Chemistry

Upper Secondary

Teacher Guide

Papua New Guinea
Department of Education

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Acknowledgments

The Upper Secondary Chemistry Teacher Guide was written, edited and formatted by the Curriculum Development Division of the Department of Education. The development of the teacher guide was coordinated

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Contents

Secretary's message

This teacher guide is to be used by teachers of Chemistry when implementing the Upper Secondary Chemistry Syllabus (Grades 11 and 12) throughout Papua New Guinea. The Chemistry syllabus states the learning outcomes and content of the subject as well as assessment requirements. The teacher guide gives practical ideas about ways of implementing the syllabus: suggestions about what to teach, strategies for facilitating teaching and learning, how to assess and suggested assessment tasks.

A variety of suggested teaching and learning activities provide teachers with ideas to motivate students to learn, and make learning relevant, interesting and enjoyable. Teachers should relate learning in Chemistry to real life issues and the local environment. Teaching using meaningful contexts and ensuring students participate in appropriate practical activities enables students to gain deeper knowledge and understanding, and demonstrate skills of chemistry.

As teachers you are expected to recognise the different needs and interests of students who have had substantial achievement already and appropriately involve them working individually and with others in practical, field and interactive activities that are related to the theoretical concepts, by applying investigative and problem solving skills. Encourage students to effectively communicate research based chemical information and appreciate the contribution that chemistry makes to living things, society and the environment.

Teachers of Chemistry must ensure safety measures are taken when students handle chemicals and equipment.

I commend and approve the Chemistry Teacher Guide for use in all schools with Grades 11 and 12 students throughout Papua New Guinea.

DR JOSEPH PAGELIO

Secretary for Education

Introduction

The purpose of this teacher guide is to help you, the teacher of Chemistry to implement the Chemistry syllabus. It is designed to stimulate you to create exciting and meaningful teaching programs and lessons by enabling you to choose relevant and purposeful activities and teaching activities. It will encourage you to research and look for new and challenging ways of facilitating students' learning in Chemistry.

The Chemistry Teacher Guide supports the syllabus. The syllabus states the learning outcomes for the subject and units, and outlines the content and skills that students will learn, and the assessment requirements.

The Chemistry Teacher Guide provides direction for you in using the outcomes approach in your classroom. The outcomes approach requires you to consider assessment early in your planning, and to develop appropriate and relevant activities that assist students to achieve particular learning outcomes. This is reflected in the teacher guide. As a teacher of Chemistry, the ideas, teaching strategies and activities that you use must be accompanied by clear directions for students to achieve learning outcomes.

This teacher guide provides examples of teaching and learning strategies for Chemistry and examples of assessment tasks and activities. It also provides detailed information on criterion referenced assessment, and the resources needed to teach Chemistry. Teaching and learning is focused on student learning. Activities in the classroom, laboratory or excursions are designed to help the students achieve the learning outcomes. The section on recording and reporting shows you how to record students' marks and how to report against the learning outcomes. This teacher guide will enhance your creativity and help you develop high level teaching programmes, and meaningful and interesting lessons.

The outcomes approach

Papua New Guinea's Lower Secondary and Upper Secondary syllabuses use an outcomes approach. The major change in the curriculum is the shift to what students know and can do at the end of a learning period, rather than a focus on what the teacher intends to teach.

An outcomes approach identifies the knowledge, skills, attitudes and values that all students should achieve or demonstrate at a particular grade in a particular subject (the learning outcomes) The teacher is responsible for identifying, selecting and using the most appropriate teaching methods and resources to achieve these learning outcomes.

Education can be seen as the process of preparing a student for adult life. Therefore, the student is on a learning journey, heading to a destination. The destination is the learning outcome, described in the syllabus. The learning experiences leading to the learning outcomes are to be determined by the teacher. The teacher uses curriculum materials, such as syllabus documents and teacher guides, as well as textbooks or electronic media and assessment guidelines to plan activities that will assist students achieve the learning outcomes. The outcomes approach has two purposes. They are to:

- equip all students with knowledge, understandings, skills, attitudes and values needed for future success
- implement programs and opportunities that maximise learning.

Three assumptions of outcomes-based education are that:

- all students can learn and succeed but at their own pace
- success breeds further success
- schools can make a difference by providing student friendly learning environments.

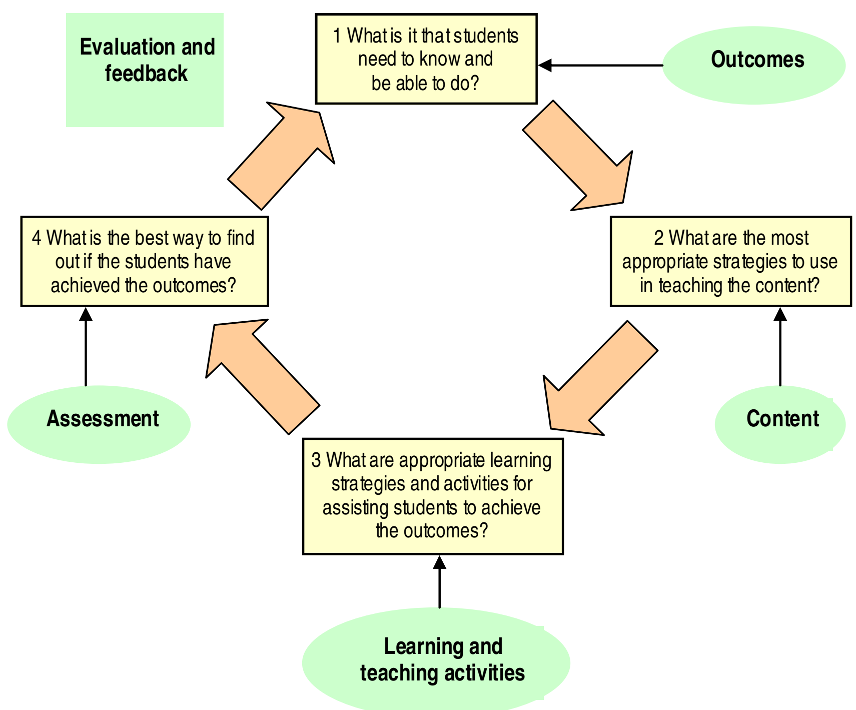
The four principles of the outcomes approach in Papua New Guinea are:

1. *Clarity of focus through learning outcomes*
   This means that everything teachers do must be clearly focused on what they want students to be able to do successfully. For this to happen, the learning outcomes should be clearly expressed. If students are expected to learn something, teachers must tell them what it is, and create appropriate opportunities for them to learn it and demonstrate their learning. Therefore, when framing tasks use cognitive terminology such as 'classify', 'analyse', 'predict', and 'create'.
2. *High expectations of all students*
   This means that teachers reject comparative forms of assessment and embrace criterion-referenced approaches. The principle of high expectations is about insisting that work be at a very high standard before it is accepted as completed, while giving students the time and support they need to reach this standard. At the same time students begin to realise that they are capable of far more than before when they are challenged with higher order thinking, open-ended questions as well as being encouraged and given time to ask questions of each other.
3. *Expanded opportunities to learn*
   This is based on the idea that not all students can learn the same thing in the same way in the same time. Some achieve the learning outcomes sooner and others later. However, most students can achieve high

standards if they are given appropriate opportunities for learning. Therefore provide expanded opportunities for all students by nurturing students' natural curiosity through frequent use of the learning cycle model such as discovery/inquiry, concept introduction and concept application.

4. *Planning and programming by designing down*
   This means that the starting point for planning, programming and assessing must be the learning outcomes—the desired end results. All decisions on inputs and outputs are then traced back from the learning outcomes. The achievement of the outcome is demonstrated by the skills, knowledge and attitudes gained by the student. The syllabus states the content and describes a variety of ways in which students can demonstrate the achievement of learning outcomes.

The diagram below shows the cycle of the outcomes-based approach to teaching and learning



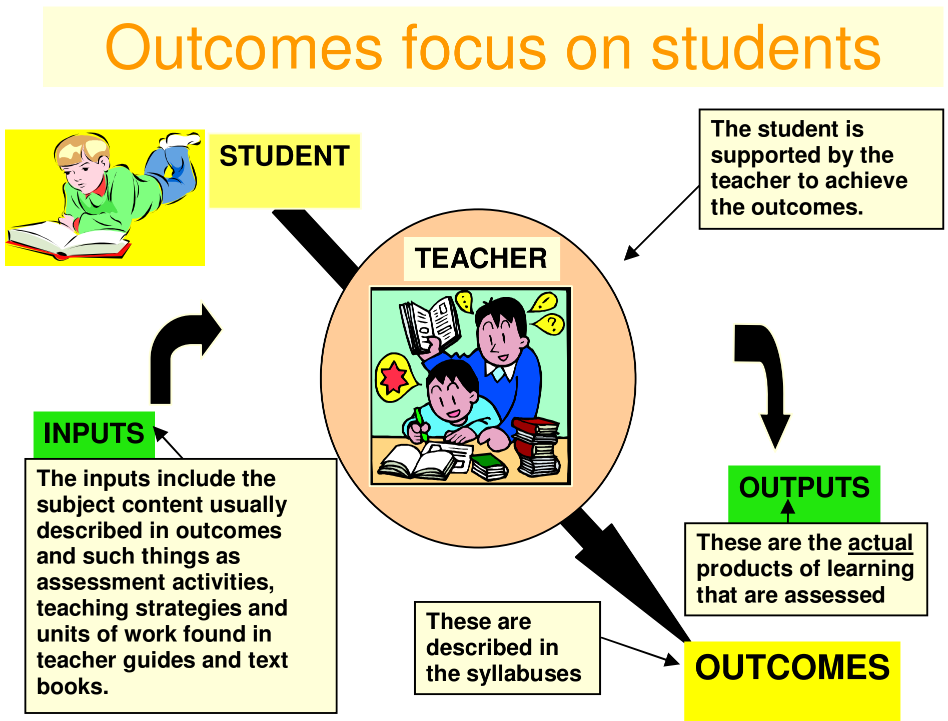
Learning outcomes provide teachers with a much clearer focus on what students should learn. They also give teachers greater flexibility to decide what is the most appropriate way of achieving the learning outcomes and meeting the needs of their students by developing programs to suit local content and involve the community.

The outcomes approach promotes greater accountability in terms of student achievement because the learning outcomes for each grade are public knowledge—available to teachers, students, parents and the community. It is not the hours of instruction, buildings, equipment or support services that are the most important aspect of the education process but rather, what students know and can do, as they progress through each grade.

The outcomes approach means that learning

- has a clearer purpose
- is more interactive between teacher and students, between students
- has a greater local context than before
- is more closely monitored and acted upon by the teacher
- uses the teacher as a facilitator of learning as well as an imparter of knowledge.

*The diagram below summarises what the reform curriculum simply means, that it is student - centred and the teacher is **mainly** the facilitator.*



Learning outcomes

The Chemistry syllabus learning outcomes describe what students know and can do at the end of Grade 12 and. The level of achievement of the learning outcome should improve during the two years of Upper Secondary study. At the end of Grade 12, students have an external examination, the summative form of assessment on the achievement of the learning outcomes. The learning outcomes for Chemistry are listed below.

Students can:

1. demonstrate an understanding of fundamental scientific principles and models
2. apply scientific thinking, motor and process skills to investigate and find solutions to problems
3. communicate findings of scientific investigations in different ways
4. analyse and interpret data, graphs and other forms of information relevant to topics studied
5. analyse and evaluate past and present scientific developments and their impacts on human beings and the environment and on the ethical decisions made
6. demonstrate understanding of traditional knowledge and skills of chemistry practised over many years and explain their relevance today.

Note

These learning outcomes together with the numbers are carried over to the units they are applied. Therefore, the teachers of Chemistry are reminded not to change the numbers of the learning outcomes.

Learning and teaching

You, as a teacher of Chemistry, need to ensure that the content specified in the syllabus is covered adequately. You must teach the knowledge that is included in the syllabus documents. Not only do you have to be able to teach what students should know, you must also be able to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which support learning and teaching. You also need to give students some opportunities to apply their knowledge, to be creative and to solve problems.

> When we like what we are learning we are more likely to maintain interest and move to higher order thinking. If we dislike what we are learning, we tend to stay at minimal levels of processing. Complexity of thinking determines the level of thought we are willing to undertake. Higher order thinking is encouraged by selecting relevant concepts and promoting through stimulating questioning and investigating.

Learning and teaching strategies

Students who participate in guided instruction learn more than students who are left to construct their own knowledge (Mayer 2004) You need to employ a variety of learning and teaching approaches because all students do not learn in the same way. The auditory learner prefers to use listening as the main way of learning new material whereas a visual learner prefers to see things written down. Students should be actively involved in their learning, so you need to design appropriate practical activities or experiments using resources that can be found in your location.

In Grades 11 and 12, students will already have had a wide variety of experiences. You need to make use of your students' experiences when designing and conducting learning in class; learning that is connected to your students' world.

To assist and encourage students to learn, you perform certain tasks. These are referred to as 'teaching strategies'. You need to engage students directly in learning, but there are times when you have to take charge of the learning in the class and teach particular concepts or ideas.

Teaching strategies include:

- group work

- skills practice
- research and inquiry
- class discussions and debates
- problem-solving activities
- teacher talk, instructions, explanations, lectures or reading aloud
- directed question and answer sessions
- audiovisual presentations
- directed assignments
- demonstration and modelling
- guest speakers
- classroom displays.

The most efficient and long-lasting learning occurs when teachers encourage the development of higher-order thinking and critical analysis skills which include applying, analysing, evaluation and creating. Attention should also be paid to developing students' affective and psychomotor skills. To ensure that this occurs you should encourage deep or rich, rather than shallow coverage of knowledge and understanding.

Developing Chemistry skills

Students need to develop chemistry skills and techniques. Skills development should happen as a part of students' learning experiences and the learning and practising of skills needs to take place in the context of visual arts.

Skills learning tends to be most effective when:

- students go from the known to the unknown
- students understand why it is necessary to master specific skills
- skills are developed sequentially at increasing levels of difficulty
- students identify the components of the skill
- the whole skill and the components of the skills are demonstrated
- there are frequent opportunities for practice and immediate feedback
- the skills being taught are varied in terms of amount and type, according to the needs of students
- the skill is used in a range of contexts.

What do students do in Chemistry?

Safety

Teachers of Chemistry must be safety conscious at all times. It is your responsibility for making the laboratory a place where students can work safely. You must take this responsibility extremely seriously. You must let students know of any potential dangers of laboratory work, and must explain what safe practices are required. You must carefully monitor students' practices, and take actions when students behave in an unsafe manner without causing unnecessary fear in students.

The most common types of accidents in the laboratory are:

- chemicals in the eye, on the body, in the mouth and inhalation
- cuts
- burns and scalds
- fainting
- allergies
- electric shocks
- explosions

You as a Chemistry teacher therefore must demonstrate:

- management skills
- appropriate knowledge
- awareness
- an appropriate attitude to safety.

Safety equipment in the laboratory should include:

- a well stocked first aid kit/box/cupboard
- fume cupboards
- a fire extinguisher
- a fire bucket with sand
- fire blanket
- student safety glasses
- disposable gloves
- bottles of eye wash
- separate waste bins for chemicals wastes.

Students learn to understand that safety is paramount. They learn to:

- understand the important roles of ethanol and methanol in society, and the safety requirements, both can kill and damage people;
- describe how electricity works and the safety requirements to avoid being killed even at low currents and low voltages;
- understand the use of safety glasses at most times in a chemical laboratory;
- wear shoes in practical classes as bare feet may be cut by pieces of glass, metal or bone;
- wash and cool with flowing water any injuries especially in the eye, due to chemical burns, hot surfaces, etc;
- realise the presence of dangerous chemicals in homes and schools especially bleaches, acids and bases such as axion, vinegar, battery acid (sulphuric acid) etc;
- realise the danger of burning flammable organic liquids such as petrol, diesel, kerosene etc;
- appreciate that gases can be handled carefully especially when being generated in a chemical reaction such as chlorine, nitrogen, sulphur, sulphur dioxide and nitrogen dioxide;

- understand that most chemical reactions are exothermic and large amounts of heat energy may be released depending on its mass, volume and the type of reaction;
- realise the need to label all containers of chemical substances and also if they are corrosive, flammable and poisonous (if applicable) and their expiratory dates used in schools and stored them safely;
- obtain material safety data sheets (MSDS) from the suppliers of chemicals or from the Internet;
- know that alkalis are corrosive and hence are dangerous to eyes and skin;
- understand that finely divided metals e.g. sodium, aluminium, magnesium, zinc are easily ignited and burn violently;
- realise the need to add acid to water;
- understand internationally accepted safety symbols used in labelling of chemicals.

Laboratory experiments, fieldwork and research

Laboratory experiments, fieldwork and research are essential parts of the study of chemistry that increase meaningful student learning. They facilitate the understanding of scientific inquiry processes and procedures. They can enhance learning opportunities for a wide range of students catering for a variety of learning and teaching approaches.

Laboratory experiments enable students to:

- identify problems; predict; test hypotheses by conducting experiments, observe, record and analyse data
- draw conclusions, recognise errors and make recommendations for improvement
- communicate findings based on evidence
- improve manipulative skills.

Fieldwork enables students to:

- acquire knowledge about chemistry and society through hypothesising, observing, experimenting, measuring and recording phenomena in the real world in a variety of places, including the school
- explore the scientific processes that inform and transform lifestyles
- use different kinds of scientific tools and approaches, including information and communication technology (ICT), to assist in the interpretation of, and decision-making about, scientific phenomena
- locate, select, organise and communicate scientific information
- explore different perspectives on scientific issues and discern between substantiated facts and opinions.

Research enables students to:

- explore various media and sources of obtaining information
- select relevant information and issues and make informed choices
- improve research writing and communication skills
- design and develop models or experiments.

Developing a program

A teaching program outlines the nature and sequence of learning and teaching necessary for students to demonstrate the achievement of the learning outcomes. The content of the syllabus describes the learning context and the knowledge required for the demonstration of each outcome. The relevant learning outcomes for each unit or topic are stated at the beginning of the unit and the requirements of the outcomes are elaborated.

Teachers must develop programs that include appropriate learning activities to enable students to develop the knowledge and skills identified in the outcome statements. The illustration on page 3 gives the cycle of planning that you can follow.

The content prescribed in the units is an indication of the breadth and depth with which topics should be treated. The sequence of teaching is prescribed by the sequence of content on page 7 of the Chemistry syllabus. The learning outcomes and assessment, however, must be central to the planning of the teaching program.

Planning and programming units

The main purpose of planning and programming is to help you to arrange the presentation of the unit in an organised manner. This will help you to know what to teach and when to teach it. It is strongly recommended that you make plans with the other teachers who teach the same subject. By planning together, you will *all* have better lessons and make better use of your limited resources.

Points to consider when programming

- Which outcomes are students working towards?
- What is the purpose of this unit or topic or learning experience?
- Which learning experiences will assist students to develop their knowledge and understandings, skills, and values and attitudes in the subject?
- What are the indicators of student learning that you would expect to observe?
- How can the learning experiences be sequenced?
- How do the learning experiences in the unit relate to students’ existing knowledge and skills?
- How are individual learning needs to be catered for?
- What are the literacy demands of this unit or learning experience?
- What authentic links can be made with the content of other subjects?
- How can school events and practices be incorporated into the program?
- Do the assessment methods address the outcomes and enhance the learning?
- How can the assessment be part of the learning and teaching program?

The planning process

In this teacher guide, ideas for learning and teaching activities and assessment tasks have been provided to help you teach the units. To plan a unit, these steps follow the thinking processes involved in the outcomes approach.

Step 1: Interpreting the learning outcomes

The first step is to read the description in the syllabus and then study the learning outcomes and what students do to achieve the learning outcome, to determine what students will know and be able to do by the end of the unit.

You need to look at the action verb, concept and context of each learning outcome. This will help you see what skills and knowledge are embedded in the outcome.

Step 2: Planning for assessment

It is necessary to plan for assessment early to ensure that you teach the content and skills students need to achieve the learning outcomes.

You will have to decide when to schedule assessment tasks to allow yourself time to teach the required content and time for students to develop the necessary skills. You will also need time to mark the task and provide feedback. Practical tasks may, for example, be broken into a series of stages that are marked over several weeks as students progress with making their product. It is not appropriate to leave all assessment until the end of the unit.

This teacher guide provides performance standards and examples of a marking guide. You should develop marking guides when you are marking tasks to ensure consistency in your assessment. You must also develop clear and detailed instructions for completing the task and make sure all students know exactly what they have to do.

Step 3: Programming a learning sequence

This step requires you to develop a program outlining a sequence of topics and the amount of time spent on each topic. If the unit involves a project, for example, you may plan to teach some theory at appropriate stages during the project, rather than teaching all theory before students start the project.

To develop your program you need to study the topics listed in the syllabus and to think about the learning activities that will best provide students with the opportunity to learn the content and practise the appropriate skills, and how long the activities will take. You will have to think about some major activities that last several weeks and smaller activities that may be completed in a single lesson.

Step 4: Elaboration of activities and content

Once you have mapped out your program for the term, you must then develop more detailed plans for each topic in the unit. All units require students to be actively engaged in learning, not just copying from the board. Make sure you develop a range of activities that suit all learning needs-some reading and writing, some speaking and listening, some observing and doing.

Browse through the textbooks and teaching resources you have access to and list chapters, pages or items that you will use for each topic in your program. The textbooks should also provide you with ideas for activities related to the topic. You may have to collect or develop some resources for yourself. Once you have sorted out your ideas and information, you can then develop your more detailed weekly program and daily lesson plans.

This teacher guide gives some suggested learning and teaching activities for each unit and some suggested assessment tasks, which you might like to use to ensure active learning. It also gives background information on some of the content.

Using the internet for classroom activities

Planning

- Where appropriate, incorporate computer sessions as part of planned learning experiences.
- Be aware that computers can be time-consuming and may require extra teacher support at unexpected times.
- Consider methods of troubleshooting, such as having students with computer expertise designated as computer assistants.
- Design activities that provide the opportunity for students to access, compare and evaluate information from different sources.
- Check protocols, procedures and policies of your school and system regarding the use of the internet.

Managing

- Ensure that all students have the opportunity to explore and familiarise themselves with the technologies, navigation tools, e-mail facilities and texts on the internet. It is likely that students have varying degrees of expertise in searching for information and navigating the internet. Students also have varying experiences and familiarity with the way texts are presented on the World Wide Web.
- Ensure that all students have an understanding of how to access the Internet and how to perform basic functions, such as searching, sending and receiving e-mail.
- Students with more experience in using the internet may have information that will benefit the whole class. Provide opportunities for students to share their experiences, interests, information and understandings. As well as planning lessons to instruct students in these skills, pairing students and peer tutoring on the computer can enable more experienced students to assist other students.
- Ensure that students critically analyse arts information gathered on the internet just as they would for any other text. They should be aware that material posted on the Web is not necessarily subject to the conventional editorial checks and processes generally applied to print-based publications. When evaluating information, students might consider:
  - the intended audience of the site
  - bias in the presentation of information, or in the information itself, including commercial or political motives
  - accuracy of information
  - balanced points of view
  - currency of information, including publishing dates
  - authority of source or author (institution, private individual)
  - ownership of the website (such as corporate, small business, government authority, academic
  - cultural or gender stereotyping.
- Ensure that software and hardware (computer, modem) are maintained in good working order.

- Ensure that all students are given equal opportunities to use the computer.

Assessing student work containing material from the internet

- Students can download large quantities of information from the internet. By itself, this information provides very little evidence of student effort or student achievement. Students must make judgements about the validity and safety of information when working from the World Wide Web. They must consider the purpose of the text, identify bias and consider the validity of arguments presented and the nature and quality of the evidence provided.
- When assessing student work that includes material drawn from the internet, it is important to recognise how students have accessed the information, what value they place on it and how they have used it for the particular unit being studied in class. It is useful to look for evidence of critical evaluation, and the development of students' capacities to access, manipulate, create, restore and retrieve information.

Chemistry requirements

There are five units in Grade 11 which all students must complete. There are five units in Grade 12 which all students must complete. There are also two assessment tasks which must be completed by students.

Grade	Weeks	Term	Unit	Essential resources for activities and assessment
11	6-7	1	Application of physical processes	Glass tube, cork, thermometer (110℃) distillation kit, magnet, centrifuge, beaker, test tube, filter paper, separating funnel, concentrated hydrochloric acid, concentrated ammonia, soluble salt.
	6-7		Chemical and Metallic Bonding	Models, plasticine and clay to make models, potassium permanganate, carbon tetrachloride, sodium chloride, naphthalene
11	6-7	2	Chemical and Metallic Bonding	Models, plasticine and clay to make models, potassium permanganate, beaker.
	6-7		Types of Chemical Reactions	Magnesium ribbon, iron, zinc, copper sulfate, hydrochloric acid, silver nitrate, beaker, test tube, safety glasses, gloves, soap to wash hands, Bunsen burner, thongs, test tube holder, gauze
11	6-7	3	Types of Chemical Reactions	Magnesium ribbon, iron, zinc, copper sulfate, diluted hydrochloric acid, silver nitrate, beaker, test tube, safety glasses, spatula, water, gloves, soap to wash hands, Bunsen burner, thongs, test tube holder, gauze
			Energy and Reaction Rates	Calcium carbonate, magnesium ribbon, hydrochloric acid, thermometer (110℃), gas syringe, balance, stop watch, safety glasses, gloves, soap to wash hands, conical flask, glass tubes, Bunsen burner, conical flask, thongs, gauze
11	6-7	4	Metals and Non-metals	Sodium, magnesium, iron, copper, zinc, lead, tin, Bunsen burner thongs, watch glass, hydrochloric acid, safety glasses, gloves, thongs
12	7-8	1	Masses, Moles and Concentrations	Balance, silver nitrate, potassium iodide, copper sulfate, potassium hydroxide, filter paper, spatula, beaker, safety glasses, gloves
	4-5		Acids, Bases and Salts	Hydrochloric acid, sulfuric acid, nitric acid, burette, pH meter, conductivity meter, ammeter phenolphthalein, methyl orange, litmus, safety glasses. beaker, test tubes, safety glasses, conical flask
12	5-6	2	Electrochemistry	Power pack, dry cell, connecting wires, Hofmann Voltameter, carbon electrodes, copper rod, zinc rod, iron rod, hydrochloric acid, copper sulfate, zinc sulfate.
	6-7		Carbon Compounds	Models, plasticine or clay to make models of carbon compounds, safety boots safety helmets, safety glasses, hand lenses for field trips
12	9-10	3	Natural Resources and Chemical industries in Papua New Guinea	Coconut, cooking oil, sodium hydroxide, lemon grass, rose wood oil, beaker, measuring cylinder
12	5	4	Revising Examinations.	Not applicable.

Assessing Chemistry

Assessment measures students' achievement of the learning outcomes described in the syllabus. Assessment is an integral part of learning and teaching. It is used to:

- evaluate and improve learning and teaching
- report achievement
- provide feedback to students on their progress
- provide feedback to stakeholders.

Criterion-referenced assessment

Assessment in Chemistry is criterion-referenced and measures students' achievement of the learning outcomes described in the syllabus. In criterion-referenced assessment, particular knowledge, skills or abilities are specified as criteria that must be achieved. The extent to which they are achieved is assessed and facilitated by the teacher.

Criterion-referenced assessment often takes on a problem-centred orientation, rather than a knowledge-based orientation. To achieve an outcome means having to demonstrate the attainment of skills and attitudes, not just write about them. Assessment becomes more than just a means of judging knowledge and performance—it becomes an integral part of the learning process itself.

Criterion-referenced assessment is:

- standards or criterion-referenced; outcomes are judged against pre-defined standards (see table below)
- direct and authentic, related directly to the learning situation. This has the potential for motivating learning, since students can see a direct relevance between what is learnt and what is assessed.

Norm-referenced assessment

'Norm-referenced' assessment makes judgments on how well the student did in relation to others who took the test. It is often used in conjunction with a curve of 'normal distribution', which assumes that a few will do exceptionally well and a few will do badly and the majority will peak in the middle, normally judged as average.

Example of a criterion-referenced test

The driving test is the classic example of a criterion-referenced test. The examiner has a list of criteria, each of which must be satisfactorily demonstrated in order to pass; for example, completing a three-point turn without hitting either kerb. The important thing is that failure in one criterion cannot be compensated for by above-average performance in others; nor can a student fail in spite of meeting every criterion (as they can in norm-referenced assessment) simply because everybody else that day surpassed the criteria and was better than him or her.

Criterion-referenced assessment has the following characteristics:

- a syllabus that describes what students are expected to learn in terms of aims, outcomes and content
- a syllabus that provides a clear sense of the syllabus standards through its aims, outcomes and content
- tasks designed to produce an image of what students have achieved at that point in the learning and teaching process relative to the outcomes
- standards of performance at different levels: the ‘performance standards’
- a report that gives marks referenced to predetermined standards
- assessment tasks that refer to syllabus outcomes, content, assessment components and component weightings.
- assessment that is better integrated with learning and teaching.

Assessment *for* learning

Assessment *for* learning is often called ‘formative assessment’. It is assessment that gathers data and evidence about student learning during the learning process. It enables you to see where students are having problems and to give immediate feedback, which will help your students learn better. It also helps you plan your program to make student learning, and your teaching, more effective. Often it is informal—students can mark their own work or their friend’s. An example is a quick class quiz to see if students remember the important points of the previous lesson.

Assessment *of* learning

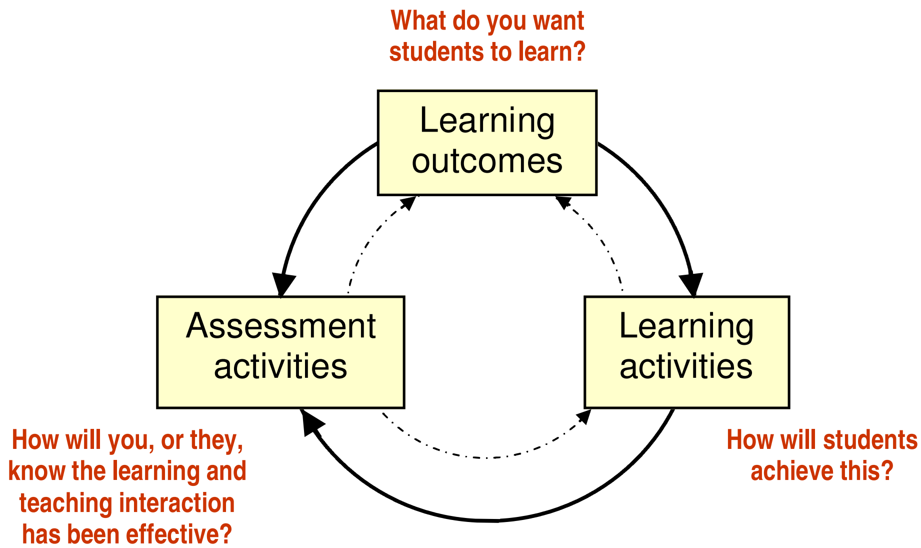
Assessment *of* learning is often called ‘summative assessment’. It is used to obtain evidence and data that shows how much learning has occurred, usually at the end of the term or unit. End-of-year examinations are examples of summative assessment. It is usually done for formal recording and reporting purposes.

Assessing Chemistry units

In Chemistry the learning outcomes are assessed using the range of assessment methods specified in the syllabus. During the year you must set assessment tasks which ensure that all the learning outcomes of the subject have been assessed internally.

In deciding what to assess, the first point to start is: ‘what do you want students to do and/or learn?’ and, following from this: ‘how will the students engage with the material?’ which leads to the design and development of learning tasks and activities. It is crucial that at this point the assessment tasks clearly link back to the learning outcomes and are appropriate for the learning activities. The assessment can be used for formative and summative purposes. Assessment can be represented as follows:

The assessment process



Once it is clear what needs to be assessed and why, then the form the assessment will take needs to be determined. There are many types of assessment tasks that can be implemented; the factors that will determine choices include:

- the students - how many are there, what is expected of them, how long will the assessment task take?
- the learning outcomes of the subject and how they might be best achieved

During the year you must set assessment tasks, which ensure that all the learning outcomes of the subject have been assessed internally. Each task you set must include assessment criteria that provide clear guidelines to students as to how, and to what extent, the achievement of the learning outcomes may be demonstrated.

Marking guides and assessment criteria help you with the marking process and ensure that your assessment is consistent across classes. It is important that marking guides and assessment criteria are collectively developed.

Students must complete the assessment tasks set. Each task must provide clear guidelines to students for how the task will be completed and how the criteria will be applied.

When you set a task make sure that:

- the requirements of the task are made as clear as possible to the student
- the assessment criteria and performance standards or marking guides are provided to student so that they know what it is that they have to do
- any sources or stimulus material used are clear and appropriate to the task
- instructions are clear and concise
- the language level is appropriate for the grade
- it does not contain gender, cultural or any other bias
- materials and equipment needed are available to students
- adequate time is allowed for completion of the task.

Assessment methods

Although assessment methods and weightings are stipulated in the syllabus, you decide which assessment method to use when assessing the learning outcomes. You should use a variety of assessment methods to suit the purpose of the assessment.

Assessment can be classified into four categories:

- tests
- product or project assessments – including group projects
- performance assessments – individual practical skills assessment
- process skills assessments.

Because each has limitations, maintaining a balance of assessment methods is very important.

Tests

A 'test' is a formal and structured assessment of student achievement and progress, which the teacher administers to the class.

Tests are an important aspect of the learning and teaching process if they are integrated into the regular class routine and not treated merely as a summative strategy. They allow students to monitor their progress and provide valuable information for you in planning further learning and teaching activities.

Tests will assist student learning if they are clearly linked to the outcomes. Evidence has shown that several short tests are more effective for student progress than one long test. It is extremely important that tests are marked and that students are given feedback on their performance.

There are many different types of tests. Tests should be designed to find out what students know and about the development of thinking processes and skills. Open questions provide more detailed information about achievement than a question to which there is only one answer.

Principles of designing classroom tests

Tests allow a wide variety of ways for students to demonstrate what they know and can do. Therefore:

- students need to understand the purpose and value of the test
- the test must assess intended outcomes
- clear directions must be given for each section of the test
- the questions should vary from simple to complex
- marks should be awarded for each section
- the question types (true or false, fill-in-the-blank, multiple-choice, extended response, short answer, matching) should be varied.

Tests should:

- be easy to read (and have space between questions to facilitate reading and writing)
- reflect an appropriate reading level
- involve a variety of tasks
- make allowance for students with special needs

- give students some choice in the questions they select
- vary the levels of questions to include gathering, processing and applying information
- provide sufficient time for all students to finish.

Product or project assessments

A ‘project’ can be an assessment task given to an individual student or a group of students on a topic related to the subject. The project results in a ‘product’ that is assessed. The project may involve both in-class and out-of-class research and development. The project should be primarily a learning experience, not solely an assessment task. Because a great deal of time and effort goes into producing a quality product from a project assignment task, you should allow class time to work on the project.

A product or project:

- allows the students to formulate their own questions and then try to find answers to them
- provides students with opportunities to use their multiple intelligences to create a product
- allows teachers to assign projects at different levels of difficulty to account for individual learning styles and ability levels
- can be motivating to students
- provides an opportunity for positive interaction and collaboration among peers
- provides an alternative for students who have problems reading and writing
- increases the self-esteem of students who would not get recognition on tests or traditional writing assignments
- allows for students to share their learning and accomplishments with other students, classes, parents, or community members
- can achieve essential learning outcomes through application and transfer.

Assignments

‘Assignments’ are unsupervised pieces of work that often combine formative and summative assessment tasks. They form a major component of continuous assessment in which more than one assessment item is completed within the term. Any of the methods of assessment can be set as assignments, although restrictions in format, such as word limits and due dates, are often put on the assessment task to increase their practicality.

Investigations

An ‘investigation’ involves students in a study of an issue or a problem. Teachers of Chemistry may guide students through their study of the issue; or individual students, or groups of students, may choose and develop an issue in negotiation with the teacher. The emphasis in this assessment component is on the student’s investigation of the issue in its context by researching, identifying the issues or problems, collecting, analysing and commenting on secondary data and information. Students should be encouraged to consider and explore a variety of perspectives as they develop and state their position on the issue. Students may present the final investigation for assessment in a variety of forms, including one or a combination of the following: a written scientific report, an oral presentation, a website, linked documents, multimedia, a video or audio recording.

Criteria for judging performance

The student's performance in the investigation will be judged by the extent to which the student:

- identifies and describes the issue or problem
- states a hypothesis
- describes and explains the causes and effects
- records and appropriately processes data
- critically analyses processed information and outlines possible steps leading to a solution or recommendation
- acknowledges errors and suggests alternatives.

Computer-based tasks

Using computers to administer student assessment can provide flexibility in the time, location or even the questions being answered of students. The most common type of computer-based assessment is based on multiple-choice questions, which can assist teachers to manage large volumes of marking and feedback.

Types of assessment tasks

Using different assessment tasks is the way to make sure that students are able to demonstrate the range of their abilities in different contexts. Each category has advantages in assessing different learning outcomes. For example, a selected response assessment task, such as a series of multiple-choice questions, is able to assess all areas of mastery of knowledge but only some kinds of reasoning.

Assessment ideas for individual students or groups

Tests	Products or projects	Performances	Process skills
Multiple-choice Short answer Practical Extended response	Case studies Displays Graphs, charts, diagrams Lab reports Models Product descriptions Projects Research papers	Cooperative learning group activities Demonstrations Field trips Laboratory experiences Presentations	Investigations Estimation Experiments Classification Measurement Prediction Manipulation of equipment Safety procedures and processes

Feedback

When you assess the task, remember that feedback will help the student understand why he or she received the result and how to do better next time. Feedback should be:

- *constructive*, so that students feel encouraged and motivated to improve
- *timely*, so that students can use it for subsequent learning
- *prompt*, so that students can remember what they did and thought at the time
- *focused on achievement*, not effort. Assess the work, not the student
- *specific to the unit learning outcomes*, so that assessment is clearly linked to learning.

Types of feedback

Feedback can be:

- *informal or indirect*: such as verbal feedback in the classroom to the whole class, or person to person
- *formal or direct*: in writing, such as checklists or written commentary to individual student either in written or verbal form
- *formative*: given during the topic with the purpose of helping the student know how to improve
- *summative*: given at the end of the topic with the purpose of letting the students know what they have achieved.

Who assesses?

Teacher assessment

Assessment is a continuous process. You should:

- always ask questions that are relevant to the outcomes and content
- use frequent formative tests or quizzes
- check understanding of the previous lesson at the beginning of the next lesson, through questions or a short quiz
- constantly mark or check the students' written exercises, class tests, homework activities and so on
- use appropriate assessment methods to assess the tasks.

Frequency of assessment

Schedule specific assessment tasks to fit in with teaching the content of each unit being assessed. Some assessment tasks might be programmed to be undertaken early in the unit, others at the end of the unit. You should take care not to overload classes with assessment tasks at the end of the term.

Judging student performance

Student achievement is recorded and reported against standards. You must use performance standards or marking guides—examples of which are provided in this teacher guide—when making a decision about the achievement of your students in relation to the learning outcomes. The performance standards describe the level at which the student has to be working to achieve a particular standard or mark. Students should always have access to a copy of the assessment criteria and performance standards so that they know what it is they have to know and be able to do to get a good mark in a particular task. The performance standards will help you in your marking and will help your students improve their performance. They are useful when providing feedback to students as they explain what the student needs to do to improve.

Moderation

To make sure that you are interpreting the performance standards correctly when assessing your students, it is important to undertake Chemistry moderation of student work within your school and with teachers of nearby schools. To moderate student work, a common assessment task must be used and a marking scheme developed so that all students complete the same task under the same conditions, and all teachers use the same marking scheme. Teachers can then compare (moderate) the students' work and come to a common understanding of the performance standards and the requirements for a particular mark or level of achievement. Moderation enables you to be sure that your understanding of the required standards for levels of achievement is similar to the understanding of other teachers and that you are assessing students at the appropriate level.

Self-assessment and peer assessment

Self-and peer assessment helps students to understand more about how to learn. Students should be provided with opportunities to assess their own learning (self-assessment) and the learning of others (peer assessment) according to set criteria. Self-assessment and peer assessment:

- continue the learning cycle by making assessment part of learning
- show students their strengths and areas where they need to improve
- engage students actively in the assessment process
- enable students to be responsible for the learning
- help to build self-esteem though a realistic view of their abilities
- help students understand the assessment criteria and performance standards.

Managing assessment tasks for Chemistry

Usually, the marking of assessment tasks is done by the teacher. To reduce the amount of work it is necessary to develop a strategic approach to assessment and develop efficiencies in marking. In Chemistry there are a number of assessment tasks that may be new to teachers and students. Below are suggestions on how to manage some of these tasks to minimise marking or presentation time.

Develop efficiency in marking

Clarify assessment criteria

Plan the assessment task carefully, and ensure that all students are informed of the criteria before they begin. Discuss the task and its criteria in class, giving examples of what is required. Distribute a written copy of the instructions and the criteria, or put them on the board. Making the assessment criteria explicit speeds marking and simplifies feedback.

Supply guidelines on what is required for the task

This reduces the amount of time that may be wasted evaluating student work that is irrelevant.

Use attachment sheets such as marking guides

An assignment attachment sheet, which is returned with the assessed work, rates aspects of the task with a brief comment. Such a system enables each student's work to be marked systematically and quickly. This strategy can be applied to posters, presentations and performances.

Assess in class

Use class time to carry out and to assess tasks. Performances or art works, marked by you or the students, enable instant developmental evaluation and feedback. Brief assessments of projects, stages of the design process, or practical work take less time to mark and are useful because they give immediate feedback to students on their progress and allow you to mark the project in stages with minimum effort.

Give feedback to the whole class

Feedback to the whole class can cut down on the amount of individual feedback required. On returning assessed work, emphasise the criteria for judging the work, discuss the characteristics of good and bad answers, and highlight common strengths and weaknesses.

Set group work alternatives

Assess one performance per group. The student's mark is the group mark, but may include a component based on the contribution of the individual. A strategy for allocating an individual mark includes each member of the group using criteria to evaluate the relative contributions of individuals, with the marks averaged for the individual.

Set clear deadlines

Set aside a time for marking. Be careful about extending this period (by allowing students to hand in work late)

Shift the responsibility

Introduce self-assessment and peer assessment

Develop in students the skills to evaluate their own work and that of their peers. With the students, use the assessment criteria against which work is judged, highlighting strengths and weaknesses. Self-assessment increases the amount of feedback students get. It can supplement or replace teacher assessment.

Treat each task differently

Every piece of work need not be evaluated to the same degree; a mark need not be the outcome in every case; and not every piece of student work needs to contribute to the final grade. Assessment is designed to enhance the learning and teaching experience for the teacher and the learner, not just to give marks.

Learning activities and assessment tasks

Examples of learning activities and assessment tasks for each units are provided in the following sections. Some examples are explained in detail.

Grade 11 units

11.1 Application of Physical Processes

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- Investigate diffusion of potassium permanganate in water
- Investigate diffusion of ammonia and hydrogen chloride gas in an enclosed tube
- Investigate and collect data on the melting and boiling points and plot heating and cooling curves
- Use Grahams Law to calculate an unknown
- Use Gas Laws to calculate an unknown
- Identify and classify pure and impure substances as elements, compounds and mixtures
- Use suitable separation techniques to separate mixtures
- Plot and interpret solubility curves and calculate solubility

Elaboration of content

Activity	Elaboration
Investigate diffusion of ammonia and hydrogen chloride gas in an enclosed test tube	Demonstrate the experiment in a fume cupboard. The students observe and discuss the reaction.
Investigate and collect data on the melting and boiling points and plot heating and cooling curve.	Pre-prepare ice, solid mixture of water and salt (salt solution) In groups, students measure melting point of ice and solid mixture of water and salt. Then measure boiling point of water and salt solution. Use the above results to differentiate between pure and impure substances.
Use Grahams, Boyles, Charles, Combined Gas Law and Ideal Gas Law to calculate the unknown.	Introduce to students the concept of Gas Law.This activity is mainly theory where relevant values are substituted into the respective equation to calculate the unknown quantity.
Use suitable separation techniques to separate mixtures.	Students use appropriate separation techniques to separate various mixtures.

Suggested assessment tasks

Practical: Physical changes - pure and impure substances

- measure melting and boiling points of pure substances
- measure melting and boiling points of impure substances
- compare the melting and boiling point of pure and impure substances
- describe the steps to separate a mixture
- determine pure and impure substances using the melting point and the boiling point
- Discuss with students the weighting of each criterion so that the students will see the importance of managing their time giving more time to criteria that have more marks.

Assessment criteria

Students will be assessed on the extent to which they can:

- identify information(data) and equipment needed for the investigation
- use terms such as hypothesis, observation, conclusion
- tabulate and analyse data /experimental results
- plan and follow the correct order of steps to carry out and report on the investigation
- evaluate the processes and procedures used
- use appropriate mathematical formulas to solve chemistry problems

Note: Assessment tasks must be given to students together with the assessment criteria.

11.1: Physical changes - pure and impure substances				15 marks
Performance Criteria	**Very High Achievement (14–15 marks)**	**High Achievement (11–13 marks)**	**Satisfactory Achievement (7–10 marks)**	**Low Achievement (0–9 marks)**
Identify information (data) and equipment needed for the investigation (2 marks)	Identify all the appropriate information and equipment required before the investigation (2 marks)	Identify most of the appropriate information and equipment required before the investigation (2 marks)	Identify some of the appropriate information and equipment required before the investigation (1-2 marks)	Identify a few aspect of the appropriate information and equipment required before the investigation (0-1 mark)
Use terms such as hypothesis, observation, conclusion etc (3 marks)	Identify and use all the scientific terms like hypothesis, observation, conclusion appropriately in their investigation and scientific report (3 marks)	Identify and use most of the scientific terms like hypothesis, observation, conclusion appropriately in their investigation and scientific report (2-3 marks)	Identify and use some of the scientific terms like hypothesis, observation, conclusion appropriately in their investigation and scientific report (1-2 marks)	Identify and use a few of the scientific terms like hypothesis, observation, conclusion appropriately in their investigation and scientific report (0-1 mark)
Tabulate and analyse data /experimental results. (3 marks)	Organise, interpret and present data in a wide range(4-5) of forms (3 marks)	Organise, interpret and present data in a wide range(3-4) of forms (2-3 marks)	Organise, interpret and present data in a wide range(2-3) of forms (1-2 marks)	Organise, interpret and present data in a wide range (0-2) of forms (0-1 mark)
Plan and follow the correct order of steps to carry out and report on an investigation (3 marks)	Use scientific investigation format and follow fully the structure when presenting a scientific report (3 marks)	Use scientific investigation format and follow most aspects of the structure when presenting a scientific report (2-3 marks)	Use scientific investigation format and follow some aspects of the structure when presenting a scientific report (1-2 marks)	Use scientific investigation format and follow few aspects of the structure when presenting a scientific report (0-1 mark)
Evaluate the processes and procedures used (2 marks)	Identify all possible sources of error in the processes and procedures used and list ways of using them (2 marks)	Identify most sources of error in the processes and procedures used and list ways of using them (2 marks)	Identify some sources of error in the processes and procedures used and list ways of using them (1-2 marks)	Identify 1 or 2 sources of error in the processes and procedures used and list ways of using them (0-1 mark)
Use appropriate mathematical formulas to solve chemistry problems (2 marks)	Select, apply, manipulate substitute and operate appropriate maths formulae correctly to solve science problems (2 marks)	Select, apply, substitute and operate appropriate maths formulae correctly to solve science problems (2 marks)	Select, apply, and operate appropriate maths formulae correctly to solve science problems (1-2 marks)	Select, apply, and operate only one appropriate maths formulae correctly to solve science problems (0-1 mark)

Assignment: Calculations using solubility curves

- solve various questions using a solubility curve

Test or assignment

Extended answer, multiple choice or short answers

Suggested topics:

Explain the diffusion of solids in water and diffusion of gases.

Use Grahams Law to calculate an unknown quantity.

Use Gas Laws to calculate an unknown quantity.

Identify and differentiate between pure and impure compounds.

Interpret heating and cooling curves.

Identify suitable methods of separating mixtures.

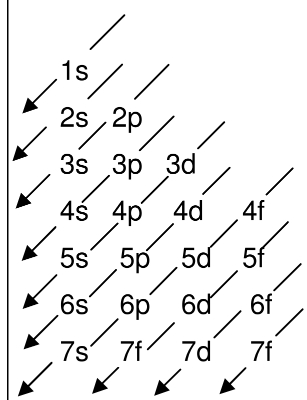
Solve solubility questions using given data and solubility curve.

11.2 Chemical and Metallic Bonding

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- draw electronic shell diagrams of atoms and ions
- discuss the trends in the Periodic Table
- draw shell diagrams to show formation of ionic and covalent compounds
- use modules to construct simple molecules
- list properties of ionic and covalent compounds
- discuss allotropes of carbon
- discuss properties of metallic bond
- investigate properties of ionic, covalent and metallic compounds.

Activity	Elaboration
Write electron configuration of atoms using s,p,d and f sub shells.	Students use the octet rule below to fill the sub shells.  Students use the octet rule to allocate electrons into the sub shells of atoms of the first 30 elements.
Discuss the trends in the Periodic Table.	Students use the Periodic table to explain the trends.
Discuss allotropes of carbon	Students discuss the structure of carbon and graphite with their physical properties.
Investigate properties of ionic, covalent and metallic compounds.	Students investigate and analyse melting points, boiling points, solubility in water and other organic solvents and conductivity to identify the type of bonding.

Practical activities

The teacher must identify relevant practical activities depending on resources and class size.

Practical activities or assessment task can be organised as follows:

1. Organise 10-15 small stations (round robin) for all students (1-2 marks each depending on the nature of each activity) For marking, you must use the assessment criteria and performance standard prescribed.
2. Completion of experiment at each station must be timed (3-4 minutes)
3. Check that all stations set up are left in order before the next class

The student

This assessment task requires the students to do the following:

1. Carefully follow all the instructions given by the teacher.
2. Within the given time limit (3-4 minutes per station), begin at one station and move to the next station clockwise until you complete all labelled activities at each station.

3. Reset completed stations before moving onto the next station.
4. Hand in the completed practical test paper and leave quietly.
5. Leave things as they are for the next class.

Suggested assessment tasks

Practical – Properties of Ionic, covalent and metallic structures

Assessment criteria

Students will be assessed on the extent to which they can:

- investigate the general physical properties of ionic, covalent and metallic substances.
- investigate the general chemical properties of ionic and covalent substances.
- differentiate between ionic, covalent and metallic substances.
- classify substances as ionic, covalent or metallic.

Test

Extended answer, multiple choice or short answers

Suggested topics

Draw diagrams showing shells and sub shells (s,p,d and f) of any of the first 30 elements.

Explain the trends in the periodic table.

Compare and explain the properties of ionic, covalent and metallic substances.

Draw shell diagrams of atoms, ions, ionic compounds and covalent molecules

Describe the structure and the properties of diamond and graphite.

Compare simple molecular compounds and giant (network) covalent structures.

11.3 Types of Chemical Reactions

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- list indicators of chemical changes.
- investigate different types of chemical reactions.
- write word equations

- write balanced chemical and ionic equations with states
- discuss oxidation-reduction reaction
- discuss and investigate exothermic and endothermic reactions

Activity	Elaboration
Discuss and list types of exothermic and endothermic reactions.	Students experiment and analyse simple experiments to illustrate an exothermic and endothermic reaction. Students then discuss different types of chemical reactions and classify as exothermic of endothermic reactions.

Suggested assessment tasks

Practical experiment – Displacement reactions

Assessment criteria

Students will be assessed on the extent to which they can:

- demonstrate observational skills
- describe changes in colour, evolving of gases and forming of precipitates
- tabulate results

Test or assignment

Suggested topics

Identify different types of chemical reactions.

Write the word and balanced chemical equations.

Write ionic and net ionic equations.

11.4 Energy and Reaction Rates

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- list and discuss the factors affecting rates of chemical reactions
- investigate how these factors affect the rate of a chemical reaction
- draw and interpret energy level diagram of exothermic and endothermic reactions
- draw and interpret energy level diagram of a reversible reaction

- draw and interpret energy level diagram of a chemical reaction with and without catalyst

Activity	Elaboration
Investigate how concentration, surface area, catalyst, temperature and pressure affects the rate of a chemical reaction	Construct experiments to measure the time needed for a reaction to be completed. Where possible construct experiments to measure the amount of product produced to determine the rate of the reaction.
Calculate the bond energy.	Students calculate the enthalpy change (ΔH) of a reaction using the bond energies.

Suggested assessment tasks

Practical experiment – Measuring the volume (cm^3) of hydrogen gas or mass

Assessment criteria

Students will be assessed on the extent to which they can:

- use laboratory apparatus correctly to obtain accurate measurements
  - use the gas syringe and the electronic weighing machines correctly
- tabulate results and draw graphs to represent the rates of reactions
- interpret rates graphs

Test or assignment

Suggested topics

Define and differentiate exothermic and endothermic reactions.

Draw and explain the graphs representing rate of reactions.

Draw and interpret energy level diagrams.

Define activation energy and enthalpy change.

Calculate the amount of energy in joules representing activation energy and enthalpy change from energy level diagrams.

Explain what happens to the value of activation energy and enthalpy change when catalyst is added.

Explain factors affecting rate of reaction.

11.5 Metals and Non-metals

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- investigate properties of metals and non-metals
- discuss properties of metals and non-metals
- discuss important uses of metals and non-metals
- discuss important uses of alloy
- discuss the chemistry of nitrogen and nitrogen compounds
- discuss the chemistry of sulfur and sulfur compounds
- discuss the chemistry of phosphorus and phosphate fertilizers
- discuss chemistry of halogens

Activity	Elaboration
Discuss the chemistry of nitrogen	In groups or individuals, research and discuss the element nitrogen. Discuss the structure, physical and chemical properties, natural occurrence, and importance of nitrogen. Students research nitrogen compounds and the production of ammonia in the Haber Process. Students discuss environmental issues where nitrogen fertilizers are being used.
Discuss the chemistry of sulphur and sulphur compounds.	In groups or individuals research and discuss the element sulphur. Discuss the structure, physical and chemical properties, natural occurrence, allotropes and importance of sulfur. Students research sulfur compounds and discuss environmental issues associated with sulphur compounds such as acid rain.
Discuss the chemistry of phosphorus	In groups or individuals, research and discuss the element phosphorus. Discuss the structure, physical and chemical properties, natural occurrence, and importance of phosphorus. Students research phosphorus compounds and the production of fertilizer containing phosphorus. Students discuss environmental issues where phosphorus fertilizers are being used.
Discuss the chemistry of halogens	In groups or individuals, research and discuss fluorine, chlorine, bromine and iodine. Discuss the physical and chemical properties, natural occurrence, and their importance. Students research their compounds and discuss environmental issues associated with their compounds.

Suggested assessment tasks

Practical Skills – Reaction of metals with acid, air and water.

Assessment criteria

Students will be assessed on the extent to which they can:

- use laboratory apparatus correctly to obtain accurate measurements
- describe the physical and chemical properties of metals and non metals
- demonstrate an understanding of the reaction of metals with acids, air and water.

Test or assignment

Suggested topics

Explain the composition and importance of some alloys.

Describe the nitrogen cycle.

Describe the environmental effects of the fertilizers.

Explain acid rain.

Outline the production of nitrogen and phosphorus fertilizers.

List properties of halogens and their compounds.

Grade 12 units

12.1 Masses, Moles and Concentrations

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- list elements of the Periodic Table and their known isotopes and calculate the relative atomic masses of these isotopes.
- conduct exercises involving calculation of relative formula mass, relative molecular mass, percentage composition in compounds, moles and the significance of Avogadro number.
- conduct exercises to calculate the empirical and molecular formula.
- conduct exercises to compare masses or volumes of products (solids, liquids, gases) formed by a chemical reaction with the mass or volume calculated from the equation at room temperature and pressure (rtp) or at standard temperature and pressure (stp)
- prepare standard solutions and dilute them to required concentration using the equation $C_1V_1 = C_2V_2$.

Activity	Elaboration
Prepare exercises involving calculation of relative formula mass, relative molecular mass, percentage composition in compounds, moles and the significance of Avogadro's number.	Teachers do an example on each type of calculation and give exercise for the students to do.
List elements of the Periodic Table and their known isotopes and calculate the relative atomic masses of these isotopes.	Students calculate the relative atomic mass (RAM) by multiplying the percentage composition by the mass of each isotope.

Suggested assessment tasks

Practical Skills – Preparation of solutions

Assessment criteria

Students will be assessed on the extent to which they can:

- demonstrate an understanding of the techniques of preparing solutions
- demonstrate an understanding of the techniques of making dilute solutions from stock (standard) solutions
- conduct a precipitate reaction and measure the actual and the theoretical mass of precipitate formed
- calculate the percentage error and explain the reason for the error.

Test or assignment

Suggested topics

Define isotopes, relative atomic mass, moles, Avogadro number, empirical and molecular formula.

Calculate relative atomic mass, percentage abundance of isotopes, relative molecular and formula masses.

Calculate moles of substances in a given solution.

Calculate empirical and molecular formula.

Calculate amount of reactants and products from a reaction.

12.2 Acids, Bases and Salts

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- define Arrhenius, Bronsted-Lowry and Lewis definition of acids and bases and their properties
- conduct calculations to show the difference between strong and weak acids and bases using pH and pOH
- conduct volumetric analysis by titrating acids against bases using an indicator/pH meter/conductivity meter/ammeter, perform necessary calculations and plot appropriate curves

Activity	Elaboration
Do calculations to show the difference between strong and weak acids and bases using pH and pOH	Students calculate pH of monoprotic, diprotic and triprotic acids using the equation: $pH = -\log [H^+]$
Conduct volumetric analysis by titrating acids and bases using an indicator/pH meter/conductivity meter/ammeter perform necessary calculations and plot appropriate graphs.	Student use phenolphthalein and methyl orange to determine the end point. Students determine conductivity by using a conductivity meter or an ammeter. Use data collected to draw graphs to obtain volume to determine concentration.

Suggested assessment tasks

Practical – Acid - Base titration

Assessment criteria

Students will be assessed on the extent to which they can:

- prepare standard solutions
- measure the volumes of solutions
- use a burette
- calculate the concentration of an unknown solution.

Assignment - Types of acids and pH calculations

Assessment criteria

Students will be assessed on the extent to which they can:

- write balanced chemical equations for complete and incomplete neutralization of acids and bases
- calculate pH and pOH of solutions.

Test or assignment

Suggested topics

Use Arrhenius', Bronsted – Lowry and Lewis definitions to define acids and bases.

Explain the differences between strong and weak acids and bases.

Explain the differences between concentrated and dilute acids and bases.

Explain the difference between monoprotic, diprotic and triprotic acids.

Define amphoteric and amphiprotic substances.

Calculate pH and pOH of solutions.

Determine the unknown quantity using acid – base titration.

12.3 Electrochemistry

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- construct simple galvanic and electrolytic cells with and without salt bridge, discuss factors affecting their performances and write balanced half-equations at the anode and cathode.
- discuss the electrolysis of molten salts, concentrated and dilute aqueous acids and bases at the electrodes and their significance of the reactivity series.
- construct a simple cell to explain the refining and electroplating of metals and calculate theoretical and actual masses deposited.

- discuss the theory of electrochemistry in the refining, electroplating and manufacturing of some other metals such as aluminium.

Activity	Elaboration
Discuss the electrolysis of molten salts, concentrated and dilute aqueous salts, acids and bases at the electrodes and the significance of their reactivity series.	Students construct simple electrolytic cells and experiment electrolysis of concentrated and dilute solutions and acidified water. Students investigate factors determining products at the cathodes and anode respectively. Students discuss and compare electrolysis of molten salts and aqueous salts.
Construct simple galvanic cells with and without salt bridge, discuss factors affecting their performances and write balanced half-equation at the anode and cathode.	Students construct simple galvanic cell. For example: Place zinc in zinc nitrate solution and copper in copper nitrate solution. Link the two solutions with a strip of filter paper soaked with potassium nitrate solution. Students investigate the anode and cathode reactions.

Suggested assessment tasks

Practical – Electrolysis of aqueous salts

Assessment criteria

Students will be assessed on the extent to which they can:

- construct an electrolytic cell to decompose selected aqueous salts
- investigate and name important parts of an electrolytic cell
- use the electrochemistry series to predict products of an electrolytic cell
- write balanced half – equations for the redox reaction and describe what happens at the anode and cathode during the electrolysis of the selected salts
- investigate and describe factors that affect an electrolysis reaction
  - effect of concentration, nature of electrolyte, nature of electrodes.

Test or assignment

Suggested topics

Define electrochemistry and differentiate between a galvanic and an electrolytic cell.

Sketch and label a galvanic cell or an electrolytic cell.

Demonstrate an understanding and explain the concepts and applications of a galvanic cell or an electrolytic cell.

Write half equations to describe what happens at the anode and cathode.

List and explain factors that affects electrochemical reactions.

Demonstrate an understanding of cell potential and standard potential.

Describe and explain the electrolysis of molten, concentrated, and dilute salts and acids.

Investigate and discuss the application of electrolysis in the electrolysis of brine, bauxite, purification of impure metals, and electroplating.

12.4 Carbon Compounds

Suggested activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- draw structures, write chemical formulae and name organic compounds:
  - hydrocarbons (alkanes, alkenes, alkynes and benzene)
  - alcohols
  - aldehydes and ketones
  - carboxylic acids and esters
- list the common names of products containing organic compounds found in homes, gardens, hospitals and chemical industries.

Activity	Elaboration
Draw structures, write chemical formulae and name organic compounds.	In group students use IUPAC system to draw structures, write formulae and name organic compounds

Suggested assessment tasks

Written Test - Multiple choice and short answer

Write correct names of hydrocarbons, alcohols, aldehydes, ketones,

carboxylic acids and esters.

Write correct formula of hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids and esters.

Differentiate between primary, secondary and tertiary alcohols.

Investigation

Identify and list the common names of organic compounds used as products in homes, gardens and hospitals. Explain the chemical processes used to prepare products.

Assessment Criteria

Assessment task two will be assessed on the extent to which students can:

- write a logically sequenced report

- categorise organic products into hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids and esters
- outline the preparation of three of the organic compounds.

12.5 Natural Resources and Chemical Industries in Papua New Guinea

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

Suggested activities

- list organic compounds found in petrol, kerosene, cooking gas, diesel and bitumen.
- describe the processes involved in the extraction of metals in PNG and the consequences of the wastes on the environment.
- extract oil from seeds and nuts (coconut) and producing soap (saponification)
- invite members of the local community and other representatives from chemical manufacturing Industries to present talk on chemical practices.
- visit a site which shows an example of environmental pollution example municipal waste dump, industrial chemical waste dump or water pollution

Activity	Elaboration
Extracting oil from seeds and nuts and produce soap	Students extract oil from seeds and nuts (coconut, oil palm, marita or karuka) Heat the oil extract with sodium hydroxide to produce soap. In the process add fragrances such as frangipanni flower, rose wood oil or lemon grass to give scent.
Describe the process involved in the extraction of metals in PNG and the consequences of the wastes on the environment	In groups, students select a mine site in PNG (Ok Tedi, Mt Sinivit, Lihir, Harmony gold, Ramu-Nickel) and do a case study.
Visit a site which shows an example of environmental pollution. Example municipal waste dump, industrial chemical waste dump or water pollution	Students do a field trip to recommended site then write a report on environmental issues on the site.

Suggested assessment tasks

Field trip, investigation and report –Industries and their impact on the environment

Specifications

- Outline the raw material used in an industry.
- Describe the industrial process involved in the conversion of the raw materials into products.
- Describe and explain the quality control of the industrial processes.
- Identify the chemical processes equation involved.
- Identify waste products of the process and methods used to minimise effects on the environment.
- Describe safety practices used in this industry.
- Describe the importance of the product to society.
- Put forward a balanced argument on the use of having an industry and its effect on the environment.

Assessment Criteria

The assessment task will be assessed on the extent to which students can:

- plan scientifically accepted methods, procedures, equipment and resources precisely to collect accurate data
- document clearly scientific methods used (collect and record data)
- support and justify interpretation through specific data and results
- communicate accurate, relevant and in-depth information of communicate in a variety of ways
- identify issues raised in relation to the implementation of the project
- identify possible sources of inaccuracy.

Instructions for the field trip

Teacher

i) Inform students early about this task.

ii) Help students to select practically doable problem to solve.

iii) Discuss the performance criteria with students especially the weighting for each criterion.

iv) Make clear to students what particular investigating steps will be assessed in the beginning of the project.

v) Explain to students the time for different stages of the project to be completed and reported including the time for final submission of the project.

vi) Mark this task using the performance standards.

vii) Ensure ethical and safety issues are clearly understood and applied.

The students

This task requires students to:

i) follow all instructions and advice carefully

ii) select and conduct any projects of interest

iii) ensure resources required are available from the start of the project

iv) take note of the time frame given and stick to it as much as possible

v) choose a real community related problem so that more realistic and meaningful activities are done to provide solutions for community improvement

vi) apply scientific investigation procedures as much as possible

vii) stick to time and submit the completed project on time.

viii) be aware of the safety issues

ix) be aware of ethical issues when dealing with the community.

Assignment – Investigate traditionally made products

Assessment Criteria

The assessment task will be assessed on the extent to which students can:

- describe the processes and methods used in a traditionally made product from local sources
- outline the physical and chemical processes involved in the processes used
- suggest ways of improving traditional methods using modern technology.

Recording and reporting

All schools must meet the requirements for maintaining and submitting student records as specified in the *Grade 12 Assessment, Examination and Certification Handbook*.

Recording and reporting student achievement

When recording and reporting student achievement you must record the achievement of the students in each unit and then, at the end of the year, make a final judgment about the overall achievement, or progress towards achievement, of the learning outcomes. To help you do this, descriptions of the levels of achievement of the learning outcomes are provided in the 'Learning outcome performance standards' table.

When reporting to parents, the school will determine the method of recording and reporting. In an outcomes-based system, student results should be reported as levels of achievement rather than marks.

Remember that the final school-based mark will be statistically moderated using the external exam results. The students' overall level of achievement may change.

Levels of achievement

The level of achievement of the learning outcomes is determined by the students' performance in the assessment tasks. Marks are given for each assessment task with a total of 100 marks for each 10-week unit, or 50 marks for each five-week unit. The marks show the student's level of achievement in the unit, and hence their progress towards achievement of the learning outcomes.

There are five levels of achievement:

- Very high achievement
- High achievement
- Satisfactory achievement
- Low achievement
- Below minimum standard.

A very high achievement means, overall, that the student has an extensive knowledge and understanding of the content and can readily apply this knowledge.

In addition, the student has achieved a very high level of competence in the processes and skills and can apply these skills to new situations.

A high achievement means, overall, that the student has a thorough knowledge and understanding of the content and a high level of competence in the processes and skills.

In addition, the student is able to apply this knowledge and these skills to most situations.

A satisfactory achievement means, overall, that the student has a sound knowledge and understanding of the main areas of content and has achieved an adequate level of competence in the processes and skills.

A low achievement means, overall, that the student has a basic knowledge and some understanding of the content and has achieved a limited or very limited level of competence in the processes and skills.

Below the minimum standard means that the student has provided insufficient evidence to demonstrate achievement of the learning outcomes.

Achievement level					
Total marks	**Very high achievement**	**High achievement**	**Satisfactory achievement**	**Low achievement**	**Below minimum standard**
600	540–600	420–539	300–419	120–299	0–119
500	450–500	350–449	250–349	100–249	0–99
400	360–400	280–359	200–279	80–199	0–79
300	270–300	210–269	150–209	60–149	0–59
200	180–200	140–179	100–139	40–99	0–39
100	90–100	70–89	50–69	20–49	0–19
60	54–60	42–53	30–41	12–29	0–11
50	45–50	35–44	25–34	10–24	0–9
40	36–40	28–35	20–27	8–19	0–7
20	18–20	14–17	10–13	5–9	0–4

Criterion/standards-referenced assessment

Learning outcomes performance standards					
Learning outcomes	**Very high achievement**	**High achievement**	**Satisfactory achievement**	**Low achievement**	**Below minimum standard**
1. Demonstrate understanding of fundamental principles and models	Demonstrates extensive knowledge and understanding of a wide range of complex scientific principles and models	Demonstrates sound knowledge and understanding of a range of scientific principles and models	Demonstrates knowledge and understanding of some scientific principles and models	Demonstrates some knowledge of scientific principles and models	Demonstrates very limited or incorrect knowledge of scientific principles or models
2. Apply scientific thinking, motor and process skills to investigate and find solutions to problems	Independently selects and proficiently applies a wide range of relevant skills and techniques to investigate and find solutions to a wide range of complex problems	Independently selects and applies a range of relevant skills and techniques to investigate and find solutions to a range of complex problems	Uses a range of skills and techniques to investigate and find solutions to problems	Uses a limited range of skills and techniques to investigate and find solutions to simple problems	Uses a very limited range of inappropriate techniques to attempt to find solutions to simple problems with assistance
3. Communicate findings of scientific investigations in different ways	Communicates complex scientific investigations and findings succinctly and logically in a variety of ways using correct and appropriate terms and conventions	Communicates scientific investigations and findings clearly in a variety of ways using correct terms and conventions	Communicates scientific investigations and findings in several different ways	Provides limited communication of scientific findings and information	Provides very limited and inaccurate communication of scientific findings and information
4. Analyse and interpret data, graphs and other forms of information relevant to topics studied	Independently and proficiently analyses and interprets a wide range of complex data, graphics and other forms of information	Proficiently analyses and interprets a range of data, graphics and other forms of information	Analyses and interprets data, graphics and other forms of information	Interprets some data, graphics and other forms of information with assistance	Interprets some simple data, with assistance
5. Analyse and evaluate past and present scientific developments and their impacts on human beings and the environment and on the ethical decisions made	Gives logical and detailed explanations and reasons for past and present chemistry related developments and their impacts on human beings and environment provides extensive evidence of being able to make informed and	Gives logical explanations and reasons for factors influencing past and present chemistry -related developments and their impacts on human beings and environment provides evidence of being able to make informed and ethical	Gives explanations for factors influencing past and present chemistry related developments and their impacts on human beings and environment provides evidence of being able to make informed and ethical decisions	Gives limited explanations for factors influencing past and present chemistry related developments and their impacts on human beings and environment and provides some evidence of being able to make informed and ethical	Gives very limited explanations for factors influencing past and present chemistry related developments and their impacts on human beings and environment and provides no evidence of being able to make informed and ethical decisions

	ethical decisions	decisions		decisions	
6. Evaluate traditional knowledge and practises of chemistry and their relevance today	Provides detailed logical explanations and reasons to give excellent evaluation of a wide range of traditional knowledge and practices of chemistry and their relevance today and to the future	Provides detailed explanations and reasons to give good evaluation of a range of traditional knowledge and practices of chemistry andtheir relevance today	Provides explanations and some reasons to evaluate traditional knowledge and practices of chemistry and their relevance today	Provides limited evaluation of traditional knowledge and practices of chemistry and their relevance today	Requires assistance to evaluate simple traditional knowledge and practices of chemistry

Sample format for recording Chemistry assessment task results

Student name:

Grade 11 assessment task results			
Unit	**Assessment task**	**Mark**	**Student mark**
11.1	Physical changes	15	
	Calculations using solubility curves	35	
	Test	35	
11.2	Properties of ionic, covalent and metallic structures	20	
	Test	35	
11.3	Displacement Reactions	20	
	Test	35	
11.4	Measuring the volume of hydrogen gas or mass.	20	
	Test	35	
11.5	Reactions of metals with acids, air and water	20	
	Test	30	
Total marks Grade 11 300 in syllabus--is this right?		**300**	

Student name:

Grade 12 assessment task results			
Unit	**Assessment task**	**Marks**	**Student mark**
12.1	Preparation of solutions	15	
	Test	30	
12.2	Acid-Base titration	20	
	Types of acids and pH calculation	30	
	Test	30	
12.3	Electrolysis of selected aqueous salts	25	
	Test	30	
12.4	Test	30	
	Research Project	35	
12.5	Field trip, investigation and reporting	30	
	Traditionally made product	25	
Total marks Grade 11		**300**	
Total marks Grade 11 and 12		**600**	

Learning outcomes and levels of achievement

Levels of achievement in Grade 11 and Grade 12 are recorded and reported against the learning outcomes. The performance standards for the levels of achievement are described in the table on pages 49 and 50

Steps for awarding final student level of achievement

1. Assess tasks using performance standards and assessment criteria and marking guides.
2. Record results for each task.
3. Add marks to achieve a unit result and term result.
4. Add term marks to get a year result.
5. Determine the overall achievement using the achievement level grid.
6. Report results using the learning outcome performance standards.

The following is an example of reporting using the learning outcomes performance standards descriptors.

Using the learning outcomes performance standards descriptors

Student: Subject: School-based assessment:	**Lena Kili** **Chemistry** **High achievement**
This assessment means that Lena:	
Demonstrates sound knowledge and understanding of a range of scientific principles and models	
Independently selects and applies a range of relevant skills and techniques to investigate and find solutions to a range of complex problems	
Communicates scientific investigations and findings clearly in a variety of ways using correct terms and conventions	
Proficiently analyses and interprets a range of data, graphics and other forms of information	
Gives logical explanations and reasons for factors influencing past and present chemistry - related developments and their impacts on human beings and environment provides evidence of being able to make informed and ethical decisions	
Provides detailed explanations and reasons to give good evaluation of a range of traditional knowledge and practices of chemistry andtheir relevance today	
Demonstrates sound knowledge and understanding of a range of scientific principles and models	
Independently selects and applies a range of relevant skills and techniques to investigate and find solutions to a range of complex problems	
Communicates scientific investigations and findings clearly in a variety of ways using correct terms and conventions	

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Glossary for Chemistry

Acid	A substance that dissolves in water to produce hydrogen ion (H^+) or oxonium ion (H_3O^+)
Acid rain	Rain that contains dilute acid derived from burning fossil fuels and that is potentially harmful to the environment.
Activation complex	A stage in a reaction when the reactants have gained enough energy to break the bonds and just ready to form the products.
Activation energy	Energy needed to break bonds in the reactants.
Alcohol	Any organic compound containing one or more hydroxyl groups bound to carbon atoms e.g. ethanol C_2H_5OH or methanol CH_3OH.
aldehydes	A highly reactive organic compound produced by the oxidation of an alcohol and having a CHO group, especially acetaldehyde.
Alkane	An open-chain hydrocarbon compounds with no carbon-to-carbon multiple bonds, belonging to a series whose members all have the same general chemical formula. Methane and ethane are alkanes. Formula: C_nH_{2n+2} *Also called* paraffin
Alkene	An open-chain hydrocarbon compound containing one carbon-to-carbon double bond, belonging to a series whose members all have the same general chemical formula. Ethylene is an alkene. Formula: C_nH_{2n} *Also called* olefin
Alkyne	An open-chain hydrocarbon compound containing one carbon-to-carbon triple bond, belonging to a series whose members all have the same general chemical formula. Formula: C_nH_{2n-2}
Allotrope	One of several different forms in which a chemical element occurs, each of which differs in its physical properties but not in the kind of atoms in its composition. Diamonds and coal are allotropes of carbon.
Amphiprotic	A substance that acts as an acid and base producing and reacting with protons e.g. HSO_4^-, HPO_4^{2-}.
Amphoteric	A substance that can react with both acid and base e.g. ZnO.
Anion	Negatively charged ion, especially one that is attracted to an anode, either during electrolysis or within a vacuum tube.
Anode	The positive electrode in an electrolytic cell.
Aqueous salt	A salt that is dissolved in water.
Atom	The basic particle of matter, indestructible and indivisible, first proposed by ancient Greek philosophers as the fundamental component of the universe.
Avogadro number	The number of atoms, ions or molecules, 6.023×10^{23}, contained in one mole of a substance. *Symbol N_A.*
Base	A chemical compound having a pH value between 8 and 14 that can neutralise an acid.
Bauxite	An impure amorphous mixture of aluminium hydroxides that is the principal ore of aluminium.
Boiling point	The temperature at which a liquid turns to gas. Water turns to steam at 100℃ at sea level.
Bond energy	The amount of energy that has to be supplied to break or form a chemical bond between two atoms in a molecule.
Carboxylic acid	Any organic acid that contains the carboxyl group COOH.
Catalyst	A substance that increases the rate of a chemical reaction without itself undergoing any change.

Cathode	The negative electrode of an electrolytic cell.
Cation	An ion that has a positive electrical charge and is attracted towards the cathode in electrolysis.
Concentration	The amount of a substance dissolved in another.
Covalent bond	Chemical bond between two atoms created by the sharing of a pair of electrons.
Covalent compound	Compounds formed by covalent bonding.
Diffusion	Movement of particles from an area of high concentration to an area of low concentration.
Diprotic acid	Acids that contain two replaceable protons e.g. H_2SO_4, and H_2SO_3.
Electrodes	Either of the two conductors (cathode or anode) through which electricity enters or leaves something such as a battery or a piece of electrical equipment.
Electrolyte	A chemical compound that separates into ions in a solution or when molten and is able to conduct electricity.
Electrolytic cell	A device in which electrolysis can be produced, usually consisting of an electrolyte, its container, and electrodes.
Electron shell diagram	Arrangement of electrons with similar energy levels.
Empirical formula	A chemical formula showing the relative proportion of elements in a compound instead of their structural arrangement or molecular weights, for example the formula H_2O.
Endothermic	Used to describe a reaction that absorbs heat.
Esters	An organic often fragrant compound formed in a reaction between an acid and an alcohol with the elimination of water.
Exothermic	Used to describe a reaction that produces heat.
Formation energy	Energy given out when new bonds are made.
Freezing point	the temperature at which a liquid solidifies, for example the temperature at which water turns to ice.
Galvanic cell	Relating to or involving the direct-current electricity that is chemically generated between dissimilar metals, for example in a battery.
Giant covalent	A substance made by covalent bond consisting of many atoms e.g. diamond and graphite.
Haber Process	A commercial process for catalytically producing ammonia from atmospheric nitrogen and hydrogen at high temperature and pressure. *Also called* Haber-Bosch process.
Halogen	Any of the five electronegative elements, fluorine, chlorine, iodine, bromine, or astatine. They are known as *'salt producers'*.
Hydrocarbon	An organic chemical compound containing only hydrogen and carbon atoms, arranged in rows, rings, or both, and connected by single, double, or triple bonds. Hydrocarbons constitute a very large group including alkanes, alkenes, and alkynes.
Impure substance	Mixed with other substances.
Indicator	A substance such as litmus that shows the presence or concentration of a particular material or chemical
Ion	An atom or group of atoms that has acquired an electric charge by losing or gaining one or more electrons.
Ionic compound	A compound formed by ionic bond.
Ionic equation	An equation that shows only the ions that takes part in a reaction.

Isotopes	Either of two or more forms of a chemical element with the same atomic number but different numbers of neutrons.
IUPAC	*Abbreviation of* International Union of Pure and Applied Chemistry.
Lewis acid	A substance that can donate a proton (H^+)
Lewis base	A substance that can accept a proton (H^+)
Melting point	The temperature at which a substance changes from a solid to a liquid form.
Metallic bond	A chemical bond characteristic of metals, in which electrons are shared between atoms and move about in the crystal.
Molarity	Amount of substance in moles dissolved in one litre of water. The unit is mol/L or mol/dm^3.
Molecular formula	A chemical formula that specifies which atoms and how many of each atom there are in a molecule of a compound.
Molecule	The smallest physical unit of a substance that can exist independently, consisting of one or more atoms held together by chemical forces.
Moles	The basic SI unit of amount of substance equal to the amount containing the same number of elementary units as the number of atoms in 12 grams of carbon-12. *Symbol* mol.
Molten salt	A salt changed into liquid form by heat.
Monoprotic acid	An acid containing one replaceable proton e.g. HCl.
pH	A measure of the acidity or alkalinity of a solution, such as vinegar, or a damp substance, such as soil. The pH of pure water is 7 with lower numbers indicating acidity and higher numbers indicating alkalinity.
Pure substance	Not mixed with any other substance.
Rate	The speed at which one measured quantity happens, runs, moves, or changes compared to another measured amount such as time.
Relative atomic mass	Average mass of an element compared with the mass of an atom of carbon-12.
Relative formula mass	Average mass of all the atoms in an ionic compound.
Relative molecular mass	Average mass of all the atoms in a molecular compound.
Salt bridge	The salt bridge is made of U-tube or filter paper soaked in salt solution to provide ions to balance ions consumed or produced in an electrochemical cell.
Saponification	The process of hydrolysis of an ester when alkaline conditions are used. The break down of natural fats to produce soap is an example of saponification.
Solubility	Amount of solute that can dissolve in 100 g of water at a given temperature.
Standard solution	A solution of a substance whose concentration is accurately known.
Titration	a method of calculating the concentration of a dissolved substance by adding quantities of a reagent of known concentration to a known volume of test solution until a reaction occurs.
Triprotic acid	An acid containing three replaceable protons e.g. H_3PO_4.

Glossary for assessment

Syllabus outcomes, criteria and performance standards, and examination questions have key words that state what students are expected to be able to do. A glossary of key words has been developed to help provide a common language and consistent meaning in the syllabus and teacher guide documents.

Using the glossary will help teachers and students understand what is expected in responses to examinations and assessment tasks.

Account	Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions
Analyse	Identify components and the relationship between them; draw out and relate implications
Apply	Use, utilise, employ in a particular situation
Appreciate	Make a judgment about the value of
Assess	Make a judgment of value, quality, outcomes, results or size
Calculate	Ascertain or determine from given facts, figures or information
Clarify	Make clear or plain
Classify	Arrange or include in classes or categories
Compare	Show how things are similar or different
Construct	Make; build; put together items or arguments
Contrast	Show how things are different or opposite
Critically (analyse or evaluate)	Add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to (analysis or evaluation)
Deduce	Draw conclusions
Define	State meaning and identify essential qualities
Demonstrate	Show by example
Describe	Provide characteristics and features
Discuss	Identify issues and provide points for and/or against
Distinguish	Recognise or note or indicate as being distinct or different from; to note differences between
Evaluate	Make a judgement based on criteria; determine the value of
Examine	Inquire into
Explain	Relate cause and effect; make the relationships between things evident; provide why and/or how
Extract	Choose relevant and/or appropriate details
Extrapolate	Infer from what is known
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Plan, inquire into and draw conclusions about

Justify	Support an argument or conclusion
Outline	Sketch in general terms; indicate the main features of
Predict	Suggest what may happen based on available information
Propose	Put forward (for example, a point of view, idea, argument, suggestion) for consideration or action
Recall	Present remembered ideas, facts or experiences
Recommend	Provide reasons in favour
Summarise	Express, concisely, the relevant details
Synthesise	Putting together various elements to make a whole

Appendixes

Appendix 1: Format for practical report

A scientific report is a piece of writing containing information about an investigation or experiment that was conducted. A scientific report generally contains the following headings:

(a) Title of the experiment
(b) Aim
(c) Method
(d) Results
(e) Discussion
(f) Conclusion
(g) References

(a) ***Title of the experiment***
The title of the experiment or investigation sets out the topic of the report.

(b) ***Aim***
The aim of the experiment gives the scope of the report of what is to be achieved from doing the experiment. It also sets out the reason for doing the experiment and what is to be achieved.

(c) ***Method***
The method gives a report of how the experiment was carried out. Labelled diagrams can be included to explain the procedure in the experiment. *Reported speech* is used to outline the procedure involved in the experiment. Remember *not* to number the procedure when writing a report.

(d) ***Results***
Observations and measurements done are recorded under this heading. It is often convenient to put the results together in a table. Sometimes the results can be presented in the form of a graph. Calculations are also done in this part of the report.

(e) ***Discussion***
This is where you look carefully at your results and try to answer what the results mean. The observations done and measurements obtained are interpreted. Do the results show any kind of pattern? Graphs and charts are particularly good at showing up patterns.

(f) ***Conclusion***
The conclusion is derived from the results of the experiment. Do your results answer your original question? Do they support your hypothesis? Sometimes the expected result is not obtained in an experiment. The reason for not getting the expected result is included in the conclusion.

(g) ***References***
This is a list of books and other printed materials consulted in writing up the report. It provides a guide to the reader on various sources that can be consulted.

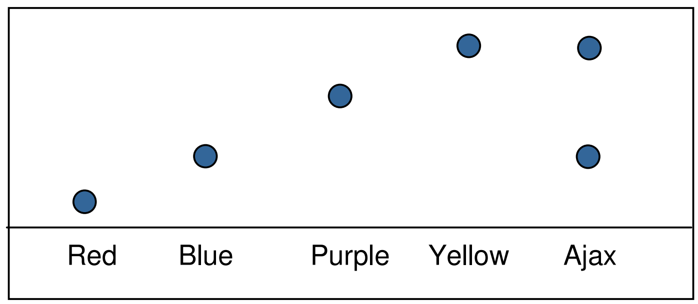
Appendix 2: Sample test questions

When setting a test you must specify the outcomes that are being assessed.

MULTIPLE CHOICE QUESTIONS

QUESTION 1

Ajax is a cleaning detergent. Ajax was analysed to find the dyes that make up the colour of the detergent. The chromatogram obtained is shown below.



It is possible to conclude that the colour of the cleaning detergent is

A. green

B. yellow

C. orange

D. purple

E. blue

QUESTION 2

In a chemical reaction, at constant temperature, the addition of a catalyst

A. increases the concentration of the final product.

B. increases the fraction of the molecules with more than the given energy.

C. increases the rate of the forward reaction but has no effect on the backward reaction.

D. decreases the amount of energy released in the overall reaction.

E. decreases the time required for the reaction to reach completion.

QUESTION 3

Bromine is an important industrial chemical. Sea water contains sodium bromide. Which of the following would produce bromine from sea water?

A. Adding chlorine gas

B. Adding a piece of copper strip

C. Adding hydrochloric acid

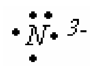
D. Adding a piece of magnesium

E. Heating the sea water

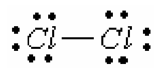
QUESTION 4

Which of the following is *not* correct?

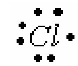
A.



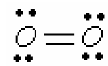
B.



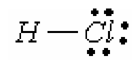
C.



D.



E.



QUESTION 5

Which of the following elements is more electronegative?

A. Sulfur

B. Lithium

C. Iodine

D. Fluorine

E. Barium

QUESTION 6

A solution of sodium hydroxide is labelled 0.40 $mol.dm^{-3}$. What is the concentration in $g.dm^{-3}$?

A. 4.0

B. 20.0

C. 1.60

D. 0.40

E. 16.0

QUESTION 7

A molecule contains 40% carbon, 6.67% hydrogen and 53.33% oxygen by mass. What is the empirical formula of the molecule?

A. CH_2O

B. CHO_2

C. C_2HO

D. CHO

E. $C_2H_2O_2$

QUESTION 8

What arrangement of an electrolytic cell would electroplate a silver coin with copper?

	Cathode	Anode	Electrolyte
A	Copper	Silver coin	Copper sulfate
B	Silver	Copper	Silver nitrate
C	Copper	Silver coin	Silver nitrate
D	Silver coin	Copper	Copper sulfate
E	Copper	Silver coin	Sodium chloride

QUESTION 9

Which of the following occurs during the electrolysis of dilute sodium chloride solution?

A. Sodium ions will gain electrons

B. Chloride ions will gain electrons

C. Oxygen is evolved at the anode

D. Chlorine is evolve at the anode

E. Chlorine is evolve at the cathode

QUESTION 10

Study the equation representing the reaction between CH_3COOH molecules and H_2O molecules.

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

In the above reaction, H_2O is behaving as:

A. Arrhenius acid

B. Arrhenius base

C. Brønsted – Lowry acid

D. Brønsted – Lowry base

E. Lewis dot substance

QUESTION 11

Which of the following list contains only basic substances?

A. ammonia, vinegar, lime

B. lime, ammonia, sodium hydroxide

C. vinegar, lime, bleach

D. sodium, lime, vinegar

E. detergent, lime, vinegar

QUESTION 12

An upset stomach may be caused by the presence of too much hydrochloric acid. This can be cured by swallowing an antacid tablet which neutralizes the excess acid.

The safest antacid tablet could be made from:

A. sodium chloride

B. sodium hydroxide

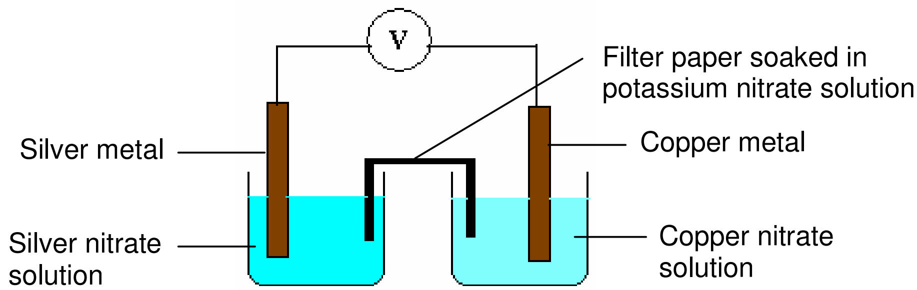
C. magnesium hydroxide

D. magnesium nitrate

E. sodium nitrate

QUESTION 13

The diagram below shows a galvanic cell.



What does the anode in this cell consist of?

A. silver metal

B silver nitrate solution

C copper metal

D copper nitrate solution

E potassium

QUESTION 14

Which is the correct strategy that can be used to separate salt from sand?

A. pulverization → dissolution → evaporation

B. dissolution → evaporation→ condensation

C. dissolution → elimination → filtration

D. dissolution → filtration → evaporation

E. crystallization → dissolution → evaporation

QUESTION 15

Most non-metallic elements are solids or gases at room temperature. Which one of the following elements is a ***liquid*** at room temperature?

A. silicon
B. sulphur
C. bromine
D. neon
E. phosphorus

QUESTION 16

Diamond and graphite are allotropes of carbon. What are allotropes?

A. Same element existing in same form and same state
B. Same element with same atomic number and different atomic mass
C. Same element existing in different physical states.
D. Same element with different atomic number and same atomic mass
E. Same element existing in different forms and same state.

QUESTION 17

Which of the following would most readily form a solution?

A. metallic substance in an organic solvent
B. an ionic substance in an organic solvent
C. an ionic substance in a non-polar solvent
D. a covalent substance in a molten salt
E. a covalent substance in a non-polar solvent

QUESTION 18

A saturated hydrocarbon contains 4 carbon atoms. How many hydrogen atoms does it contain?

A. 2
B. 4
C. 6
D. 8
E. 10

QUESTION 19

Which of the following is ***not*** a carboxylic acid?

A. H_2CO_2

B. H_2CO_3

C. C_2H_4O

D. $C_3H_6O_2$

E. $CH_3CH_2CH_2COOH$

QUESTION 20

Propyne is an alkyne because it contains:

A. carbon and hydrogen atoms

B. a triple bond and a double bond

C. a double bond

D. carbon, hydrogen and a triple bond

E. a single bond and a double bond

SHORT ANSWER QUESTIONS

Write your answer in the space provided on the ANSWER SHEET.

QUESTION 21

(a) A 0.1 $molL^{-1}$ solution of hydrochloric acid has a pH of 1.0, whereas 0.1 $molL^{-1}$ solution of citric acid has a pH of 1.6.

State one way in which pH can be measured (1)

Explain why the two solutions have different pH? (2)

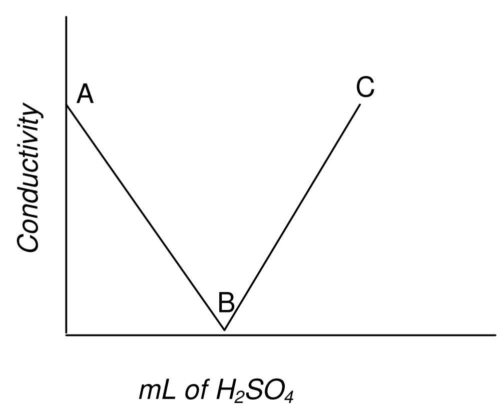
(b) Barium hydroxide and sulfuric acid react according to the following equation:

$Ba(OH)_{2(aq)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2H_2O_{(l)}$

Name the type of chemical reaction (1)

Write the net ionic equation. (1)

(c) 20 mL of barium hydroxide was titrated with 0.12 $molL^{-1}$ sulfuric acid (burette) The conductivity of the solution was measured throughout the titration and the result graphed as shown.



(i) Explain why the conductivity is decreasing from A to B and increasing from B to C. (2)

(ii) Why is the conductivity minimum at B? (1)

QUESTION 22

(a) A dilute solution of sodium chloride solution is electrolysed using graphite electrodes.

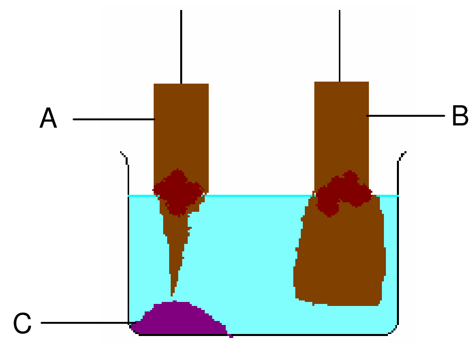
Write half-equation for the reactions at the electrodes with states.

(i) Cathode (1)

(ii) Anode (1)

(iii) Write the overall equation. (2)

(b) Impure copper is purified using the electrolysis cell as shown in the diagram below.



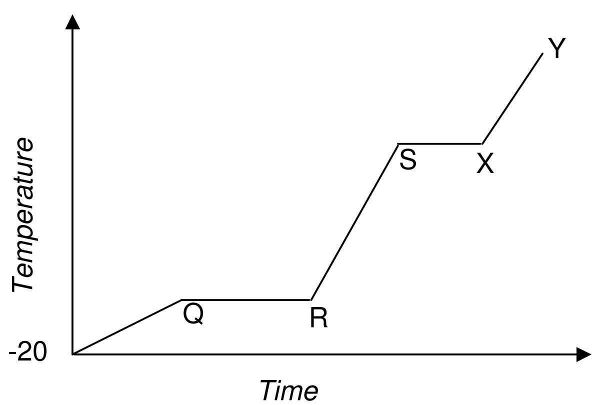
(i) What are the electrodes A and B made of? (2)

(ii) Impurities are labelled C. What is the general name of C? (1)

(iii) Write half equation for the reaction at the anode with states(1)

QUESTION 23

The graph shows the phase change of crushed ice (-20˚C) when it was heated in a beaker.



(a) What is the name of the change observed in the beaker along QR section of the graph? (1)

(b) What is the specific name of the temperature corresponding to QR section of the graph? (1)

(c) Assume that the ice was pure and was heated under normal atmospheric pressure.

What is the most likely temperature reading corresponding to the SX section of the graph? (1)

(d) What phase of ice is observed in the beaker along the RS section of the graph? (1)

(e) Write an equation giving states for the phase change occurring along the SX section. (2)

(f) Assume that the ice was pure, but was heated under twice the normal atmospheric pressure.

What would happen to the temperature reading corresponding to the SX section of the graph? (1)

(g) Why does the temperature remain steady along the QR section of the graph? (1)

QUESTION 24

(a) X is an element in period 3 with 6 electrons in the outer most shell.

(i) Draw a full shell diagram of the ion formed by X. (1)

(ii) Name the ion formed by X. (1)

(iii) Draw a full shell diagram of a compound formed between sodium and element X. (2)

(b) Part of the periodic table with elements with atomic numbers from 3 to 31 is shown below.

$^{7}_{3}\text{X}$			$^{12}_{6}\text{V}$		$^{14}_{7}\text{H}$	$^{16}_{8}\text{Q}$		$^{20}_{10}\text{D}$
	$^{24}_{12}\text{Z}$					$^{32}_{16}\text{B}$	$^{35}_{17}\text{E}$	
$^{39}_{19}\text{M}$		$^{64}_{29}\text{A}$	$^{70}_{31}\text{G}$					

Use ***only*** the letters from the table to answer the questions.

(i) The most electropositive element (1)

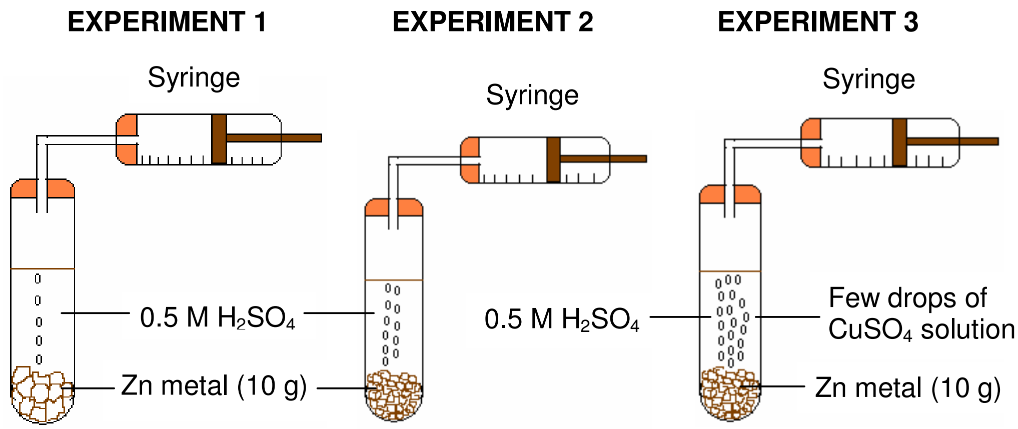
(ii) An unreactive element (1)

(iii) The formula of a compound formed between element V and element E. (1)

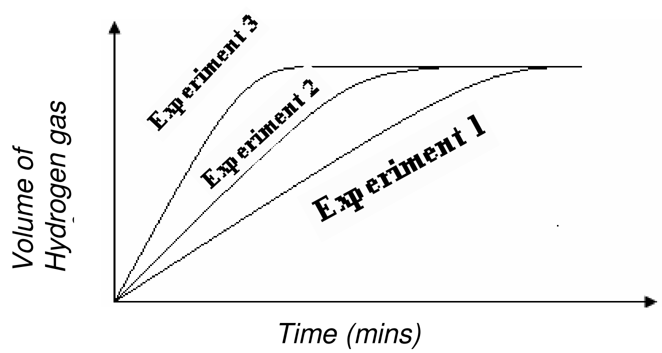
(c) Explain why ionic compounds have very high melting points. (1)

QUESTION 25

A student investigated the reaction between zinc metal and sulfuric acid as illustrated in the diagrams below. She used 10 g of zinc metal and 100 mL of dilute sulfuric acid of molarity 0.50 mol.L-1 for each experiment.



In each experiment the student measured the volume of hydrogen gas collected in the syringe at regular intervals of time. She then presented the data graphically as shown below.



(a) What does the horizontal section of the graphs indicate about each reaction? (1)

(b) Give a reason for the reaction in experiment 2 to be faster than the reaction in experiment 1. (1)

(c) Give a reason for the reaction in experiment 3 to be faster than the reaction in experiment 2. (1)

(d) What will happen to the rate of the reaction if 100 mL of H_2SO_4 of molarity 1.0 mol.L^{-1} is used in experiment 3? (1)

(e) Write a balanced chemical equation giving states for the reaction between zinc and H_2SO_4. (2)

(f) Which of the reactants will not be finished completely when the reaction stops in all the three experiments? (1)

(g) One of the products in all three of the above reaction is hydrogen gas. State a safety precaution the student should take when conducting these experiments. (1)

QUESTION 26

Draw the structures of the following:

(a) Ethyl methyl ketone (2)

(b) Pentanoic acid (2)

(c) Butanol (2)

(d) Ethyne (2)

QUESTION 27

(a) 120 dm^3 of oxygen was required to react with pentadecane ($C_{15}H_{32}$) at room temperature and pressure

(i) Write a balanced chemical equation for the reaction.

States are not required (2)

(ii) Calculate the volume of carbon dioxide produced at room temperature and pressure. (2)

(b) A solution of 0.2 M hydrochloric acid was required to react with 0.6 g of magnesium.

(i) Write a balanced chemical equation for the reaction.

States are required (2)

(ii) Calculate the volume of 0.2 M hydrochloric acid needed to react with 0.6 g of magnesium. (2)

QUESTION 28

(a) 25 ml of a solution of 0.2 M sulphuric acid in a conical flask was titrated with 40 ml of potassium hydroxide in a burette.

(i) Write a balanced chemical equation for the reaction.

States are required (2)

(ii) Methyl orange was used as the indicator. Describe the colour change at the end point. (1)

(iii) Calculate the concentration of potassium hydroxide (2)

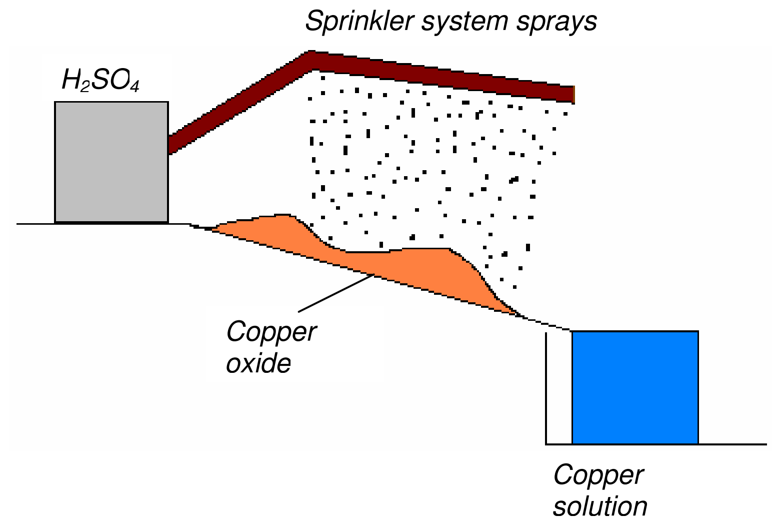
(iv) Calculate the moles of potassium hydroxide at the end point. (1)

(v) Calculate the mass of potassium hydroxide at the end point. (1)

(b) Explain what is meant by the two words weak and acid in the phrase `citric acid is a weak acid. (1)

QUESTION 29

(a) Copper ions can be extracted from copper oxide using sulfuric acid in a process called acid leaching. The diagram below illustrates this process.



The copper oxide ore is dug out of the ground and sprayed with acid. The acid leaches (soaks) through the ore and reacts with copper oxide. The resultant copper solution is collected in a tank at the bottom of the ore heap.

(i) Write a balanced chemical equation for the reaction. States are required. (2)

(ii) After the copper solution has been collected, scrap iron is added to the tank to precipitate copper. Write an equation to describe the precipitation of copper.

States are required (2)

(iii) Suggest another metal that can be used instead of iron to precipitate copper. (1)

(b) The majority of copper ores contain copper (II) sulfide. Copper sulfide exposed to atmospheric oxygen forms copper (II) oxide.

(i) Name the gas produced as a by-product of this reaction (1)

(ii) Write a balanced chemical equation for the reaction.

States are required (2)

QUESTION 30

(a) (i) Name a gas field in Papua New Guinea. 1)

(ii) Draw the structure of ethane. (1)

(b) Mineral prospecting in Papua New Guinea has resulted in more mineral deposits being found

Name one of the two minerals that will be mined at Ramu mine. (1)

(c) During fermentation, glucose is converted to ethanol

(i) What is the name of the catalyst that converts glucose to ethanol? (1)

(ii) Ethanol is easily oxidized to ethanoic acid. Write a balanced chemical equation for the oxidation of ethanol. States are required. (2)

(iii) Ethanoic acid is a weak organic acid. It dissociates in water as shown below:

Ethanoic acid → Hydrogen ion + ethanoate ion

What are the products of reaction when ethanoic acid reacts with sodium hydrogen carbonate? (2)

Answers to Sample Test Questions

MULTIPLE CHOICE ANSWERS

QUESTION 1	A	QUESTION 11	B
QUESTION 2	E	QUESTION 12	C
QUESTION 3	A	QUESTION 13	C
QUESTION 4	A	QUESTION 14	D
QUESTION 5	D	QUESTION 15	C
QUESTION 6	E	QUESTION 16	E
QUESTION 7	A	QUESTION 17	E
QUESTION 8	D	QUESTION 18	E
QUESTION 9	C	QUESTION 19	B
QUESTION 10	D	QUESTION 20	D

SHORT QUESTION ANSWERS

QUESTION 21

(a) (i) Using a pH meter or a universal indicator.

(ii) Hydrochloric acid is a strong acid which dissociates completely in water thus producing maximum amount of hydrogen ions whereas citric acid is a weak acid which does not dissociate completely in water thus producing less hydrogen ions in the solution.

(b) (i) neutralisation or precipitation

(ii) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$
$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

(c) (i) Barium hydroxide being a strong base has high conductivity in the beginning of the titration. When sulfuric acid is added amount of barium ion in the solution decreases due to the formation of solid barium sulfate. When more sulphuric acid is added after the end-point, the number of sulfate and hydrogen ions increases and therefore conductivity increases.

(ii) Because of the minimum amount of barium and sulfate ions in the solution due to the formation of solid barium sulfate and water.

QUESTION 22

(a) (i) Cathode: $2H^{+}_{(aq)} + 2e^{-} \rightarrow H_{2(g)}$

(ii) Anode: $4OH^{-}_{(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^{-}$

(iii) $2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$

(b) (i) A - impure copper, B - pure coper

(ii) Anode slime, anode sludge or anode mud.

(iii) $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^{-}$

QUESTION 23

(a) melting of ice

(b) melting point

(c) 100℃

(d) liquid (water)

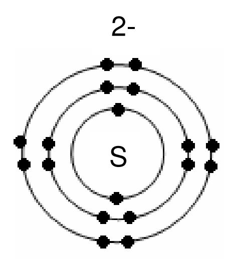
(e) $H_2O_{(l)} \rightarrow H_2O_{(g)}$

(f) The boiling point will increase.

(g) When heat is supplied at the melting point the heat is used as latent heat of fusion of ice but not to increase the temperature.

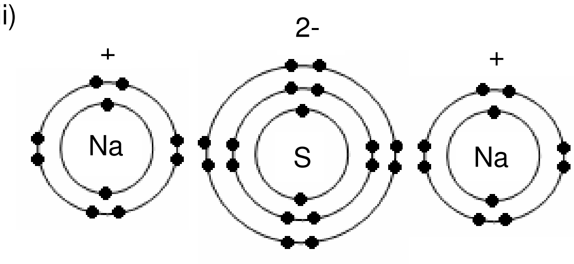
QUESTION 24

(a) (i)



(ii) sulphide

(iii)



(b) (i) M (ii) D (iii) VE_4

(c) Because of the strong force of attraction between the positively and negatively charged ions has to be overcome in order to melt.

QUESTION 25

(a) Completion of the reaction

(b) Because of the large surface of the powered zinc the reaction is faster

(c) Copper sulfate acts as a catalyst to speed up the chemical reaction

(d) Reaction will be faster

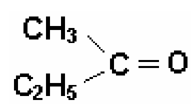
(e) $Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$

(f) Zinc

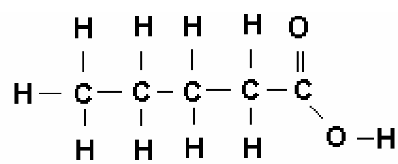
(g) Hydrogen gas being an inflammable gas it should not be exposed to naked flames or fire

QUESTION 26

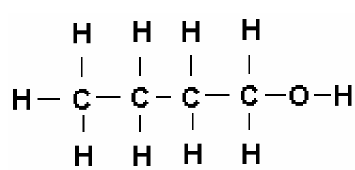
(a)



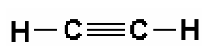
(b)



(c)



(d)



QUESTION 27

(a) (i) $C_{15}H_{32} + 23O_2 \rightarrow 15CO_2 + 16H_2O$

(ii) 78.3 L

(b) (i) $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

(ii) 0.25 L or 250 mL

QUESTION 28

(a) (i) $H_2SO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_{2(g)}$

(ii) Red to yellow.

(iii) 0.25 mol/L

(iv) 0.01 mole

(v) 0.56 g

(b) An acid donates a proton. Weak means it dissociates partially.

QUESTION 29

(a) (i) $CuO_{(s)} + H_2SO_{4(aq)} \rightarrow CUSO_{4(aq)} + H_2O_{(l)}$

(ii) $Fe_{(s)} + CuSO_{4(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

(iii) Zinc/Aluminium/ Lead

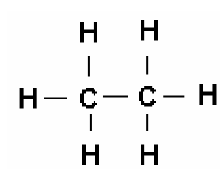
(b) (i) sulphur dioxide

(ii) $2CuS_{(s)} + 3O_{2(g)} \rightarrow 2CuO_{(s)} + 2SO_{2(g)}$

QUESTION 30

(a) (i) Kutubu, Gobe, Hides.

(ii)



(b) Nickel and cobalt

(c) (i) yeast

(ii) $C_2H_5OH_{(aq)} + O_{2(g)} \rightarrow CH_3COOH_{(aq)} + H_2O_{(l)}$

(iii) Sodium ethanoate, carbon dioxide and water.