of covalent bond between two atoms whereby both electrons are from one of the atoms. **Suggested activity:** Discuss the formation of the dative bond in an ammonium ion, NH_4^+ and a hydroxonium ion, H_3O^+.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
5.6 Metallic bond	Pupils are able to: 5.6.1 Explain the formation of metallic bond. 5.6.2 Reason out the electrical conductivity of metal.	**Note:** The valence electrons of metal atoms are delocalised to form a sea of electrons. The electrostatic forces between the sea of electrons and the positively charged metal ions form the metallic bond. Metals can conduct electricity because electrons in the sea of electrons are free and carry charges. **Suggested activity:** Use thinking tools to compare and contrast all the learned bond formation with examples.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
5.7 Ionic and covalent compounds	Pupils are able to: 5.7.1 Compare the properties of ionic compounds and covalent compounds through experiment 5.7.2 Explain with examples the uses of ionic compounds and covalent compounds in daily life.	**Note:** The differences in properties of covalent and ionic compounds is studied in terms of: (i) electrical conductivity (ii) solubility in water and organic solvents (iii) melting point and boiling point. Exposure to simple and gigantic molecular structures and to compare their melting point and boiling point. **Suggested activity:** Explain with examples the existence of Van der Waals force and relate it to the physical properties of substances such as melting point, boiling point and volatility. Carry out a problem-solving project on the usage of ionic and covalent compounds in the industrial, agricultural and medical sectors as well as in household.

PERFORMANCE STANDARD

CHEMICAL BOND

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills on chemical bonds.
2	**Understand** and explain chemical bonds.
3	**Apply** knowledge and skills about chemical bonds and its concept to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on chemical bonds in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on chemical bonds in the context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying the knowledge and skills about chemical bonds in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations creatively and innovatively; giving due considerations to social/ economic/ cultural values of the community.

THEME

INTERACTION BETWEEN MATTER

LEARNING AREA

6.0 ACID, BASE AND SALT

7.0 RATE OF REACTION

Theme 3: **INTERACTION BETWEEN MATTER**

This theme aims to introduce acids, bases and salts as well as rate of reaction. The concept of acid and base is reinforced; focusing on their chemical properties. This knowledge can be applied to analyse materials and solve contextual issues quantitatively and qualitatively through titration and chemical analysis. Pupils will also study about salt preparation methods and qualitative analysis. Interaction between substances at different rates is also emphasised. Basic concept of rate of reaction can be applied contextually.

Learning area:

6.0 Acid, Base and Salt

6.1 The role of water in showing acidic and alkaline properties

6.2 pH value

6.3 Strength of acids and alkalis

6.4 Chemical properties of acids and alkalis

6.5 Concentration of aqueous solution

6.6 Standard solution

6.7 Neutralisation

6.8 Salts, crystals and their uses in daily life

6.9 Preparation of salts

6.10 Effect of heat on salts

6.11 Qualitative analysis

7.0 Rate of Reaction

7.1 Determining rate of reaction

7.2 Factors affecting rate of reaction

7.3 Application of factors that affect the rate of reaction in daily life

7.4 Collision theory

6.0 ACIDS, BASES AND SALTS

CONTENT STANDARD	LEARNING STANDARD	REMARKS
6.1 Role of water in showing acidic and alkaline properties	Pupils are able to: 6.1.1 Define acid and alkali. 6.1.2 State the meaning of basicity of an acid. 6.1.3 Investigate the role of water in showing acidic and alkaline properties through experiment.	**Note:** Pupils have prior knowledge in acids and alkali in Form 2. **Suggested activity:** Define an acid based on the Arrhenius theory. Explain with examples acidic and alkaline substances as well as their uses in daily life. Describe the role of water in showing acidic and alkaline properties.
6.2 pH value	Pupils are able to: 6.2.1 State the meaning of pH and its uses. 6.2.2 Calculate pH values of acids and alkalis. 6.2.3 Investigate the relationship between pH value and the concentration of hydrogen ions and hydroxide ions through experiment.	**Note:** Emphasise the relationship of pH value with acidity and alkalinity. pH value of acid is $pH = - \log [H^+]$ pH value of alkali is $pOH = - \log [OH^-]$ $pH + pOH = 14$

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Carry out an activity to determine the pH values of various substances used in daily life like soap water, carbonated drinks, coffee, *teh tarik*, lime juice and so on.
6.3 Strength of acids and alkalis	Pupils are able to: 6.3.1 Define strong acid, weak acid, strong alkali and weak alkali. 6.3.2 Explain the strength of acid and alkali based on its degree of dissociation in water.	**Note:** The formation of hydroxonium ions is related to the existence of dative bond. Dissociation is also known as ionisation. **Suggested activity:** Carry out a simulation to explain the strength of an acid and alkali based on its degree of dissociation.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
6.4 Chemical properties of acids and alkalis	Pupils are able to: 6.4.1 Summarise the chemical properties of acids by carrying out the reactions between: (i) Acid and base (ii) Acid and reactive metal (iii) Acid and metal carbonate 6.4.2 Summarise the chemical properties of alkalis by carrying out the reactions between: (i) Alkali and acid (ii) Alkali and metal ion (iii) Alkali and ammonium salt	
6.5 Concentration of aqueous solution	Pupils are able to: 6.5.1 State the meaning of concentration of aqueous solution. 6.5.2 Solve numerical problems involving concentration of solution.	**Note:** The meaning of concentration and molarity is emphasised. Unit for concentration of solution is g dm^{-3} and mol dm^{-3}. Conversion of unit from mol dm^{-3} to g dm^{-3} and vice versa. The relationship between number of moles with molarity and volume of solution is emphasised.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
6.6 Standard solution	Pupils are able to: 6.6.1 State the meaning of standard solution. 6.6.2 Describe the preparation of a standard solution through activity: (i) from a solid substance (ii) through dilution of an aqueous solution. 6.6.3 Solve numerical problems involving preparation of standard solution and dilution.	**Note:** A standard solution can be prepared from a solid substance or by dilution of an aqueous solution. **Suggested activity:** Prepare a standard solution from solids such as sodium carbonate (Na_2CO_3) or oxalic acid ($H_2C_2O_4.2H_2O$). Prepare a standard solution using dilution method.
6.7 Neutralisation	Pupils are able to: 6.7.1 State the meaning of neutralisation. 6.7.2 Determine the concentration of an unknown solution through titration method. 6.7.3 Solve numerical problems involving neutralisation.	**Suggested activity:** Write chemical and ionic equations for neutralisation reaction. Carry out a PBL activity to solve infertile soil using a suitable fertiliser. Gather information about various fertilisers. For example, producing urea through the reaction between ammonia and carbon dioxide. Determine the quality of various types of ammonium fertilisers available in the market based on their percentage of nitrogen.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
6.8 Salts, crystals and their uses in daily life	Pupils are able to: 6.8.1 State the meaning of salt. 6.8.2 Characterise the physical properties of salt crystals. 6.8.3 Give examples of salts and their uses in daily life.	**Suggested activity:** Gather and interpret information about salts that exist naturally. Carry out an activity to grow crystals. Design a multimedia presentation on the uses of a variety of salts in agriculture, medicine, food preparation and preservation. Debate on the effects of salt on human health.
6.9 Preparation of salts	Pupils are able to: 6.9.1 Test the solubility of salt in water and classify them into soluble and insoluble salts through experiment. 6.9.2 Describe the preparation of a soluble salt through activity. 6.9.3 Describe the preparation of an insoluble salt through activity.	**Note:** Soluble salt can be prepared through the reactions between: (i) Acid and alkali (ii) Acid and metal oxide (iii) Acid and reactive metal (iv) Acid and metal carbonate **Suggested activity:** Carry out an activity to purify a soluble salt using the recrystallisation method.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	6.9.4 Construct an ionic equation using the continuous variation method through experiment.	Prepare an insoluble salt using the double decomposition reaction. Carry out an activity to construct an ionic equation for the formation of an insoluble salt using the continuous variation method.
6.10 Effect of heat on salts	Pupils are able to: 6.10.1 Describe briefly chemical tests to identify gases. 6.10.2 Investigate the effect of heat on salts through experiment.	**Suggested activity:** Carry out chemical tests to identify the following gases: (i) oxygen (O_2) (ii) hydrogen (H_2) (iii) carbon dioxide (CO_2) (iv) ammonia (NH_3) (v) chlorine (Cl_2) (vi) hydrogen chloride (HCl) (vii) sulphur dioxide (SO_2) Carry out activities to: (i) Construct a chemical equation for the effect of heat on salt. (ii) Study the effect of heat on carbonate and nitrate salts. (iii) Observe the colour change and the gas produced when salts are heated. (iv) Determine the salt based on the colour of the residue and the type of gas produced.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
6.11 Qualitative analysis	Pupils are able to: 6.11.1 Identify the cation and anion present in a salt through experiment. 6.11.2 Describe the confirmatory tests to identify cations and anions.	**Note:** Qualitative analysis based on the sequence of the following tests: (i) observe the colour (ii) test the solubility of salt in water (iii) test for gases (iv) determine the effect of heat on the salt (v) test with sodium hydroxide solution and ammonia solution. **Suggested activity:** 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^+ and Ca^{2+} ions in aqueous solutions using sodium hydroxide solution (NaOH) and ammonia solution (NH_3). Carry out tests to confirm the presence of Fe^{2+}, Fe^{3+}, Pb^{2+} and NH_4^+ ions in aqueous solutions. Plan and carry out tests to identify the cations and anions present in unknown salts.

PERFORMANCE STANDARD

ACIDS, BASES AND SALTS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills on acids, bases and salts.
2	**Understand** and explain acids, bases and salts.
3	**Apply** knowledge on acids, bases and salts to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on acids, bases and salts in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on acids, bases and salts in context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying knowledge and skills about acids, bases and salts in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations creatively and innovatively; giving due considerations to the social/ economic/ cultural values of the community.

7.0 RATE OF REACTION

CONTENT STANDARD	LEARNING STANDARD	REMARKS
7.1 Determining rate of reaction	Pupils are able to: 7.1.1 Classify fast and slow reactions that occur in daily life. 7.1.2 Explain the meaning of the rate of reaction. 7.1.3 Identify changes which can be observed and measured during chemical reactions through activity. 7.1.4 Determine the (i) average rate of reaction and (ii) instantaneous rate of reaction 7.1.5 Solve numerical problems based on the average and instantaneous rate of reaction.	**Note:** Examples of fast reactions are combustion, explosion and others. Examples of slow reactions are corrosion, photosynthesis and others. Observable and measurable changes such as increase in the volume of gas, decrease in the mass of reactants and formation of precipitate. The method of measuring the observable changes in determining the rate of reaction is emphasised. For activity 7.1.4, the rate of reaction is determined using the data obtained from experiment 7.1.3. **Suggested activity:** Carry out an experiment to determine the time taken for the reactions between: (i) zinc and acid (ii) potassium iodide solution and lead(II) nitrate solution

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Discuss to identify the changes that can be observed on the reactants or products and determine the rate of reaction. Carry out numerical problem solving activities on rate of reactions including drawing a graph to calculate the average and instantaneous rate of reactions.
7.2 Factors that affect the rate of reaction	Pupils are able to: 7.2.1 Investigate factors affecting the rate of reactions through experiment, based on: (i) size of reactants (ii) concentration (iii) temperature (iv) presence of catalyst	**Suggested activity:** View computer simulations/ video/ multimedia presentation to investigate pressure factor that affects the rate of reaction. The reactions suggested to investigate the factors affecting rate of reactions are: (i) Calcium carbonate ($CaCO_3$) with hydrochloric acid (HCl) (ii) Sodium thiosulphate ($Na_2S_2O_3$) with sulphuric acid (H_2SO_4) (iii) Decomposition of hydrogen peroxide(H_2O_2) in the presence of catalyst. Discuss how to solve problems related to the rate of reaction and determine the variables in a particular reaction.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
7.3 Application of factors that affect the rate of reaction in daily life.	Pupils are able to: 7.3.1 Explain with examples the application of factors that affect the rate of reaction in daily life.	**Suggested activity:** Solve problems in various activities in daily life through acting, field trips or camping. Discuss the application of factors that affect the rate of reaction in the following daily activities: (i) Burning of coal (ii) Storage of food in a refrigerator (iii) Using pressure cooker to cook (iv) Production of ammonia, sulphuric acid and nitric acid in industry.
7.4 Collision theory	Pupils are able to: 7.4.1 Describe the collision theory. 7.4.2 Explain activation energy using examples.	**Note:** Pupils have prior knowledge on the Kinetic Theory of Matter in Form 1. The collision theory and the kinetic theory of matter are related in terms of energy transfer. The following must be emphasised : (i) Change in particle energy (ii) Movements and collisions of particles (iii) Effective collisions (iv) Activation energy (v) Frequency of collision (vi) Frequency of effective collision.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	7.4.3 Interpret an energy profile diagram for exothermic and endothermic reactions.	Introduction to the energy profile diagram for exothermic reaction and endothermic reaction as well as to determine the activation energy from the diagram. Exothermic and endothermic reactions will be emphasised in Thermochemistry in Form 5. **Suggested activity:** View computer simulations/ video/ multimedia presentation to show: (i) movements and collisions between particles in the chemical reactions and (ii) movements and collisions of particles in reactions that are affected by temperature, size of reactants, pressure, concentration and catalyst. Discuss to conceptualise the collision theory of reactions that are affected by temperature, size of reactants, pressure, concentration and catalyst.

PERFORMANCE STANDARD

RATE OF REACTION

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills about rate of reaction.
2	**Understand** and explain rate of reaction.
3	**Apply** knowledge on the rate of reaction to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on the rate of reaction in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on rate of reaction in the context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying the knowledge on rate of reaction in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations in a creatively and innovatively; giving due considerations to social/ economic/ cultural values of the community.

THEME

INDUSTRIAL CHEMISTRY

LEARNING AREA

8.0 MANUFACTURED SUBSTANCES IN INDUSTRY

Theme 4: **INDUSTRIAL CHEMISTRY**

This theme introduces properties of materials used widely in the development of technology in todays world. The materials introduced are alloys, superconductors, glass, ceramics and composite materials. The study includes their compositions and uses. Pupils can apply the knowledge gained in this theme to design prototype products using these materials.

Learning Area: **8.0 Manufactured Substances in Industry**

8.1 Alloy and its importance

8.2 Composition of glass and its uses

8.3 Composition of ceramics and its uses

8.4 Composite materials and its importance

8.0 MANUFACTURED SUBSTANCES IN INDUSTRY

CONTENT STANDARD	LEARNING STANDARD	REMARKS
8.1 Alloy and its importance	Pupils are able to: 8.1.1 Describe briefly alloy with examples. 8.1.2 Compare the properties of an alloy with its pure metal through experiment 8.1.3 Justify the usage of alloys based on their composition and properties.	**Note:** The strength and hardness of alloy are based on the arrangement of particles. Superconductors are examples of alloy which function to increase the effectiveness of electrical conductivity. **Suggested activity:** Carry out a competition to build the strongest model of particle arrangement in alloy by using balls/ spheres. Design a multimedia presentation or poster to relate the properties of alloys and its qualities using examples in daily life.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
8.2 Composition of glass and its uses	Pupils are able to: 8.2.1 Describe briefly with examples the type of glass, their composition, properties and uses.	**Suggested activity:** Gather information and prepare a multimedia presentation on the types of glass, their composition, properties and uses.
8.3 Composition of ceramics and its uses	Pupils are able to: 8.3.1 Describe briefly with examples of ceramics, their composition, properties and uses. 8.3.2 Explain the uses of ceramics in daily life.	**Suggested activity:** Classify ceramics into traditional and advanced ceramics. Gather information and design a multimedia presentation about the classification, properties and the uses of ceramics. Explain the purpose of ceramics in construction of houses based on its properties.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
8.4 Composite materials and their importance	Pupils are able to: 8.4.1 State the meaning and properties of composite materials. 8.4.2 Describe with examples the uses of composite materials. 8.4.3 Compare and contrast the properties of a composite material with its constituent materials.	**Suggested activity:** Gather information and design multimedia presentation about the properties, examples and comparison of composite materials with their constituent materials. Create an object made of composite material using various substances such as egg trays, cotton wool, plastic or paper, example wire-reinforced paper mache. This object should combine at least two constituent materials like metals, glass, ceramics, alloys and composite materials.

PERFORMANCE STANDARD

MANUFACTURED SUBSTANCES IN INDUSTRY

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills about manufactured substances in industry.
2	**Understand** and explain about manufactured substances in industry.
3	**Apply** knowledge on manufactured substances in industry to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on manufactured substances in industry in the context of problem solving the natural occurrences or phenomena.
5	**Evaluate** knowledge on manufactured substances in industry in the context of problem solving and decision-making to carry out a task**.**
6	**Invent** by applying the knowledge on manufactured substances in industry in the context of **problem solving and decision-making** or when carrying out an activity/ task in new situations creatively and innovatively; giving due considerations to the social/ economic/ cultural values of the community.

Content Standard,
Learning Standard
and Performance Standard
Form Five

THEME

CHEMICAL PROCESS

LEARNING AREA

9.0 REDOX EQUILIBRIUM

Theme 5: **CHEMICAL PROCESS**

This theme gives opportunity for pupils to understand and apply the concept of oxidation and reduction in redox reaction. Standard electrode potential is introduced as a measure of the strength of oxidising and reducing agents. Redox reactions in voltaic cell and electrolytic cell are discussed too. The applications of redox reactions in industry such as electroplating, purification of metal and extraction of metal and its effect to the environment are explored. Pupils will discover the mechanism and methods of preventing rusting.

Leaning area:

9.0 Redox equilibrium

- 9.1 Oxidation and reduction
- 9.2 Standard electrode potential
- 9.3 Voltaic cell
- 9.4 Electrolytic cell
- 9.5 Extraction of metal from its ore
- 9.6 Rusting

9.0 REDOX REACTION

CONTENT STANDARD	LEARNING STANDARD	REMARKS
9.1 Oxidation and reduction	Pupils are able to: 9.1.1 Describe redox reactions through activities.	**Note:** Explanation on the meaning of oxidation and reduction with examples based on: (i) loss or gain of oxygen, (ii) loss or gain of hydrogen, (iii) transfer of electrons, (iv) change in oxidation number. Item need to be emphasised: (i) meaning of redox reaction, (ii) meaning of oxidising agent and reducing agent, (iii) examples of oxidising agents such as acidified potassium manganate(VII) solution, acidified potassium dichromate(VI) solution, bromine water, chlorine water and hydrogen peroxide, (iv) examples of reducing agents such as reactive metals and sulphur dioxide. **Suggested activity:** Carry out activities to study the transfer of electrons at a distance.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	9.1.2 Explain redox reaction based on the change in oxidation number through activities.	**Note:** Item need to be emphasised: (i) oxidation number of elements, (ii) relationship between oxidation number of an element to the name of its compound according to IUPAC nomenclature, (iii) change in the oxidation number of the elements in a redox reaction and their relationship with the transfer of electrons, (iv) half equations of oxidation and reduction processes, (v) ionic equation for redox reaction. **Suggested activity:** Carry out activities to study the conversion of Fe^{2+} ion to Fe^{3+} ion and vice versa.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	9.1.3 Investigate displacement reaction as a redox reaction through activites.	**Note:** The emphasis is on the observation and inference in a redox reaction. Writing of half equations for oxidation and reduction as well as ionic equation for redox reaction are required. **Suggested activity:** Carry out activities to study the following redox reactions: (i) displacement of metal from its salt solution. (ii) displacement of halogen from its halide solution.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
9.2 Standard electrode potential	Pupils are able to: 9.2.1 Describe the standard electrode potential.	**Note:** Introduction to cells that use the standard hydrogen electrode and zinc electrode to obtain the value of standard electrode potential, E^0. Standard conditions for the cells are: i) aqueous concentration of ions 1.0 mol dm^{-3} ii) temperature 25°C or 298K iii) pressure of 1 atm or 101 kPa iv) platinum is used as inert electrode **Suggested activity:** Dispaly a video/ simulation on electrochemical cell that has standard hydrogen cell and standard zinc half cell.
	9.2.2 Determine oxidising agent and reducing agent based on their value of standard electrode potentials.	**Note:** The more positive the value of standard electrode potential, E^0, the easier for the atom or ion to undergo reduction. The more negative the value of standard electrode potential, E^0, the easier for the atom or ion to undergo oxidation.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		The E^0 value is used to predict the following: (i) atom or ion that will undergo oxidation or reduction, (ii) strength of oxidising agent or reducing agent. Pupils are not required to determine the E^0 value but they have to know how it is done. The discussion is limited to the comparison of values of standard electrode potential, E^0, to determine the oxidising agent or reducing agent. **Suggested activity:** Carry out hands on activities to relate the strength of oxidising or reducing agents with the E^0 value for displacement reaction.
9.3 Voltaic cell	Pupils are able to: 9.3.1 Explain redox reaction in voltaic cell through experiment.	**Note:** Potential difference between two electrodes causes the movement of electrons that produces electric current. Anode and cathode or positive terminal and negative terminal of the voltaic cell are determined based on the E^0 value. Anode and cathode are associated with oxidation process and reduction process respectively.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Description on the reactions that occur in the simple voltaic cell and Daniell cell including writing of cell notation. The E^0 value is used to calculate the voltage of various cells based on the formula, $E^0_{cell} = E^0$ cathode $- E^0$ anode **Suggested activity:** Carry out an investigation activity by constructing a simple voltaic cell and Daniell cell to: (i) identify the anode and cathode for different pairs of electrodes (ii) determine the voltage.
9.4 Electrolytic cell	Pupils are able to: 9.4.1 Describe electrolysis.	**Note:** Pupils have prior knowledge on electrical conductivity concept for ionic compound and covalent compound in Form 4. Item need to be emphasised: (i) the meaning of electrolyte and non-electrolyte, (ii) relationship between electrical conductivity and the existence of freely moving ions, (iii) comparison between conductor and electrolyte.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Classify various substances as electrolyte or non-electrolyte. Make an observation and conclusion about electrolysis from a multimedia presentation or other presented sources.
	9.4.2 Describe electrolysis of molten compound through activities.	**Note :** Description of electrolysis in molten compound includes: (i) observation and inference for reaction that occurs at anode and cathode, (ii) ions present in electrolyte, (iii) ions attracted to anode and cathode, (iv) discharge process of ions at anode and cathode, (v) half equations for the reaction at anode and cathode, (vi) redox reaction that occurs. **Suggested activity:** Carry out an activity to study electrolysis of molten lead(II) bromide. Predict the products of electrolysis for several molten compounds.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	9.4.3 Explain factors that affect electrolysis of aqueous solution through experiment.	**Note:** Description of electrolysis process in aqueous solution includes: (i) observation and inference for reaction that occurs at anode and cathode, (ii) ions present in electrolyte, (iii) ions attracted to anode and cathode, (iv) selective discharge process of ions at anode and cathode, (v) half equations for the reactions at anode and cathode, (vi) products of electrolysis in aqueous solution based on factors affecting formation of products in electrolysis, (vii) redox reaction that occurs. Factors that affect the formation of products in electrolysis include: (i) the E^0 value (ii) concentration of solution, and (iii) types of electrode. **Suggested activity:** Carry out an experiment to study electrolysis of the following: (i) dilute sulphuric acid (H_2SO_4) and copper(II) sulphate solution ($CuSO_4$) using carbon electrode. (ii) concentrated and dilute hydrochloric acid using carbon electrode.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		(iii) copper(II) sulphate solution ($CuSO_4$) using copper electrode and carbon electrode.
	9.4.4 Compare voltaic cell and electrolytic cell.	**Note:** Comparison between voltaic cell and electrolytic cell based on: (i) set-up of apparatus, (ii) energy changes, (iii) direction of electron flow, (iv) electrode polarity, (v) oxidation and reduction. **Suggested activity:** Prepare a creative presentation on similarities and differences of voltaic cell and electrolytic cell.
	9.4.5 Describe electroplating and purification of metal by electrolysis through activities.	**Note:** Item need to be emphasised: (i) the importance of electroplating and purification of metal in industry, (ii) half equations at anode and cathode, (iii) redox reaction in electroplating and metal purification processes.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Purify copper and electroplate a metal object with copper through electrolysis.
9.5 Extraction of metal from its ore	Pupils are able to: 9.5.1 Explain extraction of metal from its ore through electrolysis process.	**Note:** Description on extraction of aluminium from bauxite includes: (i) half equations at anode and cathode, (ii) redox reaction that occurs, (iii) effects of extraction of aluminium from bauxite to the environment. **Suggested activity:** Watch and analyse the extraction process of aluminium from bauxite through a video/ simulation.
	9.5.2 Explain metal extraction from its ore through reduction process by carbon.	**Note :** Pupils have prior knowledge on metal extraction from its ore using reactivity series in Form 3. Description on iron extraction from its ore through reduction process by carbon including the redox reaction that occurs.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Reduction reaction of metal oxide by other metals is discussed. Metal extraction method depends on the reactivity of metal. **Suggested activity:** Watch and analyse the extraction of iron from its ore through a video/ simulation.
9.6 Rusting	Pupils are able to: 9.6.1 Describe metal corrosion process as redox reaction through activities.	**Note:** Description on the mechanism of rusting of iron includes: (i) labelled diagram that shows anode, cathode and direction of electron flow, (ii) half equations for oxidation and reduction processes, (iii) conditions for rusting. **Suggested activity:** Experiment to study how corrosion of metal can occur on copper and iron.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	9.6.2 Experiment to prevent rusting.	**Note:** The emphasis is on methods of prevention of rusting through: (i) protection of its iron surface (painting or coating using other substances), (ii) galvanisation. **Suggested activity:** Carry out an experiment to study the effects of other metals in contact with iron towards rusting of iron. Solve rusting problems in daily life.

PERFORMANCE STANDARD

REDOX EQUILIBRIUM

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills on oxidation and reduction concept.
2	**Understand** redox reaction and explain the understanding using examples.
3	**Apply** knowledge on redox reaction to explain the natural occurrences or phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on redox reaction in the context of problem solving on the natural occurrences or phenomena.
5	**Evaluate** knowledge on redox reaction in the context of **problem solving and decision-making** to carry out a task.
6	**Invent** creatively and innovatively by applying the knowledge on redox reaction in the context of **problem solving and decision-making** or in carrying out an activity/ task in new situations; giving due considerations to social/ economic/ cultural values of the community.

THEME

ORGANIC CHEMISTRY

LEARNING AREA

10.0 CARBON COMPOUND

Theme 6: **ORGANIC CHEMISTRY**

This theme discusses basic organic substances around us, classification of hydrocarbon compounds based on homologous series, physical properties and chemical properties. Knowledge on preparation methods and chemical properties of substances are important in the application of processing and production of commercial and industrial substances.

Learning Area:

10.0 Carbon compound

- 10.1 Types of carbon compound
- 10.2 Homologous series
- 10.3 Chemical properties and interconversion of compounds between homologous series
- 10.4 Isomers and naming based on IUPAC nomenclature

10.0 CARBON COMPOUND

CONTENT STANDARD	LEARNING STANDARD	REMARKS
10.1 Types of carbon compound	Pupils are able to: 10.1.1 Understand carbon compound.	**Note:** Item need to be emphasised: (i) definition of carbon compound, (ii) classification of carbon compounds into organic compounds and inorganic compounds, (iii) classification of organic compounds into hydrocarbon compounds and non hydrocarbon compounds, (iv) meanings of saturated hydrocarbon and unsaturated hydrocarbon.
	10.1.2 Explain sources of hydrocarbon.	**Note:** Item need to be emphasised: (i) main source of hydrocarbon, (ii) alternative sources of hydrocarbon, (iii) uses of hydrocarbons in daily life, (iv) meaning of cracking process in petroleum refinery. **Suggested activity:** Carry out fractional distillation of petroleum. Produce alternative fuels from organic waste such as biogas, biodiesel or ethanol.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
10.2 Homologous series	Pupils are able to: 10.2.1 Explain homologous series.	**Note:** Item need to be emphasised: (i) meaning of homologous series, (ii) examples of homologous series, (iii) properties of homologous series, (iv) functional groups and general formula for each homologous series namely alkane, alkene, alkyne, alcohol, carboxylic acid and ester. **Suggested activity:** Explore and find information on homologous series. Classify creatively various structural formulae based on functional group of homologous series for alkane, alkene, alkyne, alcohol, carboxylic acid and ester.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	10.2.2 Construct molecular formulae and structural formulae, and name the members of the homologous series.	**Note:** Item need to be emphasised: (i) writing molecular formulae for the first ten members of the homologous series of alkane and the first nine members of alkene, (ii) writing molecular formulae for the first six members of homologous series of alkyne, alcohol and carboxylic acid, (iii) drawing of structural formulae and naming based on the IUPAC nomenclature for the first ten members of homologous series of alkane and the first nine members of alkene, (iv) drawing of structural formulae and naming based on the IUPAC nomenclature for the first six members of homologous series of alkyne, alcohol and carboxylic acid. Drawing of structural formulae and naming based on the IUPAC nomenclature is limited to straight-chain structural formula only. **Suggested activity:** Build models of structural formula using organic molecule model kit or any other creative ways.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	10.2.3 Describe physical properties of the compounds in a homologous series.	**Note:** Item need to be emphasised: (i) physical properties of compounds in a homologous series, (ii) changes in physical properties with the increase in the number of carbon atoms per molecule. Physical properties of ester is introduced in the learning standard 10.3.2. **Suggested activity:** Determine the order of physical properties for the compounds in a homologous series through games.
10.3 Chemical properties and interconversion between homologous series	Pupils are able to: 10.3.1 Describe the chemical properties of each homologous series through activities.	**Note:** Description of chemical properties of each homologous series for alkane, alkene, alkyne, alcohol dan carboxylic acid includes: (i) construction of chemical equations for reactions involved, and (ii) interconversion between homologous series. Chemical properties of **alkane** for the following reactions: (i) combustion (ii) substitution

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Chemical properties of **alkene** for the following reactions: (i) combustion (ii) addition • hydrogen • halogen • hydrogen halide • water • oxidation (iii) polymerisation Chemical properties of alkene is limited to ethene only. Chemical properties of alkyne is not required to be expained. Comparison between alkane (saturated hydrocarbon) and alkene (unsaturated hydrocarbon) is based on: (i) composition (ii) type of bond (iii) percentage of carbon per molecule (iv) sootiness Description of preparation for ethanol and chemical properties of **alcohol** in the following reactions: (i) combustion (ii) dehydration (iii) oxidation Description on the preparation of ethanoic acid and chemical properties of **carboxylic acid** in the following reactions:

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		(i) neutralisation (ii) with reactive metals (iii) with metallic carbonates **Suggested activity:** Carry out a laboratory activity to compare alkane (saturated hydrocarbon) and alkene (unsaturated hydrocarbon) based on: (i) combustion (sootiness) (ii) chemical reaction with bromine water and acidified potassium manganate(VII) solution Carry out an activity to prepare ethanol through fermentation process. Carry out a laboratory activity to study dehydration and oxidation of ethanol. Carry out an activity to study the chemical properties of carboxylic acid.
	10.3.2 Understand ester through activity.	**Note:** Item need to be emphasised: (i) Writing of molecular formulae, (ii) Drawing of structural formulae and naming according to IUPAC nomenclature,

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		(iii) Physical properties, (iv) Writing chemical equation of esterification. Writing molecular formulae, drawing structural formulae and naming according to IUPAC nomenclature of ester are limited to reactions between the first three members of alcohol and carboxylic acid. **Suggested activity:** Carry out a laboratory activity to prepare various esters.
10.4 Isomer and naming according to IUPAC nomenclature	Pupils are able to: 10.4.1 Describe structural isomerism.	**Note:** Item need to be emphasised: (i) meaning of structural isomerism and (ii) comparison of physical properties and chemical properties for isomers
	10.4.2 Construct structure of isomers.	**Note:** Item need to be emphasised: (i) construction of various structural formulae for alkane, alkene, alkyne and alcohol which have than five or less carbon atoms, (ii) naming of isomers according to IUPAC nomenclature.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Constructing structural formulae models using organic molecule model kit or through any other creative ways.
	10.4.3 Explain with examples the uses of each homologous series in daily life.	**Note:** Justification for the usage of substances in homologous series of alkane, alkene, alcohol, carboxylic acid and ester in daily life. Effects of misuse of alcohol are discussed. **Suggested activity:** Conduct a debate on the usage of alkane, alkene, alcohol, carboxylic acid and ester in daily life.

PERFORMANCE STANDARD

CARBON COMPOUND

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills about carbon compound.
2	**Understand** and explain carbon compound with examples.
3	**Apply** knowledge on carbon compounds to explain the natural occurrences and phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on carbon compound in the context of problem solving about natural occurrences and phenomena.
5	**Evaluate** knowledge on carbon compound in the context of **problem solving and decision-making** to perform a task.
6	**Invent** creatively or innovatively by applying knowledge on carbon compound in the context of **problem solving and decision-making** or in carrying out an activity/ task in new situations; giving due considerations to the social/ economic/ cultural values of the community.

THEME

HEAT

LEARNING AREA

11.0 THERMOCHEMISTRY

Theme 7: **HEAT**

This theme analyses heat change in chemical reactions. The study of heat of reaction includes heat of precipitation, heat of displacement, heat of neutralisation and heat of combustion. Applications of exothermic and endothermic reactions in daily life is discussed. Knowledge on fuel value is used in choosing the most suitable daily fuel. Pupils' creativity and innovativeness are fostered through product designing activities which involve knowledge applications on exothermic and endothermic reactions.

Learning area:

11.0 Thermochemistry

- 11.1 Heat change in reactions
- 11.2 Heat of reaction
- 11.3 Application of endothermic and exothermic reactions in daily life

11.0 THERMOCHEMISTRY

CONTENT STANDARD	LEARNING STANDARD	REMARKS
11.1 Heat change in reactions	Pupils are able to: 11.1.1 Deduce exothermic and endothermic reactions through activities.	**Note:** Pupils have prior knowledge on the concept of exothermic and endothermic reaction in Form 3. **Suggested activity:** Study the types of reaction based on heat change and the differences in thermometer readings through activities of dissolving Item substances in water: (i) sodium hydroxide (NaOH), (ii) anhydrous calcium chloride ($CaCl_2$), (iii) ammonium nitrate (NH_4NO_3), (iv) sodium thiosulphate ($Na_2S_2O_3$).
	11.1.2 Interpret energy level diagram	**Note:** Item need to be emphasised: (i) construction and interpretation of energy level diagrams, (ii) meaning of heat of reaction (ΔH). **Suggested activity:** Display computer simulation/ animation, carry out game activities or other methods to explain the changes in heat energy during the formation and breaking of bonds in a chemical reaction.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
11.2 Heat of reaction	Pupils are able to: 11.2.1 Determine heat of precipitation through activity.	**Note:** Item need to be emphasised: (i) meaning of heat of precipitation, (ii) determining the endothermic and exothermic heat of precipitation for magnesium carbonate ($MgCO_3$) and silver chloride (AgCl), (iii) thermochemical equation for precipitation reaction, (iv) construction of energy level diagram. Numerical problem solving related to heat of precipitation.
	11.2.2 Determine heat of displacement through activity.	**Note:** Item need to be emphasised: (i) meaning of heat of displacement, (ii) determining the heat of displacement of metal from its salt solution, (iii) thermochemical equation for displacement reaction, (iv) construction of energy level diagram. Numerical problem solving related to heat of displacement.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Compare heat of displacement of metal from its salt solution by metals with different electropositivity through activity.
	11.2.3 Compare heat of neutralisation through experiments for reactions between Item: (a) strong acid and strong alkali, (b) weak acid and strong alkali, (c) strong acid and weak alkali, (d) weak acid and weak alkali.	**Note:** Item need to be emphasised: (i) meaning of heat of neutralisation, (ii) thermochemical equation, (iii) comparison of heat of neutralisation, (iv) construction of energy level diagram for heat of neutralisation. Description of heat of neutralisations for monoprotic acid versus diprotic acid with strong alkali. Numerical problem solving related to heat of neutralisation. **Suggested activity:** Carry out an experiment to compare heat of neutralisation for reactions between: (i) hydrochloric acid (HCl) and sodium hydroxide solution (NaOH), (ii) ethanoic acid (CH_3COOH) and sodium hydroxide solution (NaOH),

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		(iii) hydrochloric acid (HCl) and aqueous ammonia (NH_3), (iv) ethanoic acid (CH_3COOH) and aqueous ammonia (NH_3).
	11.2.4 Compare heat of combustion for various types of alcohol through experiment.	**Note:** Item need to be emphasised: (i) meaning of heat of combustion, (ii) thermochemical equation, (iii) comparison of heat of combustion, (iv) construction of energy level diagram. Numerical problem solving related to heat of combustion. **Suggested activity:** Carry out an experiment to compare heat of combustion for methanol (CH_3OH), ethanol (C_2H_5OH), propanol (C_3H_7OH) and butanol (C_4H_9OH).
11.3 Application of endothermic and exothermic reactions in daily life	Pupils are able to: 11.3.1 State a few examples of application of exothermic and endothermic reactions in daily life.	**Suggested activity:** Design products which apply endothermic and exothermic reactions for everyday use.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	11.3.2 Analyse fuel value.	**Note:** Item need to be emphasised: (i) meaning of fuel value, (ii) comparison of fuel value for various fuels. Justification for the choice of effective fuel for certain activities in daily life. **Suggested activity:** Choose the most suitable fuel (in terms of fuel value) for everyday use, for example, frying eggs or making popcorns.

PERFORMANCE STANDARD

THERMOCHEMISTRY

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills about heat change.
2	**Understand** and explain heat of reaction with examples.
3	**Apply** knowledge on heat of reaction to explain the natural occurrences and phenomena and be able to carry out simple tasks.
4	**Analyse** knowledge on heat of reaction in the context of problem solving about natural occurrences and phenomena.
5	**Evaluate** knowledge on heat of reaction in the context of **problem solving and decision-making** to carry out a task.
6	**Invent** creatively or innovatively by applying knowledge on heat of reaction in the context of **problem solving and decision-making** or in carrying out an activity/ task in new situations; giving due considerations to social/ economic/ cultural values of the community.

THEME

TECHNOLOGY IN CHEMISTRY

LEARNING AREA

12.0 POLYMER

13.0 CONSUMER AND INDUSTRIAL CHEMISTRY

Theme 8: **TECHNOLOGY IN CHEMISTRY**

This theme creates awareness and understanding on the importance of chemistry application in daily life and industries in line with the current technology for the benefit of the society. The scope of the study of Polymer Chemistry covers its definitions, classifications, uses and its effects on the environment. The introduction to food industry and consumer materials encourages the engagement of students in entrepreneurship. The application of knowledge on nanotechnology and green technology is aimed at raising student awareness on responsibilities towards environmental sustainability.

Learning area:

12.0 Polymer Chemistry

- 12.1 Polymer
- 12.2 Natural rubber
- 12.3 Synthetic rubber

13.0 Consumer and Industrial Chemistry

- 13.1 Oils and fats
- 13.2 Cleaning agents
- 13.3 Food additives
- 13.4 Medicines and cosmetics
- 13.5 Application of nanotechnology in industry
- 13.6 Application of green technology in industrial waste management

12.0 POLYMER CHEMISTRY

CONTENT STANDARD	LEARNING STANDARD	REMARKS
12.1 Polymer	Pupils are able to: 12.1.1 Explain polymer.	**Note:** Pupils have prior knowledge on addition polymerisation process in Carbon Compound topic. The following need to be emphasised: (i) meaning of monomer, (ii) meaning of polymer, (iii) classification of polymers. Polymers can be classified according to: (i) sources obtained from either natural materials or synthetic materials, (ii) characteristics of thermoplastics, thermosets or elastomers, (iii) polymerisation process either by addition or condensation reaction. Examples of natural polymers and synthetic polymers and their monomers are listed. Examples of synthetic polymers are polyethene, polypropene, polyvinyl chloride and polystyrene.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Observe and classify various materials used in daily life according to their sources, characteristics and process of polymer produced.
	12.1.2 Explain polymerisation reaction through activities.	**Note:** Explanation on the processes of addition polymerisation and condensation polymerisation. **Suggested activity:** Carry out an activity to produce nylon and study the properties of nylon through the reaction between 1,6-hexanediamine and decanedioyl dichloride.
	12.1.3 Justify the use of polymers in daily life.	**Note:** Discussion on the following: (i) uses of synthetic polymers in medicines, packaging, coating, textiles and others (ii) effects of using synthetic polymers on the environment **Suggested activity:** Produce products such as decoratives, toys and others from polymer waste.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
12.2 Natural rubber	Pupils are able to: 12.2.1 Explain on natural rubber in terms of naming, structural formula and its properties.	**Note:** The following need to be emphasised: (i) natural rubber monomer and its name based on the IUPAC nomenclature (ii) drawing of structural formula for natural rubber and its monomer (iii) properties of natural rubber (iv) uses of natural rubber
	12.2.2 Experiment on latex coagulation.	**Note:** Classification of chemicals according to coagulant and anticoagulant for latex. Description of latex coagulation process using chemicals and through natural process. Description of the process of latex coagulation prevention. **Suggested activity**: Conduct an experiment to investigate latex coagulation and methods in preventing coagulation. Carry out an activity to produce latex products.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	12.2.3 Explain the vulcanisation process using sulphur through an activity.	**Note:** Besides sulphur, vulcanisation process can also be done using metal oxides, peroxides and irradiation. **Suggested activity:** Carry out an activity to produce vulcanised rubber.
	12.2.4 Study the elasticity of vulcanised rubber and unvulcanised rubber through experiments.	**Note:** Comparison between vulcanised rubber and unvulcanised rubber in terms of: (i) elasticity, (ii) strength and hardness, (iii) resistance towards heat, (iv) resistance towards oxidation. **Suggested activity:** Study the elasticity of vulcanised rubber and unvulcanised rubber through experiments.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
12.3 Synthetic rubber	Pupils are able to: 12.3.1 Explain synthetic rubber.	**Note:** Description of synthetic rubber includes meanings, examples and characteristics. The types of synthetic rubber discussed are neoprene, styrene-butadiene (SBR) and silicon rubber.
	12.3.2 Justify the use of natural rubber and synthetic rubber.	**Note:** Discussion on the use of natural rubber and synthetic rubber and their effects on the environment. **Suggested activity:** Conduct a field study or field trip to a rubber based industry/ rubber research institute.

PERFORMANCE STANDARD

POLYMER CHEMISTRY

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** basic knowledge and skills on polymer.
2	**Understand** and explain polymer.
3	**Apply** knowledge on polymer to explain natural occurrences or phenomena and carry out a simple task.
4	**Analyse** knowledge on polymer in the context of problem solving about natural occurrences or phenomena.
5	**Evaluate** knowledge on polymer in the context of **problem solving and decision-making** to carry out a task.
6	**Invent** creatively and innovatively using knowledge on polymers in the context of **problem solving** and **decision-making** or in carrying out activities/ tasks in new situations; giving due considerations to social/ economic/ cultural values of the community.

13.0 CONSUMER AND INDUSTRIAL CHEMISTRY

CONTENT STANDARD	LEARNING STANDARD	REMARKS
13.1 Oils and Fats	Pupils are able to: 13.1.1 Compare and contrast oils and fats.	**Note:** Pupils have prior knowledge on general formula, functional group, molecular formula, structural formula and naming ester in Carbon Compound topic. The functional group in oils and fats shows that oils and fats are a type of ester. Comparison between oils and fats in terms of: (i) Saturation (ii) Source (iii) Physical properties **Suggested activity:** Study types of oils available in the market in terms of saturation, sources, physical properties and others.
	13.1.2 Explain the conversion process of unsaturated fats to saturated fats.	**Note:** Hydrogenation reaction as the conversion process from an unsaturated fat to saturated fat. For example, the process of manufacturing margarine in industry.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested acitivity: Display a video on the process of manufacturing margarine in industry. Organise a field trip to a factory to observe the manufacturing of margarine.
	13.1.3 Justify the use of oils and fats in daily life.	**Note:** The importance of oils and fats and their effects on health. Description on the usage of biofuels and palm oil biodiesel as renewable energy. **Sugessted activity:** Present creatively about saturated fat and unsaturated fat in food products and their importance to a healthy lifestyle.
13.2 Cleaning agents	Pupils are able to: 13.2.1 Describe soap and detergent.	**Note:** The meanings of soap and detergent are stated. Soap and detergent are identified based on their structural formula.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	13.2.2 Describe soap preparation process through an activity.	**Note:** The following need to be emphasised: (i) soap production through saponification process, (ii) detergent production through sulphonation and neutralisation reactions. **Suggested activity:** Carry out an activity to create a creative commercial soap using cooking oil/ milk through saponification process.
	13.2.3 Compare the cleansing action of soap and detergent through experiments.	**Note:** Description of cleansing actions of soap and detergent. Comparison between cleansing effectiveness of soap and detergent in soft water, hard water and acidic water. Additives in detergents and their functions are identified. **Suggested activity:** Design an experiment to study the cleansing effectiveness of soap and detergent.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Study/ design the ratio of additive components and their functions in cleansers/ detergent.
13.3 Food Additives	Pupils are able to: 13.3.1 Describe with examples the types of food additives and their functions.	**Note:** Explanation of the importance of food additives in food processing industry and the evolution of food processing technology. The types of food additives include preservatives, antioxidants, flavours, stabilisers, emulsifiers, thickeners and dyes. **Suggested activity:** Carry out chromatography on food colouring. Carry out ice cream/ mayonnaise/ jelly/ yogurt making competition.
	13.3.2 Justify the usage of food additives.	**Note:** Discussion on the effects of using food additives. **Suggested activity:** Carry out a survey/ project/ debate/ public speaking on the impact of food additives on nutritional values and functions of food.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
13.4 Medicines and cosmetics	Pupils are able to: 13.4.1 Explain with examples types of medicine, their functions and side effects.	**Note:** Traditional medicines with examples and their uses are listed. Modern medicines include analgesics, antimicrobials, psychotic drugs, anti allergy and corticosteroids. Each type of medicine should emphasise on: (i) example, (ii) function, (iii) the correct way to use, (iv) side effects. **Suggested activity:** Design a poster/ infographic/ brochure to illustrate the deterioration of human health due to: (i) consumption of processed food, (ii) improper consumption of medicines/ supplements

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	13.4.2 Justify the usage of medicines.	**Note:** Discussion on the usage of traditional and modern medicines as well as their misuses. Discussion on safety issues and effectiveness of traditional and modern medicines. **Suggested activity:** Make a folio/ scrapbook on the uses of traditional and modern medicines in daily life. Prepare a creative presentation on the title "Harmonising traditional and modern medicines"
	13.4.3 Explain cosmetics with examples.	**Note:** Explanation on cosmetics as a product to cleanse, protect and enhance one's appearance. The basic contents of cosmetics are water, emulsifier, preservative, thickener, moisturiser, dye and fragrance.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		The classification of cosmetics includes make-up cosmetics, treatment cosmetics and fragrances. Make-up cosmetics are used as enhancers for face. For example, powder, lipstick, eyebrow liner, blusher, eyeshadow, eyeliner and mascara. Treatment cosmetics include products that are used to treat the body, including creams, skin moisturisers and facial masks. Examples of fragrances are deodorants and perfumes. **Suggested activity:** Produce cosmetic products from organic materials that can be commercialised. For example, hair dyes, lotions, nail polish, lipstick and others.
	13.4.4 Justify the usage of cosmetics	**Note:** Side effects of cosmetics usage. Justification on the usage of homemade cosmetics.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Organise an exhibition on medicines and cosmetics.
13.5 Application of nanotechnology in industry	Pupils are able to: 13.5.1 Explain the meaning of nanotechnology.	**Note:** Nanoscience is the study on processing of substances at nano scale. Nanotechnology is the development of substances or gadgets using the properties of nano particles. Nano particle is a particle with the size between 1 to 100 nanometer (1 nm = 10^{-9} meter). The smaller the size of the particle, the bigger the ratio of the surface area to its volume. The extremely small size of the particle enables it to penetrate the skin layer, blood circulation, lymphatic system and others. This phenomenon has enabled inventions of various interesting materials as well as their uses. **Suggested activity:** Show a computer simulation/ video on the benefits of nano particle properties.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
	13.5.2 Describe nanotechnology with examples and its application in daily life	**Note:** Development of nanotechnology throughout the world. Areas/ Fields of nanotechnology applications include: (i) semiconductor and electronics, (ii) energy and electric, (iii) agriculture, (iv) textile, (v) food, (vi) medical, (vii) cosmetics. Discussion on graphene in terms of: (i) physical properties, (ii) chemical properties, (iii) usage in polymer industry, energy and electronics. **Suggested activity:** Organise a field trip to industry/ agencies related to nanotechnology. Collect information on the application of nanotechnology in the field of food technology, cosmetics, medical and others. Conduct a forum on nanotechnology and its application in daily life.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
13.6 Application of green technology in industrial waste management	Pupils are able to: 13.6.1 Explain green technology with examples.	**Note:** Green Technology is the development and the application of products or equipment, and a system to conserve the environment in order to minimise the negative effects from human activities. Discussion on relationship between environmental issues and Green Technology.
	13.6.2 Describe application of Green Technology in the sectors of waste management and industrial waste water.	**Note:** Description on the usage of Green Technology concept which includes the disposals, disposal site and waste water treatment. Explanation on landfill leachate treatment method for disposals and at the disposal site. Explanation on waste water treatment. For example, the usage of sludge from waste water treatment in the industrial and agricultural fields.

CONTENT STANDARD	LEARNING STANDARD	REMARKS
		Suggested activity: Carry out a project to produce a product using green material. (4R concept) Carry out an activity on heavy metal separation through electrolysis of waste water.
	13.6.3 Justify the application of Green Technology in daily life.	**Suggested activity:** Conduct a forum/ campaign/ exhibition on the application of Green Technology. Design a green building.

PERFORMANCE STANDARD

CONSUMER AND INDUSTRIAL CHEMISTRY

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** knowledge and basic skills on consumer and industrial chemistry.
2	**Understand** and explain consumer and industrial chemistry.
3	**Apply** knowledge of consumer and industrial chemistry to explain the natural occurrences and phenomena and carry out a simple task.
4	**Analyse** knowledge on consumer and industrial chemistry in the context of problem solving on the natural occurrences and phenomena.
5	**Evaluate** knowledge on consumer and industrial chemistry in the context of **problem solving and decision-making** to perform a task.
6	**Invent** creatively and innovatively by applying knowledge on consumer and industrial chemistry in the context of **problem solving and decision-making** or in carrying out an activity/ task in new situations; giving due considerations to the social/ economic/ cultural values of a community.

Appendix

RELATED ACTION VERBS IN PERFORMANCE STANDARDS AND LEARNING STANDARD WITH EXAMPLES OF PUPIL'S ACTIVITIES

PERFORMANCE STANDARD		VERB IN LEARNING STANDARDS	EXAMPLES OF PUPILS' ACTIVITIES
LEVEL	VERB		
1	**Remember** (Recall or identify specific information)	Recognise Recall List Identify Name State Tell etc.	Quiz Definition Fact Worksheet Work Test Label List Workbook Reproduce
2	**Understand** (Translate material or ideas from one form to another; interpret material or ideas, estimate trends)	Elaborate Give examples Summarise Translate Choose Explain etc.	Memorisation Summary Collection Explanation Show and explain Example Quiz Label List Framework
3	**Apply**	Show Adjust	Illustration Simulation

PERFORMANCE STANDARD		VERB IN LEARNING STANDARDS	EXAMPLES OF PUPILS' ACTIVITIES
LEVEL	VERB		
	(Using knowledge, skills, and values in different situations to carry out things)	Use Illustrate Build Complete Check Classify Demonstrate Draw Sketch Predict Prepare Produce Reuse Execute Role play etc.	Carve Demonstration Performance Interview Show Diary Journal
4	**Analyse** (Break down the information to small sections to understand in depth as well as to interrelate between the relevant section)	Break down Differentiate Examine Compare Detect Investigate Categorise Display Evaluate Test Predict	Questionnaire Data Abstract Report Graph Checklist Chart Guidelines

PERFORMANCE STANDARD		VERB IN LEARNING STANDARDS	EXAMPLES OF PUPILS' ACTIVITIES
LEVEL	VERB		
		Making inference Interpret etc.	
5	**Evaluate** (Make judgments and decisions using knowledge, experience, skills and values as well as justification)	Consider Choose Make decisions Give reasons Argue Confirm Suggest Assess Make conclusion Defend Support Determine priorities Predict Make justification etc.	Debate Forum Report Evaluation Investigation Decision Conclusion Speech
6	**Create** (Generate creative and innovative ideas, products or methods)	Upgrade Change Plan Build Suggest Generate Develop Prepare Rearrange	Film Story Project Plan Games Song Media Advertisement Drawing

PERFORMANCE STANDARD		VERB IN LEARNING STANDARDS	EXAMPLES OF PUPILS' ACTIVITIES
LEVEL	VERB		
		Combine Assemble Summarise Produce Invent Sketch etc.	

Note: A verb can be categorized at different Performance Level based on the context of the Learning Standard.

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