# M I N I S T R Y  O F  E D U C A T I O N

## TEACHING SYLLABUS FOR CHEMISTRY
## (SENIOR HIGH SCHOOL 1-3)

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# TEACHING SYLLABUS FOR CHEMISTRY

## RATIONALE FOR TEACHING CHEMISTRY

Chemistry is concerned with the study of matter and its changes. As such, it is about us humans and everything around us. Chemistry keeps living things alive through the numerous changes that take place in their bodies. Around us for example, there is chemistry in foods, clothing, medicine, shelter and in our transportation system. There is also chemistry in the outer space. Household items like soap, plastics, books, radio, TV, video and computers would not exist without chemistry. Chemistry enables us to understand, explain, control and prevent phenomena like bush fires, industrial pollution, corrosion of metals and the depletion of the ozone layer. Chemistry is therefore a subject of vital importance for life.

## GENERAL AIMS

This syllabus is intended to:

i. Create awareness of the interrelationship between chemistry and the other disciplines or careers.
ii. Provide knowledge, understanding and appreciation of the scientific methods, their potential and limitations.
iii. Create awareness that chemical reactions and their applications have significant implications for society and the environment.
iv. Develop the ability to relate chemistry in school to the chemistry in modern and traditional industries or real world situations
v. Use facts, patterns, concepts and principles to solve personal, social and environmental problems.
vi. Use appropriate numeric, symbolic, nomenclature and graphic modes of representation and appropriate units of measurement (e.g. SI units)
vii. Produce, analyse, interpret and evaluate qualitative and quantitative data; solve problems involving quantitative data; identify sources of error and suggest improvements to reduce the likelihood of error.
viii. Apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting hazard symbols; by using appropriate techniques for handling, maintaining and storing laboratory materials and by using appropriate personal protection equipment.
ix. Develop the ability to communicate ideas, plans, procedures, results, and conclusions of investigations orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g. data, tables, laboratory reports, presentations, debates, models)
x. Make the subject interesting and motivating through designing hand-on activities for students to enhance their understanding of the subject
xi. Train students to use their theoretical ideas to design experiments to solve practical chemistry problems.
xii. Encourage investigative approach to the teaching and learning of chemistry and make chemistry lessons, problem solving in nature.

## SCOPE OF CONTENT

The syllabus builds upon the science learnt at the Junior High School level, and is designed to offer at the Senior High School level, the chemistry required to promote an understanding of the chemical processes taking place all around us. The syllabus is also designed to provide enough chemistry to students who:

i. will end their study of chemistry at the SHS level,
ii. require knowledge of chemistry in their vocational studies,
iii. wish to continue their studies at tertiary institutions.

In providing a course based on this syllabus, a wide range of activities including projects have been suggested to bring out the initiative and creativity of both the teacher and the student.

## PRE-REQUISITE SKILLS

The outline of the course requires

(A) . Proficiency in English language and a high level of achievement in JHS Integrated Science.

(B) Mathematical Knowledge in the following areas, is also required to facilitate the learning of the subject :

i. Arithmetical and algebraic addition, subtraction, multiplication, division, including fractions.
ii. Indices, reciprocals, standard forms, decimals, significant figures and approximations
iii. Variations, simple proportions and ratios.
iv. Squares, square roots and other roots.
v. Logarithms and antilogarithms to base 10 and base e
vi. Averages including weighted averages.
vii. Algebraic equations: linear, quadratic, simultaneous linear equations and their solutions.
viii. Graph drawing and their interpretations
ix. Equation of a straight line, slopes and intercepts.
x. Familiarization with the following shapes: triangles, squares, rectangles, circles, cubes, spheres, pyramids and other two and three-dimensional structures.
xi. Basic calculus.
xii. Use of scientific calculators.
xiii. Use of the internet and search engines
xiv. Knowledge in food and nutrition such as carbohydrates, fats and oils and proteins.

**Duration of the course**: Three (3) out of the three (3) years of Senior High School education.

**Period allocation per week**

A total of six periods per week is allocated to the teaching of chemistry with each period consisting of forty minutes. The teaching periods is divided as follows:

| YEAR | PRACTICAL | THEORY | TOTAL |
|---|---|---|---|
| 1 | 2 | 4 | 6 |
| 2 | 2 | 4 | 6 |
| 3 | 2 | 4 | 6 |

**Note:**

1. Teachers should ensure that students are adequately prepared before each practical class.
2. Teachers should also ensure that practical classes are started in the second year alongside the theory classes.

## ORGANIZATION OF THE SYLLABUS

The syllabus has been structured to cover the three years of SHS programme. Each year's work consists of a number of sections with each section comprising a number of units. The structure of the syllabus is as follows:

**STRUCTURE OF THE CHEMISTRY SYLLABUS**

| SHS 1 | SHS 2 | SHS 3 |
|---|---|---|
| **SECTION 1**<br>**INTRODUCTION TO CHEMISTRY(**Pg 1-3)<br><br>Unit 1 : Chemistry as a discipline<br>Unit 2 : Measurement of Physical Quantities<br>Unit 3 : Basic Safety Laboratory Practices<br><br>**SECTION 2**<br>**ATOMIC STRUCTURE (**Pg 4-6)<br><br>Unit 1 : Particulate Nature of Matter<br>Unit 2 : Structure of the Atom<br>Unit 3 : Periodicity<br><br>**SECTION 3**<br>**CHEMICAL BONDS(**Pg 7-11)<br><br>Unit 1 : Interatomic Bonding<br>Unit 2 : Intermolecular Bonding<br>Unit 3 : Hybridization and Shapes of Molecules<br><br>**SECTION 4**<br>**CONSERVATION OF MATTER AND STOICHIOMETRY(**P12-17)<br><br>Unit 1 : Carbon-12 Scale<br>Unit 2 : Solutions<br>Unit 3 : Stoichiometry and Chemical Equations<br>Unit 4 : Nuclear Chemistry | **SECTION 1**<br>**ENERGY AND ENERGY CHANGES**(pg 21-24)<br><br>Unit 1 : Energy changes in Physical and Chemical Processes<br>Unit 3 : Energy Cycles and Bond Enthalpies<br><br>**SECTION 2**<br>**INORGANIC CHEMISTRY**(pg 25-28)<br>Unit 1 : Periodic Chemistry<br>Unit 2 : Transition Chemistry<br><br>**SECTION 3**<br>**CHEMICAL KINETICS AND EQUILIBRIUM**(pg 29-33)<br><br>Unit 1 : Rate of Reactions<br>Unit 2 : Chemical Equilibrium<br><br>**SECTION 4**<br>**ACID AND BASES**(pg 34-40)<br><br>Unit 1 : The Concept of Acids and Bases<br>Unit 2 : Properties of Acid, Bases and acid-base Indicators<br>Unit 3 : Classification of acids and bases<br>Unit 4 : Concept of pH and pOH<br>Unit 5 : Buffer solutions<br>Unit 6 : Solubility of Substances<br>Unit 7 : Salt and Chemicals from Salt. | **SECTION 1**<br>**CHEMISTRY, INDUSTRY AND ENVIRONMENT**(pg 53-59)<br><br>Unit 1 : Chemical Industry<br>Unit 2 : Extraction of Metals<br>Unit 3 : Extraction of Crude Oil and Petroleum Processing<br>Unit 4 : Environmental Pollution<br>Unit 5 : Biotechnology<br>Unit 6 : Cement and its uses<br><br>**SECTION 2**<br>**BASIC BIOCHEMISTRY**(pg 60-64)<br><br>Unit 1 : Fats and oils<br>Unit 2 : Proteins<br>Unit 3 : Carbohydrates<br>Unit 4 : Synthetic polymers |

| SHS 1 | SHS 2 | SHS 3 |
|---|---|---|
| **SECTION 5**<br>**STATES OF MATTER(**pg18-20)<br><br>Unit 1 : Solids and Liquids<br>Unit 2 : Gases and their properties | **SECTION 5**<br>**REDOX REACTIONS AND ELECTROCHEMISTRY**(pg 41-46)<br><br>Unit 1 : Oxidation – reduction processes and oxidizing – reducing agents<br>Unit 2 : Balancing redox reaction equations<br>Unit 3 : Redox Titrations<br>Unit 4 : Electrochemical Cells<br>Unit 5 : Electrolytic Cells<br>Unit 6 : Corrosion of Metals<br><br>**SECTION 6**<br>**CHEMISTRY OF CARBON COMPOUNDS**(pg 47-52)<br><br>Unit 1 : Bonding in Carbon<br>Unit 2 : Classification of Organic Compounds.<br>Unit 3 : Identification of elements in Organic Compounds<br>Unit 4 : Separation and purification of Organic Compounds<br>Unit 5 : Alkanes<br>Unit 6 : Alkenes<br>Unit 7 : Alkynes<br>Unit 8 : Benzene<br>Unit 9 : Alkanols<br>Unit 10: Alkanoic Acids<br>Unit 11 : Alkanoic Acids derivatives: Alkylalkanoate(esters) | |

## SUGGESTIONS FOR TEACHING THE SYLLABUS

**New concepts in the design and use of the syllabus General Objectives:**

General Objectives have been listed at the beginning of each Section. The general objectives specify the skills and behaviours students should acquire as a result of learning the units of a section. Read the general objectives very carefully before you start teaching the section. After teaching all the units of a section, go back and read the general objectives again to be sure you have covered the objectives adequately in the course of your teaching.

**Sections and Units**
The syllabus has been planned on the basis of Sections and Units. Each year's work is divided into sections. A section consists of a fairly homogeneous body of knowledge within the subject. Within each section are units. A unit consists of a more related and homogeneous body of knowledge and skills.

**Columns**
The syllabus is structured in five columns: Units, Specific Objectives, Content, Teaching and Learning Activities and Evaluation. A description of the contents of each column is as follows:

Column 1 - Units: Column 1 consists of the unit topics of the section. You are expected to follow the unit topics according to the linear order in which they have been presented. However, if you find at some point that teaching and learning in your class will be more effective if you branched to another unit before coming back to the unit in the sequence, you are free to do so.

Column 2 - Specific Objectives: Column 2 shows the Specific Objectives for each unit. The specific objectives begin with numbers such as 1.3.5 or 2.2.1. These numbers are referred to as "Syllabus Reference Numbers". The first digit in the syllabus reference number refers to the section; the second digit refers to the unit, while the third digit refers to the rank order of the specific objective. For instance, 1.3.5 means: Section 1, Unit 3 (of Section 1) and Specific Objective 5. In other words, 1.3.5 refers to Specific Objective 5 of Unit 3 of Section 1. Similarly, the syllabus reference number 2.2.1 simply means Specific Objective number 1 of Unit 2 of Section 2. Using syllabus reference numbers provide an easy way for communication among teachers and other educators. It further provides an easy way for selecting objectives for test construction. Let's say for instance, that Unit 2 of Section 2 has five specific objectives: 2.2.1 - 2.2.5. A teacher may want to base his/her test items/questions on objectives 2.2.3 and 2.2.4 and not use the other three objectives. In this way, a teacher would sample the objectives within units and within sections to be able to develop a test that accurately reflects the importance of the various skills taught in class.

You will note also that specific objectives have been stated in terms of the student i.e., *what the student will be able to do after* instruction *and learning in the unit*. Each specific objective hence starts with the following, "The student will be able to.." This in effect, means that you have to address the learning problems of each individual student. It means individualizing your instruction as much as possible such that the majority of students will be able to master the objectives of each unit of the syllabus.

Column 3 - Content: The "content" in the third column of the syllabus presents a selected body of information that you will need to use in teaching the particular unit. In some cases, the content presented is quite exhaustive. In some other cases, you could add more information to the content presented. In a few cases the content space has been left blank for you to develop.

Column 4 -Teaching and Learning Activities (T/LA**) :** T/L activities that will ensure maximum student participation in the lessons are presented in column 4. Avoid rote learning and drill-oriented methods and rather emphasize participatory teaching and learning, and also emphasize the cognitive, affective and psychomotor domains of knowledge in your instructional system wherever appropriate. You are encouraged to re-order the suggested teaching and learning activities and also add to them where necessary in order to achieve optimum student learning. As we have implied already, the major purpose of teaching and learning is to make students able to apply their knowledge in dealing with issues both in and out of school. A suggestion that will help your students acquire the habit of analytical thinking and the capacity for applying their knowledge to problems is to begin each lesson with a practical problem. Select a practical problem for each lesson. The selection must be made such that students can use knowledge gained in the previous lesson and other types of information not specifically taught in class. At the beginning of a lesson, state the problem, or write the problem on the board. Let students analyze the problem, suggest solutions etc., criticize solutions offered, justify solutions and evaluate the worth of possible solutions. There may be a number of units where you need to re-order specific objectives to achieve such required effects. The emphasis is to assist your students to develop analytical thinking and practical problem solving techniques.

Column 5 - Evaluation : Suggestions and exercises for evaluating the lessons of each unit are indicated in Column 5. Evaluation exercises can be in the form of oral questions, quizzes, class assignments, essays, structured questions, project work etc. Try to ask questions and set tasks and assignments that will challenge your students to apply their knowledge to issues and problems as we have already said above, and that will engage them in developing solutions, and positive scientific attitudes as a result of having undergone instruction in this subject. The suggested evaluation tasks are not exhaustive. You are encouraged to develop other creative evaluation tasks to ensure that students have mastered the instruction and behaviours implied in the specific objectives of each unit. For evaluation during class lessons, determine the mastery level you want students to achieve in their answers and responses. If for instance, you take 80% as the mastery level, ensure that each student's answer to questions asked in class achieves this level of mastery.

**PROFILE DIMENSIONS**

A central aspect of this syllabus is the concept of profile dimensions that should be the basis for instruction and assessment. A 'dimension' is a psychological unit for describing a particular learning behaviour. More than one dimension constitutes a profile of dimensions. A specific objective as follows: The student will be able to describe.etc. contains an action verb "describe" that indicates what the student will be able to do after teaching and learning have taken place. Being able to "describe" something after the instruction has been completed means that the student has acquired "knowledge". Being able to explain, summarize, give examples etc. means that the student has understood the lesson taught. Similarly, being able to develop, plan, construct etc. means that the student has learnt to create, innovate or synthesize knowledge. You will note that each of the specific objectives in this syllabus contains an "action verb" that describes the behaviour the student will be able to demonstrate after the instruction. "Remembering, understanding, Applying" etc. are dimensions that should be the prime focus of teaching and learning in schools. Instruction in most cases has tended to stress knowledge acquisition to the detriment of other higher level behaviours such as application, analysis etc. Each action verb indicates the underlying profile dimension of each particular specific objective. Read each objective carefully to know the profile dimension toward which you have to teach.

Lastly, please bear in mind that the syllabus cannot be taken as a substitute for lesson plans. It is therefore, necessary that you develop a scheme of work and lesson plans for teaching the units of this syllabus.

## DEFINITION OF PROFILE DIMENSIONS

As already stated, profile dimensions describe the underlying behaviours for teaching, learning and assessment. In Chemistry, the three profile dimensions that have been specified for teaching, learning and testing are:

| | |
|---|---|
| Knowledge and Understanding | 30% |
| Application of Knowledge | 40% |
| Practical and Experimental Skills | 30% |

Each of the dimensions has been given a percentage weight that should be reflected in teaching, learning and assessment. The weights, indicated on the right of the dimensions, show the relative emphasis that the teacher should give in the teaching, learning and testing processes. The focus of this syllabus is to get students not only to acquire knowledge but also be able to understand what they have learnt and apply them practically. Combining the three dimensions in your teaching will ensure that Chemistry is taught not only at the factual knowledge level but that students will also acquire the ability to apply scientific knowledge to issues and problems, and will also acquire the capacity for practical and experimental skills that are needed for scientific problem solving. The explanation of the dimensions and the key action verbs associated with each profile dimension are as follows:

### Knowledge and Understanding (KU)

Knowledge

The ability to:
Remember, recognize, retrieve, locate, find, do bullet pointing, highlight, bookmark, network socially, bookmark socially, search, google, favourite, recall, identify, define, describe, list, name, match, state principles, facts and concepts. Knowledge is simply the ability to remember or recall material already learned and constitutes the lowest level of learning.

Understanding

The ability to:
Interpret, explain, infer, explain, exemplify, do advanced searches, categorize, comment, twitter, tag, annotate, subscribe, summarize, translate, rewrite, paraphrase, give examples, generalize, estimate or predict consequences based upon a trend. Understanding is generally the ability to grasp the meaning of some material that may be verbal, pictorial, or symbolic.

### Application of Knowledge (AK)

The ability to use knowledge or apply knowledge, as implied in this syllabus, has a number of learning/behaviour levels. These levels include application, analysis, innovation or creativity, and evaluation. These may be considered and taught separately, paying attention to reflect each of them equally in your teaching. The dimension “Applying Knowledge” is a summary dimension for all four learning levels. Details of each of the four sub levels are as follows:

Application

The ability to:
Apply rules, methods, principles, theories, etc. to concrete situations that are new and unfamiliar. It also involves the ability to produce, solve, operate, demonstrate, discover, implement, carry out, use, execute, run, load, play, hack, upload, share, edit etc.

| | |
|---|---|
| Analysis | The ability to:<br>Break down a piece of material into its component parts, to differentiate, compare, deconstruct, attribute, outline, find, structure, integrate, mash, link, validate, crack, distinguish, separate, identify significant points etc., recognize unstated assumptions and logical fallacies, recognize inferences from facts etc. |
| Innovation/Creativity | The ability to:<br>Put parts together to form a new whole, a novel, coherent whole or make an original product. It involves the ability to synthesize, combine, compile, compose, devise, construct, plan, produce, invent, devise, make, program, film, animate, mix, re-mix, publish, video cast, podcast, direct, broadcast, suggest (an idea, possible ways), revise, design, organize, create, and generate new ideas and solutions. The ability to create or innovate is the highest form of learning. The world becomes more comfortable because some people, based on their learning, generate new ideas, design and create new things. |
| Evaluating | The ability to:<br>Appraise, compare features of different things and make comments or judgement, contrast, critique, justify, hypothesize, experiment, test, detect, monitor, review, post, moderate, collaborate, network, refractor, support, discuss, conclude, make recommendations etc. Evaluation refers to the ability to judge the worth or value of some material based on some criteria and standards. We generally compare, appraise and select throughout the day. Every decision we make involves evaluation. Evaluation is a high level ability just as application, analysis and innovation or creativity since it goes beyond simple knowledge acquisition and understanding. |

A number of examination questions at the secondary school level begin with the word “Discuss”. Discuss belongs to the evaluation thinking skill and implies the ability to analyze, compare, contrast, make a judgement etc. The word “discuss” asks for a variety of thinking skills and is obviously a higher order thinking behaviour. Students consequently do poorly on examination questions that start with “Discuss”. For this reason, and also for the reason that discussion of issues, discussion of reports etc., are some of the major intellectual activities students will be engaged in, in work situations and at higher levels of learning after they have left secondary school, it will be very helpful if you would emphasize discussion questions etc. both in class and in the tests you set.

**Practical and Experimental Skills (PES)**

**Practical skills**: This involves the demonstration of manipulative skills using tools, machines and equipment for practical problem solving. The teaching of practical skills should involve projects, case studies and field studies where students will be intensively involved in practical work and in the search for practical solutions to problems and tasks.

**Experimental Skills:** This involve the demonstration of the inquiry processes in science and refer to skills in planning and designing experiments, observation, manipulation, classification, drawing, measurement, interpretation, recording, reporting, and conduct in the laboratory/field. Practical and Experimental skills refer to the psychomotor domain. A summary of the skills required for effective practical and experimental work are the following:

1. Equipment Handling
2. Planning and designing of experiments
3. Observation
4. Manipulation
5. Classification
6. Drawing
7. Measuring
8. Interpretation
9. Recording
10. Reporting
11. Conduct in Laboratory/Field

Equipment Handling***:*** Proper handling and use of tools and equipment for practical and experimental work. The teacher should ensure that students acquire a high level of proficiency in the use of tools and equipment for scientific work.

Planning and designing of Experiments**:** Development of hypotheses, planning and designing of experiments, persistence in the execution of experimental activities, modification of experimental activities where necessary, in order to reach conclusions.

Research evidence shows that when confronted with a problem, scientists who excel in their respective fields of work develop a number of hypotheses within a short time, review and critique each hypothesis and then select the best one. Less ingenious scientists on the other hand, tend to focus on only one or two hypotheses. The implication of this for the teacher of chemistry to lead students to learn to generate a number of hypotheses for every problem tackled in class; criticize each hypothesis generated before selecting the best one. Some of the critical characteristics to encourage in students are:

* Hypotheses generation
* Ability to modify and change procedures when difficulties arise
* Creativity
* Persistence

Observation: Use of the senses to make accurate observations. The student for instance, should be able to tell the colour, form, texture and the structure of specimens provided and be able to classify them.

Manipulation: Manipulation involves the skillful handling of scientific objects and tools for accomplishing specific tasks. It involves setting up laboratory apparatus, preparing specimens and other material for observation.

Classification: Group specimens and objects according to their common properties or characteristics.

Drawing: Draw clearly and label specimens, objects etc.

Measuring: Refers to the accurate use of measuring instruments and equipment for measuring, reading and making observations.

Interpretation: The ability to

(i) evaluate data in terms of its worth: good, bad, reliable, unreliable etc.

(ii) make inferences and predictions from written or graphical data
(iii) extrapolate
(iv) derive conclusions

Interpretation is also referred to as “Information Handling”.

Recording: Draw or make graphical representation boldly and clearly, well labeled and pertinent to the issue at hand.

Reporting: Students should be able to present pertinent and precise reports on projects they undertake. Reports, oral or written, should be concise, clear and accurate.

Conduct in Laboratory/Field: Observation of safety measures in the laboratory; care and concern for the safety of one’s self and for others; ability to work alone and with others; good co-operative spirit, economical use of materials; maintenance of clean and orderly work area; persistence in achieving results; creative use of materials

Attitudes**:** For success in any endeavour, the individual needs to cultivate attitudes relevant to that area of endeavour. The learning of chemistry should aim at acquisition of the following attitudes by students:

i. Curiosity: The inclination or feeling toward seeking information about how things work in a variety of fields
ii. Perseverance: The ability to continuously pursue an investigation until results are achieved.
iii. Flexibility in ideas: Tolerance and willingness to change opinion in the face of more plausible evidence.
iv. Respect for evidence: Willingness to collect and use data in one's investigation and also have respect for data collected by others and respect for the scientific conclusions others have arrived at.
v. Reflection: The habit of critically reviewing ways in which an investigation has been carried out to see possible faults and other ways in which the investigation could be improved upon.

The action verbs and the definitions provided in the explanations of the three profile dimensions should help you to structure your teaching such as to achieve the effects needed. Select from the action verbs provided for your teaching, in evaluating learning before, during and after the instruction. Use the action verbs also in writing your test questions. This will ensure that you give your students the chance to develop good thinking skills, and the capacity for excellent performance in integrated science and in examinations. Check the weights of the profile dimensions to ensure that you have given the required emphasis to each of the dimensions in your teaching and assessment.

## FORM OF ASSESSMENT

In developing assessment procedures, select specific objectives in such a way that you will be able to assess a representative sample of the syllabus objectives. Each specific objective in the syllabus is considered a criterion to be achieved by the student. When you develop a test that consists of items or questions that are based on a representative sample of the specific objectives taught, the test is referred to as a “Criterion-Referenced Test”. In many cases, a teacher cannot test all the objectives taught in a term, in a year etc. The assessment procedure you use i.e. class tests, home work, projects etc. must be developed in such a way that it will consist of a sample of the important objectives taught over a period.

The example below shows an examination consisting of three papers, Paper 1, Paper 2, Paper 3 and School Based assessment. Paper 1 will usually be an objective-type paper; Paper 2 will consist of structured questions or essay questions, essentially testing “Applying Knowledge”, but also consisting of some questions on “Knowledge and Understanding”. Paper 3 will be the practical test paper. The School Based assessment (SBA) will be based on all three dimensions as indicated. The distribution of marks for the objective test items, essay type questions and the practical questions in the three

papers and in the SBA should be in line with the weights of the profile dimensions already indicated and as shown in the last column of the table on the next page.

The West African Examinations Council (WAEC) generally sets about 60 objective test items and some structured questions and essay questions at the WASSCE (Paper 1). Try to emulate this. Paper 2 could consist of 3 practical questions.

In the examination structure presented below, Paper 1 is marked out of 60. Paper 2 is marked out of 90. Paper 3 is marked out of 60 marks and the SBA out of 90. The last row shows the weight of the marks allocated to each of the four test components. The three papers are weighted differently. Paper 2 is a more intellectually demanding paper and is therefore weighted more than Papers 1 and 3.

**Distribution Of Examination Paper Weights And Marks**

| **Dimensions** | **Paper 1** | **Paper 2** | **Paper 3** | **School Based Assessment** | **Total Marks** | **% Weight of Dimension** |
|---|---|---|---|---|---|---|
| Knowledge and Understanding | 40 | 30 | - | 20 | 90 | **30** |
| Application of Knowledge | 20 | 60 | - | 40 | 120 | **40** |
| Practical and Experimental Skills | - | - | 60 | 30 | 90 | **30** |
| **Total Marks** | 60 | 90 | 60 | 90 | **300** | |
| **% Contribution of Papers** | 20 | 30 | 20 | 30 | | **100** |

You will note that Paper 1 has a contribution of 20% to the total marks; Paper 2 has a contribution of 30% to the total marks; Paper 3 has a contribution of 20%, and the SBA has a contribution of 30% to the total marks. The numbers in the cells indicate the marks to be allocated to the items/questions that test each of the dimensions within the respective test papers.

The last but one column shows the total marks allocated to each of the dimensions. Note that the numbers in this column are additions of the numbers in the cells and they agree with the profile dimension weights indicated in the last column. Of the total marks of 300, 90 marks, equivalent to 30% of the total marks, are allocated to Knowledge and Understanding. 120 marks, equivalent to 40% of the total marks, are allocated to each of Application of Knowledge and 90 marks equivalent to 30% of total marks, allocated to Practical/Experimental Skills. The weight of each of the three dimensions is indicated in the last column. The ratio of theory to practice in chemistry is 70:30.

WAEC's examination structure at the WASSCE consists of two papers. Paper 1 includes the objective test and essay test components. Paper 2, the practical test is separate. In the example above, we recommend three separate papers to give your students extended practice for adequate examination preparation.

Item Bank: Obviously the structure of assessment recommended in this syllabus will need a lot of work on the part of the teacher. In preparation for setting examination papers, try to develop an item bank. The term "item bank" is a general term for a pool of objective items, a pool of essay questions or a pool of practical test questions. As you teach the subject, try to write objective test items, essay questions, structured essay questions and practical test questions to fit selected specific objectives which you consider important to be tested. If you proceed diligently, you will realize you have written more than 100 objective test items, and more than 30 essay-type questions in a space of one year. Randomly select from the item bank to compose the test papers. Select with replacement. This means, as items/questions are selected for testing, new ones have to be written to replace those items/questions already used in examinations. Items and questions that have been used in examinations may also be modified and stored in the item bank.

An important issue in the preparation for a major examination such as the WASSCE, is the issue of "test wiseness". To be test wise means the student knows the mechanics for taking a test. These mechanics include writing your index number and other particulars accurately and quickly on the answer paper; reading all questions before selecting the best questions to answer; apportioning equal time to each question or spending more time on questions that carry more marks; making notes on each question attempted before writing the answer; leaving extra time to read over one's work; finally checking to see that the personal particulars supplied on the answer sheet are accurate. Some good students sometimes fail to do well in major examinations because of weakness in the mechanics of test taking; because they are not test wise. Take your students through these necessary mechanics so that their performance in major examinations may not be flawed by the slightest weakness in test taking.

**GUIDELINES FOR SCHOOL BASED ASSESSMENT**

A new School Based Assessment system (SBA) will be introduced into the school system in 2011. The new SBA system is designed to provide schools with an internal assessment system that will help schools to achieve the following purposes:

- Standardize the practice of internal school-based assessment in all Senior High Schools in the country
- Provide reduced assessment tasks for subjects studied at SHS
- Provide teachers with guidelines for constructing assessment items/questions and other assessment tasks
- Introduce standards of achievement in each subject and in each SHS class
- Provide guidance in marking and grading of test items/questions and other assessment tasks
- Introduce a system of moderation that will ensure accuracy and reliability of teachers' marks
- Provide teachers with advice on how to conduct remedial instruction on difficult areas of the syllabus to improve class performance.

The arrangement for SBA may be grouped in categories as follows. Laboratory work, Projects, Group Work and End of Term Examinations

1. Laboratory Work:

   Students will be required to keep laboratory notebook. It is of utmost importance that records be neatly and accurately kept by both student and teacher.

2. Projects/Field Work: These are tasks assigned to students to be completed over an extended time.

These will involve the following:

i) Practical work
ii) Experiment
iii) Investigative study (including case study)

A report must be written for each project undertaken.

3. Mid-Term Test: The mid-term test following a prescribed format will form part of the SBA

4. Group Exercise: This will consist of written assignments or practical work on a topic(s) considered important or complicated in the term's syllabus

5. End-of-Tem Examination: The end-of-term test is a summative assessment system and should consist of the knowledge and skills students have acquired in the term. The end-of-term test for Term 3 for example, should be composed of items/questions based on the specific objectives studied over the three terms, using a different weighting system such as to reflect the importance of the work done in each term in appropriate proportions. For example, a teacher may build an End-of-Term 3 test in such a way that it would consist of the 20% of the objectives studied in Term 1, 20% of objectives studied in Term 2 and 60% of the objectives studied in Term 3. The end-of-term 3 test should therefore sample the knowledge and skills acquired over the three school terms in appropriate proportions.

**GRADING PROCEDURE**

To improve assessment and grading and also introduce uniformity in schools, it is recommended that schools adopt the following WASSCE grade structure for assigning grades on students' test results.

| | | | |
|---|---|---|---|
| Grade A1: | 80 - 100% | - | Excellent |
| Grade B2: | 70 - 79% | - | Very Good |
| Grade B3: | 60 - 69% | - | Good |
| Grade C4: | 55 - 59% | - | Credit |
| Grade C5: | 50 - 54% | - | Credit |
| Grade C6: | 45 - 49% | - | Credit |
| Grade D7: | 40 - 44% | - | Pass |
| Grade D8: | 35 - 39% | - | Pass |
| Grade F9: | 34% and below | - | Fail |

In assigning grades to students' test results, you are encouraged to apply the above grade boundaries and the descriptors which indicate the meaning of each grade. The grade boundaries i.e., 60-69%, 50-54% etc., are the grade cut-off scores. For instance, the grade cut-off score for B2 grade is 70-79% in the example. When you adopt a fixed cut-off score grading system as in this example, you are using the criterion-referenced grading system. By this system a student must make a specified score to be awarded the requisite grade. This system of grading challenges students to study harder to earn better grades. It is hence a very useful system for grading achievement tests.

Always remember to develop and use a marking scheme for marking your class examination scripts. A marking scheme consists of the points for the best answer you expect for each question, and the marks allocated for each point raised by the student as well as the total marks for the question. For

instance, if a question carries 20 marks and you expect 6 points in the best answer, you could allocate 3 marks or part of it (depending upon the quality of the points raised by the student) to each point , hence totaling 18 marks, and then give the remaining 2 marks or part of it for organisation of answer. For objective test papers you may develop an answer key to speed up the marking.

# SHS 1

# SECTION 1

## INTRODUCTION TO CHEMISTRY

**General Objectives:** The students will

1. Recognize the centrality of chemistry among science subjects and the role it plays to solve the numerous problems facing society.
2. Recognize that science depends heavily on measurement and that one's ability to measure accurately and precisely is a prerequisite for learning chemistry.
3. Understand that different forms of matter behave differently and know how to handle them.
4. Identify and describe careers related to chemistry and contribution of scientists including Ghanaians in chemistry related fields.

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**CHEMISTRY AS A DISCIPLINE** | The students will be able to:<br><br>1.1.1 describe chemistry as a subject and as a central science discipline. | Chemistry as a subject and as a central science discipline. | Let students:<br><br>Discuss what chemistry is about. Discuss some important things chemistry has done and what it can be used to do. Use examples mostly from the immediate environment.<br><br>Discuss the centrality of chemistry as a science discipline which relates with and help to explain many things in other science and science related subjects. | |
| | 1.1.2 describe the various branches of chemistry. | Chemistry and its branches<br><br><u>Division</u>: Pure and Applied<br><br><u>Pure:</u> Physical; Inorganic; Organic<br><br><u>Applied</u> : Biochemistry, Biotechnology, Geochemistry, Medicine, Pharmacy, Petrochemistry, Environmental chemistry, Radiochemistry | Discuss the pure and applied branches of chemistry. | |
| | 1.1.3 outline some careers in chemistry and their importance. | Some careers in chemistry Chemist, Biochemist, Teacher chemist, Geochemist, Pharmacist, Environment chemist, Phytochemist, Chemical Engineer, Food Scientist, Atmospheric Scientist, Forensic Scientist, Water Quality Analyst | Discuss some careers in chemistry and chemistry related fields, what they do and the education and training necessary for these careers. | Identify **two** applied chemistry professions and explain the chemistry they practice and the education and training necessary for these careers. |

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2** | The students will be able to: | | Let students: | |
| **MEASUREMENT OF PHYSICAL QUANTITIES** | 1.2.1 describe the importance of scientific measurements to the study of chemistry. | Scientific Measurements and their importance in chemistry | Discuss the importance of scientific measurements to the study of chemistry. | |
| | 1.2.2 measure some physical quantities using appropriate instruments. | Measurement of physical quantities | Select appropriate instruments(e.g. balance, glassware, titration instruments)and materials(e.g. solutes) and identify appropriate methods, techniques and procedures for using or measuring them<br><br>Demonstrate how to measure mass, length, time, temperature and volume and assign appropriate SI units and significant figures.<br>Discuss the terms, precision and accuracy associated with measurements and demonstrate them.<br><br>Do simple calculations on precision and accuracy(e.g. in a volumetric exercise) | |
| | 1.2.3 identify the uses laboratory equipment. | identification and uses of laboratory equipment | Correctly identify laboratory equipment and materials. | |
| | 1.2.4 differentiate between basic and derived units of measurement. | Basic and Derived Unit of measurement | Compare basic and derived units of measurement using specific physical quantities. | |
| | 1.2.5 outline the scientific method. | The Scientific Method | Discuss the scientific method of inquiry; include Identification of problem, hypothesis, experimentation, formulation of laws and theories. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 3**<br><br>**BASIC SAFETY LABORATORY PRACTICES** | The students will be able to:<br><br>1.3.1 read and follow rules and instructions in the laboratory. | Rules and instructions in the laboratory | Let students:<br><br>Discuss rules, regulations and regulations that should be followed in the chemistry laboratory. | |
| | 1.3.2 explain what hazard symbols are and relate their importance to the handling and use of laboratory chemicals and equipment. | Hazard symbols and their meanings and significance | Discuss hazard symbols on chemical bottles, glassware, electrical gadgets and other materials found in the laboratory and demonstrate how to handle those materials safely. | What is a hazard? sketch three hazard symbols and explain what they mean. |
| | 1.3.3 handle some minor laboratory accidents and give first aid. | Laboratory emergencies and First Aid | Discuss and practice how to handle some minor laboratory accidents and give first aid. | |
| | 1.3.4 outline the need to have personal protective equipment in the chemistry laboratory. | Personal protective equipment | List some personal protective equipment in the chemistry laboratory and discuss their uses. Examples of personal protective equipment are:<br>* Chemical goggles<br>* Eyewash station<br>* Safety shower<br>* Gloves(corrosive resistant)<br>* Apron/laboratory coat<br>* Sleeve gauntlets<br>* Respirator/gas mask<br>* Face shield<br>* Fume cupboard | Outline the importance of using personal protective equipment when working in a chemistry laboratory. |
| | 1.3.5 explain why some chemicals should not be stored alphabetically. | Storage of chemicals. | Practice the safety procedures for storing and disposing of laboratory materials(chemicals, glassware and others)<br>. | Explain why some chemicals should not be stored alphabetically. |
| | 1.3.6 quench small fire in the laboratory. | Extinguishing fire in the lab. | Discuss and practice how to put out small fire using fire blanket and fire extinguisher. | |

# SHS 1

## SECTION 2
## ATOMIC STRUCTURE

**General Objectives:** The students will

1. Recognize that atomic models are used to explain atoms and help us understand the interaction of elements and compounds observed on a macroscopic scale.
2. Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus) and Bohr (planetary model of atom) and understand how these discoveries lead to the modern atomic theory.
3. Understand how periodic properties like atomic radii, ionization energy and electron affinity change with atomic number and principal quantum number.
4. Show understanding of both IUPAC and the North American ways of grouping elements on the periodic table.

| NIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | Let students: | |
| **PARTICULATE NATURE OF MATTER** | 2.1.1 describe the characteristics and nature of matter. | Characteristics and nature of matter | Review the particulate nature of matter(atoms, molecules and ions) from JHS syllabus<br><br>Demonstrate with experiments to show that matter is made up of tiny discrete particles | |
| **UNIT 2**<br>**STRUCTURE OF THE ATOM** | 2.2.1 explain Dalton's atomic theory. | Dalton and the atom | Discuss Dalton's Atomic theory and state any limitations associated with the theory. | |
| | 2.2.2 describe the various experiments that were carried out to reveal the structure of the atom. | The Atomic Structure:<br>• J.J. Thompson<br>• Rutherford<br>• Bohr | Discuss J.J. Thompson, Rutherford and Bohr's contribution towards the development of atomic structure.<br><br>Draw the structure of the Bohr's model of the atom.<br>Discuss the wave nature of the atom.<br>Discuss the quantum numbers:<br>* Principal quantum number<br>* Angular momentum quantum number/ Azimuthal quantum number<br>* Magnetic quantum number<br>* Spin quantum number<br>Discuss the importance of quantum numbers to the electronic structure of the atom.<br><br>Draw the shapes of **s** and **p**-orbital. | Describe Rutherford's contribution towards the development of atomic structure. |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2**<br><br>**STRUCTURE OF THE ATOM (Cont'd)** | The students will be able to:<br><br>2.2.3 write detailed electron configurations (s, p, d) for atoms of the first thirty elements. | Electron Configuration | Let students:<br><br>Write detailed electron configuration for atoms of the first thirty elements in the periodic table.<br>State and discuss the three rules or principles (Aufbau, Pauli Exclusion and Hund's rule of maximum multiplicity) used to arrange electrons in the atom.<br>Explain the differences in stability between half filled, partially filled and fully filled orbitals in sub-shells. | Write detailed electron configurations for $_{11}Na$, $_{12}Mg$, $_{18}Ar$, $_{25}Mn$ and $_{30}Zn$ |
| | 2.2.4 describe an isotope. | Characteristics of isotopes.<br>* Same proton number<br>* Different nucleon numbers<br>* Same chemical properties | Discuss the meaning of the terms, nucleon number, nuclide, proton number, atomic mass, relative atomic mass and isotope and outline their importance to the atom. How are the terms important to the study of isotopes?<br>Draw attention to the big changes in the mass of the isotopes of hydrogen. | |
| | 2.2.5 describe the operations of the mass spectrometer. | Mass Spectrometer | Discuss the operations of the mass spectrometer in the detection of the isotopes of an element and the molecular ion of a molecule<br>Discuss how to determine the relative atomic mass of an element from a mass spectrum data<br><br>Discuss the importance of the mass spectrometer in the determination of the relative molecular mass of a compound. | How will you determine the number of isotopes, relative atomic and molecular masses and isotopic abundance from atomic and molecular spectrum? |
| **UNIT 3**<br><br>**PERIODICITY** | 2.3.1 relate the position of an element in the periodic table to its atomic number and electron configuration. | Electron configuration and the position of elements in the periodic table | Discuss how the electron configuration of an element relates to its position in the periodic table and to its reactivity with other elements in the table. | |
| | 2.3.2 Use the periodic table to identify metals, semi-metals, non-metals and halogens. | Identifying the different categories of elements in the periodic table: Metals, semi-metals, and non-metals | Discuss the different categories of elements, metals, semi-metals, nonmetals on the periodic table and within the metals, identify alkali metals, alkaline earth metals and transition metals as metals. Identify halogens and noble gases as nonmetals. | |
| | 2.3.3 describe the physical and chemical properties of some representative elements. | Physical and chemical properties of the elements: Na, Mg, Fe, Si and Cl | Discuss the pattern in physical properties (hardness, density, melting point, boiling point and physical state) of the alkali, alkaline Earth, semi-metal and the halogens.<br>Discuss the chemical reactions of the elements with water. Data can be used. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 3**<br><br>**PERIODICITY (Cont'd)** | The students will be able to: | | Let students: | |
| | 2.3.4 distinguish between the terms 'group' and 'period | Groups and periods of the periodic table | Identify groups and periods of the periodic table. Explain why the elements in the same group behave similarly although they have differences in size and nucleon number.<br>Discuss the similarities in chemical nature of elements in the same group and account for the gradation in properties.<br>Use the following reactions for your discussions:<br>Alkali metals: Li, Na and K with water | |
| | 2.3.5 explain the periodic law | Periodic Law | Discuss the use of the periodic law in predicting the properties of a given element. | Place the following elements;<br>$_{11}Na$, $_{26}Fe$, $_{15}P$<br>in their respective groups, periods and blocks. |
| | 2.3.6 identify trends in atomic size, ionization energy, electron affinity, electronegativity and ionic size for elements on the periodic table. | Trends on the Periodic table:<br>* relative size of atoms and ions<br>* ionization energy,<br>* electron affinity,<br>* electronegativity | Discuss and explain the periodic trends in atomic size, ionic size, ionization energy, electron affinity and electronegativity for elements, $Li \rightarrow Cs$, halogens and period 2 & 3 elements ($Li \rightarrow Ne$ and $Na \rightarrow Ar$)<br><br>Account for any discrepancies in the periodic properties with respect to beryllium, boron, oxygen and nitrogen. | Describe how atomic size, ionic size, ionization energy, electron affinity, electronegativity vary across periods and down the groups on the periodic table. |
| | 2.3.7 describe the periodic gradation of elements in the third period. | Periodic gradation of elements in the third period | Discuss the progression of the elements from metallic to non-metallic and ionic to covalent compounds of the elements in period 3 ($Na \rightarrow Ar$). | |
| | 2.3.8 use the periodic table to determine the number of electrons available for bonding. | The periodic table and chemical bonding. | Discuss the relationship between the position of an element on the periodic table and its proton number, electron configuration, physical properties and the type of chemical bonding it can undergo. | |

# SECTION 3
# CHEMICAL BONDS

**General Objectives:** The students will:

1. Understand that atoms combine to form molecules by sharing valence electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bond.
2. Understand how electronegativity and ionization energy relate to chemical bond formation.
3. Predict chemical formulas based on the number of valence electrons.
4. Recognize the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of ionic and molecular compounds.
5. Understand that, the type of chemical bond in a compound determines the physical and chemical properties of the compound.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**INTERATOMIC BONDING** | The student will be able to:<br><br>3.1.1 explain the meaning of a chemical bond. | Chemical Bond | Let students:<br><br>Review the terms atoms, molecules and ions(SHS 2, Section 2, Unit 1)<br>Discuss the term chemical bond.<br>Discuss the differences in stability of atoms and their ions. | |
| | 3.1.2 describe how ionic bond is formed between two chemical species. | Formation of ionic bonds and ionic compounds | Identify elements that form cations and anions readily<br>Discuss the formation of ionic bond.<br>Identify the characteristics of the chemical species involved in ionic bond formation.<br><br>Discuss the formation of some ionic compounds.<br>e.g. NaCl, $CaCO_3$, $MgCl_2$, CaO. | |
| | 3.1.3 draw Lewis dot structures for simple ionic compounds. | Lewis dot structures for simple ionic compounds<br><br>Factors that influence the formation of ionic bond | Write Lewis dot structures for simple binary ionic compounds, e.g. NaCl, $MgF_2$<br><br>Explain how the following factors influence the formation of ionic bonds:<br>* ionization energy<br>* electronegativity difference<br>* electron affinity<br>* lattice energy | Use electron dot diagrams to show how NaCl is formed.<br><br>Arrange the following ionic compounds in order of increasing lattice energy<br>NaCl, $CaCl_2$ and LiCl |
| | 3.1.4 identify factors that promote the introduction of covalent character into ionic bond. | Covalent character in ionic bond | discuss the factors that promote the introduction of covalent character into ionic bonds. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**INTERATOMIC BONDING (Cont)** | The student will be able to:<br><br>3.1.5 name some binary and ternary ionic compounds from their formulae and write formulae from their names. | Names of ionic compounds | Let students:<br><br>Name and write the chemical formulae for simple ionic compounds including those that contain the polyatomic ions: ammonium, hydroxide, trioxocarbonate(IV), trioxonitrate(V), tetraoxophosphate(V), tetraoxosulphate(VI) and trioxochlorate(V). | Write the names of the following compounds using the IUPAC convention; $Cu_2O$, $K_3PO_4$, $(NH_4)_2SO_4$ |
| | 3.1.6 describe the general properties of ionic compounds. | Properties of ionic compounds. | Discuss and demonstrate the following properties of binary ionic compounds.<br>* Solubility in polar and non-polar solvent<br>* Electrical conductivity<br>* Hardness<br>* Melting points. | Account for why $Na_2CO_3$ is thermally stable but $CaCO_3$ is not. |
| | 3.1.7 describe how covalent bond is formed. | Formation of covalent bond | Identify elements that form covalent bonds readily<br>Discuss the characteristics of the atoms and groups involved in the formation of covalent bonds. | |
| | 3.1.8 draw Lewis dot structures for some covalent compounds. | Lewis dot structures of covalent compounds and molecules | Use the octet rule to draw Lewis dot structures for molecules ($H_2$, $O_2$ , $N_2$) and covalent compounds. e.g. $H_2O$, $NH_3$, $BF_3$. | Differentiate between lone pair and bonding pair of electron. |
| | | Factors which influence the formation of covalent bond. | Discuss and explain the effect of the following factors on the formation of covalent bond.<br>* atomic size<br>* ionization energy<br>* election affinity<br>* electronegativity<br><br>Discuss dative covalent bonding and show the difference between pure covalent bond and dative covalent bond.<br><br>Discuss the characteristics of the species involved in the formation of dative covalent bond. | Give one example each of electron rich species and electron deficient species. Illustrate with diagrams |
| | | Polar covalent bonds | Discuss ionic character (polarity) in covalent bonds based on electronegativity difference between the species involved. | |
| | 3.1.9 describe the properties of covalent compounds.. | Properties of covalent compounds | Discuss properties of covalent compounds under<br>* solubility in polar and non-polar solvents<br>* melting point<br>* boiling point<br>* electrical conductivity | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**INTERATOMIC BONDING (Cont)** | The student will be able to: | | Let students:<br><br>Discuss the effect of covalent and ionic characters in ionic and covalent bonds on the solubility, thermal stability and boiling points of ionic and covalent compounds. | |
| | 3.1.10 describe how metallic bond is formed. | Metallic bonding | Discuss the characteristics of the atoms and groups involved in the formation of metallic bond.<br>Discuss the formation of metallic bond. | |
| | | Factors that favour metallic bonding. | Discuss the factors which influence the formation of metallic bond and explain how the factors relate to the hardness and softness of metals. | What factors influence the formation of metallic bond |
| | 3.1.11 state and describe the properties of metals. | Properties of metals. | Discuss and explain some properties of metals. e.g<br>* heat and electrical conductivity<br>* hardness<br>* ductility<br>* malleability<br>* lustre<br>* sonority | |
| **UNIT 2**<br><br>**INTER-MOLECULAR BONDING** | 3.2.1 describe the different types of intermolecular forces found in covalent compounds. | Intermolecular forces in covalent compounds | Discuss the different types of intermolecular forces in covalent compounds. Include:<br>* Hydrogen bond<br>* van der Waal's forces (Dipole-dipole attraction and Induced dipole- Induced dipole attraction). | What is viscosity? What is the relationship between intermolecular forces and viscosity? |
| | 3.2.2 explain how intermolecular forces arise from the structural features of molecules. | Relationship between intermolecular forces and the structural features of molecules. | Discuss the structures of the following molecules; $H_2O$, HF, $NH_3$ , HCl, $CH_4$, and $CH_3COOH$<br><br>Discuss the importance of lone pairs of electrons in intermolecular attraction and structures of molecules | |
| | 3.2.3 describe how intermolecular forces affect the solubility melting point and boiling points of substances. | Effect of intermolecular forces on the properties of molecular substances. | Discuss using specific examples, the effect of intermolecular forces on the structural features and properties of molecules<br><br>Discuss the effect of intermolecular forces on the solubility, boiling points and density/viscosity of named molecular compounds with comparable molecular masses. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2**<br><br>**INTER-MOLECULAR BONDING (Cont)** | The student will be able to:<br><br>3.2.4 describe the formation of hydrogen bond.<br><br>3.2.5 describe the existence of van der Waals forces between covalent molecules. | Hydrogen bonding.<br><br>van de Waals forces. | Let students:<br><br>Explain the formation of hydrogen bond.<br>Discuss the effect of hydrogen bonding on the boiling points of compounds. Use $H_2O$ and $H_2S$ as examples.<br><br>Discuss van der Waals forces of attraction between and within covalent molecules.<br>* Dipole-dipole forces<br>* Induced dipole - induced dipole forces<br><br>Discuss factors which influence the strength of van der Waals forces. Include:<br>* Molar mass<br>* Size/surface area of molecule,<br>* Number of electrons per molecule.<br><br>Compare the melting and boiling points of noble gases, halogens and the alkane homologous series. | Explain what is meant by hydrogen bonding.<br>Describe the hydrogen bonding between two water molecules.<br><br>Give an example for each type of intermolecular forces.<br>(a). Dipole-dipole interaction.<br>(b). induced dipole-induced dipole forces |
| **UNIT 3**<br><br>**HYBRIDIZATION AND SHAPES OF MOLECULES** | 3.3.1 explain the term 'hybridization'. | Hybridization of atomic orbitals. | Brainstorm to come out with the meaning of the term hybridization.<br>Discuss the procedures involved in the hybridization of atomic orbitals. | |
| | 3.3.2 describe how **$sp^3$**, **$sp^2$** and **sp** hybrid orbitals are formed. | Formation of **$sp^3$**, **$sp^2$** and **sp** orbitals. | Discuss how **$sp^3$, $sp^2$** and **sp** hybrid atomic orbitals are formed and sketch the shapes of the following molecules:<br>* $CH_4$, $NH_3$, $H_2O$ -- $sp^3$<br>* $BCl_3$, $H_2C=CH_2$ - $sp^2$<br>* $BeCl_2$, $HC\equiv CH$ -- sp | Describe the bonding in ethene ($H_2C=CH_2$) in terms of sigma($\sigma$) and ($\pi$) pi-bonding |
| | 3.3.3 describe how sigma and pi-bonds are formed. | Formation of sigma($\sigma$) and ($\pi$) pi-bonds. | Discuss and sketch to show how sigma ($\sigma$) and ($\pi$) pi-bonds are formed in ethene ($H_2C=CH_2$) and ethyne ($CH\equiv CH$).<br>Account for the differences in bond strength between sigma and pi-bonds. | |
| | 3.3.4 illustrate the shapes of given molecular compounds. | Shapes of molecular compounds. | Discuss and sketch the shapes (linear, planar, and tetrahedral) for some molecular compounds e.g. $BeCl_2$, $BF_3$, $CH_4$, and $NH_3$, $CO_2$. | |

# SHS 1

## SECTION 4
## CONSERVATION OF MATTER AND STOICHIOMETRY

**General Objectives:** The students will

1. Recognize that the introduction of the Carbon-12 scale was the beginning of the quantitative measurement of the amount of substance contained in different materials
2. Demonstrate an understanding of the mole concept and its significance to the quantitative analysis of chemical reaction.
3. Demonstrate an understanding of qualitative and quantitative properties of solutions.
4. Understand that balanced chemical equations indicate the quantitative relationships between reactants and products involved in chemical changes
5. Recognize that chemical reactions and their applications have significant implications for society and the environment.
6. Recognize that the particles in the nucleus of an atom repel each other and that a strong force needs to be present to keep the nucleus.

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**CARBON-12 SCALE** | The student will be able to:<br><br>4.1.1 describe the Carbon-12 scale of measurement of mass | Carbon-12 Scale. | Let students:<br><br>Discuss the need for a reference scale for measurement of masses of elements and compounds.<br><br>Discuss the choice of Carbon - 12 isotope as a reference scale for measurement of masses of elements and their compounds.<br><br>Explain the atomic mass unit, $\mu$ (mui)<br><br>Express atomic masses in terms of atomic mass unit, $\mu$ | |
| | 4.1.2 explain relative atomic and molecular mass. | Relative atomic mass ($A_r$) and relative molecular mass ($M_r$). | Illustrate with given relative atomic mass to show the understanding of the use of the Carbon - 12 scale. | |
| | 4.1.3 explain the mole as a unit of measurement of amount of substance. | Amount of substance (n) in moles(mol)<br><br>Avogadro constant, L. | explain that a mole of any substance contains the same number of entities as the number of atoms contained in 12g of Carbon-12 isotope<br><br>Explain that the number of atoms in 12g of Carbon - 12 is the Avogadro constant, $N_A/L = 6.02\times10^{23}$ entities $mol^{-1}$. | |

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The student will be able to: | | Let students: | |
| | 4.1.4 identify molar quantities of substances. | Molar quantities. | Establish the relationship between amount of substance and molar quantities: $n = \frac{m}{M}$; $n = \frac{V}{Vm}$; $n = \frac{N}{N_A}$; $n = \frac{Q}{F}$<br>**Note**: Understand that molar quantity means per mol ($mol^{-1}$) of the quantity, e.g.<br>Molar mass (M) — n = amount of substance<br>Molar volume $V_m$ — m = mass in grams<br>Avogadro constant, L or $N_A$ — V = volume in $dm^3$<br>Faraday constant, F — N =number of particles<br>Q = quantity of electricity | Calculate the number of atoms in 16g of Cu. |
| | 4.1.5 calculate amount of substance, number of entities and molar quantities from a given data. | Calculations involving amount of substance, number of entities and molar quantities. | Practice calculation involving amount of substance, number of entities and molar quantities.<br>Discuss the relationship between the Avogradro's number, the mole concept and the molar mass of any given substance. | How many moles are there in 2.7g of Al? |
| **UNIT 2 SOLUTIONS** | 4.2.1 explain solute, solvent and solution and give examples | Concept of solution. | Discuss the formation of solution from solute and solvent<br>Discuss the different types of solutions and give examples. For example:<br>• Gas-gas solution<br>• Gas-liquid solution<br>• Liquid-liquid solution<br>• Liquid-solid solution<br>• Solid-solid solution | Give one example each of the following types of solutions.<br>1. Gas-liquid solution<br>2. Liquid-liquid solution<br>3. Liquid-solid solution<br>4. Solid-solid solution |
| | 4.2.2 prepare solutions of given concentration from solid solutes. | Preparation of standard solutions. | Discuss and prepare standard solutions from the following solid solutes using water as solvent. e.g. $Na_2CO_3$, $(COOH)_2 .2H_20$/ $(H_2C_2O_4 .2H_2O)$.<br>Outline the steps involved in the preparation of standard solutions from solid solutes.<br>**Note:**<br>1 Concentration may be expressed as mass concentration, $g/dm^3$, and amount concentration, $mol/dm^3$, ppm.<br>2 Current IUPAC chemical terminologies, units, symbols and conventions should be used**.** | A sample of $NaNO_3$ weighing 0.38g is placed in a 50.0ml volumetric flask. The flask is then filled with water to the mark. What is the molarity of the resulting solution? |

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2 SOLUTIONS (CONT'D)** | The student will be able to:<br>4.2.3 prepare solutions of given concentration from liquid solutes by diluting a concentrated solution. | Preparing solutions from liquid solutes by the method of dilution. | Let students:<br>Prepare solutions of known concentration from liquid solutes; HCl acid, $H_2SO_4$ acid, $HNO_3$ acid and $NH_3$(aq)<br>Outline the steps involved in the preparation of solutions from liquid solutes.<br>Explain and calculate dilution factor.<br>Determine the concentration of liquid solutes (stock solution) given density { (w/v), (w/w)}, specific gravity, relative molecular mass or molar mass, and % purity.<br>Practice the preparation of<br>i. 250cm$^3$ and 500cm$^3$ of dilute HCl solution(2.0M and 0.1M) from 36.5% stock solution, which has a density of 1.2g/cm$^3$.<br>ii. 250cm$^3$ and 500cm$^3$ of dilute $HNO_3$ solution(2.0M and 0.1M) from 63% stock solution of $HNO_3$, which has a density of 1.4g/cm$^3$<br>Keep the solutions for simple titration and qualitative analysis practical. | You are given a solution of 14.8M $NH_3$. How many milliliters of this solution do you require to give 100.0ml of 1.00M $NH_3$ when diluted?<br>You are given HCl stock solution of % purity 36.5% and density 1.2g/cm$^3$, what is the concentration of the acid? |
| | 4.2.4 explain the terms primary standard, secondary standard and standardized solution. | Primary standard, secondary standard and standardized solution | Brainstorm to come out with the meaning of the terms primary standard, secondary standard and standardized solution and give examples in each case.<br>Discuss the uses of primary standards and explain why some solutions should be standardized before use. | |
| **UNIT 3 STOICHIOMETRY AND CHEMICAL EQUATIONS** | 4.3.1 write correct formula for named chemical compounds. | Writing formula for named chemical compounds | Write chemical formula for named binary and ternary compounds.<br>Write chemical formula for simple hydrocarbon compounds. | Write the chemical formulae for these compounds:<br>i. iron (II) tetraoxosulphate(VI)<br>ii. calcium hydroxide<br>iii. tetraoxosulphate(VI) acid<br>iv. ethene ; v. propane |
| | 4.3.2 write the name of a given compound correctly. | Naming chemical compounds | Write the IUPAC names for given binary and ternary compounds and ions and also for simple hydrocarbon compounds.<br>Determine the oxidation states or numbers of the chemical species in a compound. | Give the IUPAC names for the following compounds.<br>i. $KMnO_4$<br>ii. $Fe_2O_3$<br>iii. NaClO<br>iv. $CaCl_2$<br>v. $HC \equiv CH$ |

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 3 STOICHIOMETRY AND CHEMICAL EQUATIONS (CONT)** | The student will be able to:<br>4.3.3 write and balance chemical equations | Writing and balancing chemical equations | Let students:<br>write and balance chemical equations for:<br>* combustion reactions (including combustion of simple hydrocarbons)<br>* synthesis<br>* displacement or replacement<br>* decomposition<br>* ionic reactions | Balance the following equations:<br>i. $Na_2S_2O_3 + I_2 \rightarrow NaI + Na_2S_4O_6$<br>ii. $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + NaCl$ |
| | 4.3.4 explain the laws of chemical combination. | Laws of chemical combination | Discus the three laws of chemical combination.<br>* Law of conservation of matter<br>* Law of constant proportion<br>* Law of multiple proportion<br>Apply the laws of chemical combination to balance given chemical equations | How many grams of carbon are there in 83.5g of formaldehyde, $CH_2O$? (C=40.0%; H=6.73%; O=53.3%) |
| | 4.3.5 demonstrate the principle of conservation of matter through experiment. | Demonstration of the law of conservation of mass /matter | Perform a simple experiment to show that mass is conserved in a chemical reaction.<br>**Note**: You can use the reaction between molar solutions of $Na_2CO_3$ and $CaCl_2$. Let students record what they see as the reaction goes on. Assist students weigh chemicals, prepare solutions and manipulate equipment. | A compound of nitrogen and oxygen is analyzed, and a sample weighing 1.587g is found to contain 0.483g N and 1.104g O. What is the empirical formula of the compound? |
| | 4.3.6 identify and write mole ratios for chemical species in balanced chemical equations. | Mole ratio and its applications in quantitative analysis | Determine mole ratio of species in a chemical reaction.<br>Use mole ratio to calculate the following quantities in chemical reactions:<br>* Number of entities<br>* Amount of substance.<br>* Mass of substance<br>* Concentrations in g/dm$^3$, mol/dm$^3$ and ppm<br>* Volume of substance<br>* Percentage yield of products | 4.0g of magnesium ribbon was burnt in excess oxygen. What is the mass of magnesium oxide that will be formed? |
| | 4.3.7 determine limiting and excess reagents in a chemical reaction. | Limiting and excess reagents in a chemical reactions | Determine the limiting and excess reagents in chemical reactions by comparing the available moles of each reactant to the moles required for complete reaction using the mole ratio. | |

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The student will be able to: | | Let students: | |
| **UNIT 3 STOICHIOMETRY AND CHEMICAL EQUATIONS (CONT)** | 4.3.8 determine the formula of compounds from experimental and given data. | Empirical and Molecular formula | Discuss empirical and molecular formula determination<br>Calculate % composition of elements from given formulae.<br><br>Determine the empirical and molecular formulae for inorganic and organic compounds and for compounds obtained from the combustion of inorganic and organic compounds, e.g. hydrocarbons, amides, alkanols, MgO, $Cu_2O$ and CuO. | |
| | 4.3.9 determine the formula of magnesium oxide through experiment. | Determination of the chemical formula of magnesium oxide | Deduce the formula of magnesium oxide through experiment.<br>**Note:**<br>1. In this experiment, a known mass of magnesium ribbon is burnt in a crucible in contact with air. The mass of magnesium oxide produced is found. Then, using mole concept the formula can be determined.<br>2. Assist students in the skill of weighing materials. | |
| **UNIT 4 NUCLEAR CHEMISTRY** | 4.4.1 explain some terms associated with the nucleus of the atom. | Some terms associated with the nucleus of the atom:<br>* Proton number<br>* Nucleon number<br>* Isotope<br>* Nucleon<br>* Nuclide | Discuss some terms associated with the nucleus of the atom as stated in the content. | What is radioactivity?<br><br>Write one equation each to show how alpha ($\alpha$), beta ($\beta$) and gamma ($\chi$) radiations are emitted from the nucleus of a radioactive nuclide. |
| | 4.4.2 Identify stable and unstable nuclide. | Nuclear stability | Discuss the stability of nuclides using the factors: binding energy, neutron –proton ratio, and half-life( $t_{\frac{1}{2}}$ )<br><br>Discuss and do calculations involving half-life from a given data. | Explain why the nuclei of some atoms are stable but others are not. |
| | 4.4.3 classify nuclear reactions as spontaneous or stimulated/induced nuclear reactions. | Spontaneous nuclear reactions (Radioactivity) | Discuss the meaning of radioactivity.<br>Distinguish between spontaneous nuclear reactions (radioactivity) and stimulated nuclear reactions (fission and fusion). | |
| | 4.4.4 identify the main types of emissions that occur in radioactivity | Types of emissions:<br>* Alpha($\alpha$) decay<br>* Beta($\beta$) decay<br>* Gamma($\chi$) decay | Describe the main types of emissions that occur in radioactivity: alpha and beta particles and gamma rays and how to detect them using Geiger-Muller counter. | |

| *UNIT* | SPECIFIC OBJECTIVE | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 4 NUCLEAR CHEMISTRY (Cont)** | The student will be able to: | Nature and properties of alpha, beta particles and gamma rays | Let students:<br>Discuss the nature and properties of alpha, beta particles and gamma rays in terms of:<br>1. charge<br>2. relative mass<br>3. penetration power<br>4. ionising power | Explain why the lost of a small mass of a nuclide results in the release of enormous amount of energy. |
| | | Radioactive decay | Write and balance equations for nuclear reactions that result in alpha, beta and gamma radiation emission.<br>Draw and discuss the decay curve from a given data.<br>Relate half-life to the radioactive decay law. | Which releases more energy, chemical or nuclear reaction? Explain your answer. |
| | | Induced /stimulated nuclear reactions:<br>• Nuclear fission<br>• Nuclear fusion | Discuss nuclear fission and fusion reactions and support them with balanced equations.<br>Discuss the differences between nuclear fission and fusion reactions<br>Discuss the development of atomic bomb from uncontrolled nuclear fission reactions. | |
| | 4.4.5 differentiate between nuclear and chemical reactions. | Differences between nuclear and chemical reactions. | Discuss the differences between nuclear and chemical reactions.<br>Explain why matter is not conserved in nuclear reactions. | |
| | 4.4.6 describe some applications of nuclear chemistry. | Applications of nuclear chemistry. | discuss some applications of nuclear chemistry in;<br>* Agriculture and industry<br>* Energy<br>* Health<br>* Archaeology<br>* Food processing and preservation<br>* Research<br>* Mining and petroleum industries | |
| | | Hazards associated with nuclear radiations. | Discuss some natural and technological sources of exposure to nuclear radiation and its effects on humans.<br>Discuss the dangers associated with the applications of nuclear chemistry, e.g. nuclear accidents, fall-outs, effects on biological processes in plants and animals, and storage/disposal of nuclear waste. | |

# SHS 1

## SECTION 5

## STATES OF MATTER

**General objectives:** The student will:

1. Understand that the characteristics, nature and properties of solids and liquids depend on the type of physical and chemical bonds that exist between the species forming the solid or liquid.
2. Appreciate the domestic and industrial uses of some solids and liquids.
3. Show understanding of the preparation, uses and behaviour of some gases under different conditions.
4. Understand that the state of matter depends on temperature

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The student will be able to: | | Let students: | |
| **SOLIDS AND LIQUIDS** | 5.1.1 describe the characteristics and nature of solids. | Characteristics and nature of solids. | Discuss the characteristics of solids based on shape, volume, density, forces of attraction and repulsion, compressibility and melting point.<br>Discuss the arrangement of particles (atoms, ions and molecules) in solids.<br><br>Discuss the different types of solids (ionic, molecular, metallic, covalent network/atomic solids) and give examples in each case. | Draw to show the arrangement of particles in solids and liquids.<br><br>Explain why some solids are hard, others are soft. |
| | 5.1.2 relate the properties of solids to the type of interatomic or intermolecular bonding in the solids. | Properties of solids | Identify the type of chemical bonds in Fe, NaCl, $SiO_2$, $I_2$, diamond and graphite and account for the differences in the physical properties (melting point, hardness, electrical conductivity) of the solids. | Explain why solid NaCl does not conduct electricity but solid Fe does. |
| | 5.1.3 outline some uses of diamond and graphite. | Uses of diamond and graphite. | Discuss some uses of diamond and graphite and relate these uses to their molecular structures.<br>Outline some uses of iodine in everyday life. | |
| | 5.1.4 determine the melting point of some covalent solids. | Determination of melting points of covalent solids | Discuss and demonstrate how to determine the melting point of covalent solids e.g. phenylmethanoic acid (benzoic acid), ethanedioic acid (oxalic acid) and ethanamide. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**SOLIDS AND LIQUIDS (cont'd)** | The student will be able to:<br><br>5.1.5 describe the characteristics and nature of liquids. | Characteristics and nature of liquids. | Let students:<br><br>Discuss the characteristics and nature of liquids based on arrangement of particles, shape, volume, compressibility, density, viscosity and fluidity. | |
| | 5.1.6 distinguish between vapour and gas. | Vapour and gases | Discuss the concept of external pressure, saturated vapour pressure, boiling, evaporation and differentiate between vapour and gas.<br>Discuss the relationship between vapour pressure and boiling point of liquids.<br>Discuss the effect of external vapour pressure on boiling points of liquids and its application in everyday life, e.g. pressure cookers. | Distinguish between vapour and gas. |
| | 5.1.7 make a liquid boil at a temperature below its boiling point. | Boiling at reduced pressure | Perform a simple experiment to make water boil at a temperature below its boiling point when vapour pressure is reduced.<br><br>Use a given vapour pressure-temperature data to determine the vapour pressure of a given liquid at a specific temperature. | |
| **UNIT 2**<br><br>**GASES AND THEIR PROPERTIES** | 5.2.1 describe the characteristics and nature of gases. | Characteristics and nature of gases | Discuss the characteristics and nature of gases: arrangement of particles, density, shape and compressibility. | |
| | 5.2.2 describe the laboratory preparation of hydrogen, ammonia and carbon dioxide. | Laboratory preparation of gases<br>* hydrogen<br>* ammonia<br>* carbon dioxide | Review the laboratory preparation and test for hydrogen, ammonia and carbon dioxide gases (acids and bases in Integrated Science for SHS).<br><br>Discuss methods of collecting gases and explain why different gases have different methods of collection.<br><br>Demonstrate how to dry gases (hydrogen, ammonia and carbon dioxide) using appropriate drying agents.<br>Explain why different gases are dried with different drying agents. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2**<br>**GASES AND THEIR PROPERTIES (cont)** | The student will be able to:<br>5.2.3 use the gas laws to explain the behviour of gases under different conditions. | Gas Laws and behaviour of gases | Let students ;<br>Discuss how Charles Law, Boyles law, Graham's law, Avogadro's law and Dalton's law of partial pressures are used to explain the behaviour of gases at standard conditions of temperature and pressure.<br>Write equations to represent each law.<br>Apply Dalton's law of partial pressures to describe the composition of gases and Graham's law to predict the diffusion of gases.<br>Use the kinetic molecular theory to explain changes in gas volumes, pressure and temperature and solve problems using $PV = nRT$. | A sample of $SO_2$ gas at a pressure of 1.0atm occupies a volume of 3.0L. What volume will it occupy when the pressure is changed to 1.5 atm? |
| | | Ideal and rare gases | Discuss the factors that promote the deviation of ideal gases from ideal situation | |
| **UNIT 3**<br>**THE KINETIC MODEL OF MATTER** | 5.3.1 explain the kinetic theory of matter. | Kinetic theory of matter. | Discuss the five postulates of the kinetic theory of matter and use them to explain the processes of;<br>* Melting of solids,<br>* Boiling of liquids<br>* Evaporation of liquid<br>* Dissolution of solute<br>* Brownian motion<br>* Diffusion. | |
| | 5.3.2 relate the speed at which different gas particles move to the masses of the particles. | Experiment to demonstrate the rate of diffusion of gases. | Discuss Graham's law of diffusion.<br>Perform an experiment to show that, gases diffuse at different rates and depend on molecular masses of the gases.<br>**Note:**<br>1. You can use conc. HCl, ammonia and a long glass tube or any other chemicals or methods convenient to do this experiment.<br>2. Help students to acquire the skills of<br>* Observing<br>* Measuring<br>* Recording<br>* Analyzing and interpreting data<br>* Communicating results | Explain why diffusion occurs more slowly in liquids than in gases.<br>Which diffuses faster in water, KI or $Pb(NO_3)_2$? Explain your answer. |
| | 5.3.3 demonstrate diffusion in liquids. | Experiment to demonstrate the diffusion of solute particles in liquids | Perform an experiment to show how different solute particles diffuse through a liquid e.g. water.<br>**Note**: You can use the reaction between KI and $Pb(NO_3)_2$. Or any two convenient chemicals. You will also need deionised water and a transparent bowl/plate. | |

# SHS 2

## SECTION 1

## ENERGY AND ENERGY CHANGES

**General objectives:** The student will:

1 Understand, determine, interpret and communicate energy changes in chemical reactions.
2 Recognize that reorganization of atoms in chemical reactions results in the release or absorption of heat energy.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**ENERGY CHANGES IN PHYSICAL AND CHEMICAL PROCESSES** | The student will be able to:<br><br>1.1.1 explain the terms system and surrounding. | System and its surrounding. | Let students:<br><br>Brainstorm to come out with the meaning of the terms **system** and **surrounding**.<br><br>Distinguish among open, closed and isolated systems and give examples. | Explain the terms **close** and **open** systems and give one example in each case. |
| | 1.1.2 explain the terms energy and enthalpy. | Energy and enthalpy | Discuss the energy changes associated with chemical processes. | |
| | 1.1.3 measure the enthalpy change using experiment. | Experiment to estimate the enthalpy change involved when a sample of $CaO$ reacts with water | Carry out experiment to estimate the heat change involved when a sample of $CaO$ (fresh) reacts with water to give $Ca(OH)_2$.<br><br>**Note:** Similar experiments can be performed by dissolving NaOH pellets, solid $NH_4Cl$ and conc. HCl acid separately in water. | |
| | 1.1.4 identify the type of enthalpy change associated with a given physical/chemical process. | Enthalpy changes associated with given physical/chemical processes (Endothermic and Exothermic processes) | Discuss physical/chemical processes that take in heat (endothermic) or give out heat (exothermic) and give examples.<br><br>Classify chemical reaction and /or phase changes as exothermic or endothermic. | Explain why freezing is an exothermic change of state. |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The student will be able to: | | Let students:<br><br>Discuss the enthalpy change involved in the following processes:<br>* Formation<br>* Combustion<br>* Atomization<br>* Sublimation<br>* Hydration/Solvation<br>* Dissolution<br><br>Analyze and label energy diagrams of chemical reactions, including reactants, products, enthalpy change and activation energy. | Draw energy profile diagram for a reaction that gives out heat. Label the reactant, product, and the enthalpy change. |
| **UNIT 2**<br><br>**ENERGY CYCLES AND BOND ENTHALPIES** | 1.1.5 describe the enthalpy change associated with 'burning' of food and fuels. | Energy in foods and fuels. | Discuss energy changes that occur when food is consumed and fuel burnt | |
| | 1.2.1 define and use the terms standard state and standard enthalpy change of formation $(\Delta H_f^\circ)$ combustion $(\Delta H_c^\circ)$ and neutralization $(\Delta H_n^\circ)$. | Standard state and standard enthalpy change of reactions | Discuss the terms standard state and standard enthalpy change of formation $(\Delta H_f^\circ)$, combustion $(\Delta H_c^\circ)$ and neutralization $(\Delta H_n^\circ)$. | |
| | 1.2.2 determine the enthalpy change associated with chemical reactions using experimental data. | Enthalpy change of a reaction.<br><br>* Hydration<br>* Combustion | Discuss the enthalpy change of reactions under the following factors<br>* Specific quantities of reactants<br>* Specific quantities of products<br>* Mass of substance<br>* Specific heat capacity<br>* Temperature change<br>Analyse experimental data for enthalpy changes in reactions under the content. (1). Enthalpy of hydration of anhydrous $CuSO_4$; (2). Enthalpy of combustion of Mg solid. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2**<br><br>**ENERGY CYCLES AND BOND ENTHALPIES (Cont)** | The student will be able to:<br><br>1.2.3 determine the heat of combustion of a given fuel. | Experiment to determine the heat of combustion of alcohol | Let students:<br><br>Carry out a simple experiment to determine the heat of combustion of a given mass of an alcohol.<br>Account for any difference between the experimental and theoretical $\Delta H_c^{\circ}$ of ethanol. State one assumption you will make.<br><br>**Note:**<br>A. *You will need*<br>* Spirit lamp<br>* Ethanol<br>* Metal can, water and thermometer<br>* Specific heat capacity of water<br>* Heat capacity of metal can<br><br>B. *Help students to acquire the following skills*:<br>* Experimental design<br>* Observation<br>* Recording<br>* Computation<br>* Communication of experimental results. | |
| | 1.2.4 explain Hess's law of constant heat summation and its application in the development of the Born- Haber cycle. | Hess's law of heat summation and the Born- Haber cycle. | Discuss Hess's law of heat summation using different energy cycles.<br>Apply Hess's law to calculate enthalpy changes using thermochemical equations, energy cycles/diagrams and given data<br><br>Use the Born-Haber cycle to demonstrate a pathway in which elements in their natural state are converted first to gaseous atoms, then to gaseous ions, and finally to the crystalline ionic solid.<br><br>Example, $2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$<br>This should include:<br>* Heat of sublimation<br>* heat of atomization/dissociation<br>* ionization energy and electron affinity<br>* lattice energy | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The student will be able to:<br><br>1.2.5 determine the enthalpy of neutralization for a given acid-base reaction.<br><br>1.2.6 explain bond energy and bond dissociation energy. | Enthalpy of neutralization of an acid-base reaction<br><br>Bonds Energy | Let students:<br><br>Measure the enthalpy of neutralization for the reaction between HCl and NaOH. Account for the difference between the theoretical and the experimental enthalpy values.<br><br>**Note:**<br>(A). You can use 1.0M solutions of both HCl and NaOH and a thermometer.<br>(B). Help students to acquire the following inquiry skills:<br>* Preparation of solution<br>* Manipulation of equipment<br>* Observation and recording<br>* Computation and communication<br><br>Differentiate between bond energy (average value) and bond dissociation energy (for specified bonds).<br>Discuss energy content (bond energy) as a measure of bond strength.<br>Discuss chemical reactions in terms of the energy transfers associated with making and breaking chemical bonds.<br>Perform calculations using summation of bond energies in reactant and products as a measure of enthalpy of reaction. | Explain the importance of bond enthalpy in the study of chemical compounds and chemical reactions. |

# SHS 2

## SECTION 2

## INORGANIC CHEMISTRY

General objectives: The student will:

1 Understand the physical and chemical properties and uses of compounds formed by the elements on the periodic table.
2 Recognize the colour production, catalytic properties and many applications of transition elements in industries.
3 Use inorganic chemistry to explain the many processes that go on in our environment.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | Let students: | |
| **PERIODIC CHEMISTRY** | 2.1.1 describe the patterns in physical and chemical properties of the period 3 elements. | Physical and chemical properties of period 3 $Na \rightarrow Cl$ elements | Compare the physical and chemical properties of period-three (3) elements. | Which compounds are formed when dil HCl acid reacts separately with calcium oxide and calcium trioxocarbonate(iv)? |
| | 2.1.2 Describe the pattern in physical and chemical properties of compounds of period 3 | Physical and chemical properties of compounds of period 3 elements | Compare the physical and chemical properties of the following compounds (hydrides, oxides, hydroxides and chlorides) of period 3 elements. | |
| | 2.1.3 account for the differences in thermal stability of the trioxocarbonate(IV) and trioxonitrate(V) of some metals. | Thermal stability of the $CO_3^{2-}$ and $NO_3^-$ of some metals | Discuss the thermal stability of $CO_3^{2-}$ and $NO_3^-$ of Li, Na, K, Mg and Ca and account for the differences.<br>Write chemical equations where possible to show how the compounds decompose on heating. | |
| | 2.1.4 demonstrate the thermal stabilities of some trioxocarbonate(iv) in the laboratory | Experiment to compare the thermal stabilities of some trioxocarbonate(iv) of some metals e.g. $Na_2CO_3$ and $Li_2CO_3$ / $CuCO_3$ | Perform simple experiments to compare the thermal stabilities of $Na_2CO_3$ and $Li_2CO_3$ / $CuCO_3$.<br>Test for any gas that evolves by passing it through lime water.<br>Write balanced chemical equations for the reactions that take place. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**PERIODIC CHEMISTRY (cont)** | The students will be able to:<br><br>2.1.5 describe the uses of Silicon. | Uses of Silicon | Let students:<br><br>Discuss the structures for $SiO_2$ and $CO_2$ and account for the differences between their physical and chemical properties.<br><br>Discuss the uses of Silicon and its compounds. Include: microchips, ceramics, glass and silica gel. | |
| | 2.1.6 explain the physical properties of the halogens(Group 17 elements). | Physical properties of Group 17 elements | Discuss the variations in the physical properties of the halogens:<br>* Physical State<br>* Melting and Boiling points<br>* Interatomic bond energies<br>Discuss any anomalies in the physical properties. | |
| | 2.1.7 relate the electron configurations of the halogens to their chemical properties. | Electron configurations and Variable Oxidation states of halogens | Discuss the electron configurations and the exhibition of variable oxidation state of the halogens.<br>Link up the electron configurations of the halogens to their chemical properties.<br><br>Discuss the similarities in chemical nature of the halogens.<br>Use the following reactions for your discussions:<br>* Halogens ( $Cl_2$ , $Br_2$ and $I_2$ ) with halide ions ( $Cl^-$ , $Br^-$ and $I^-$ ); Displacement reactions<br>Halide ions ( $Cl^-$ , $Br^-$ and $I^-$ ).with silver ions (Precipitation reactions). | What will be the observation when chlorine water is added to a solution of sodium bromide? |
| | 2.1.8 describe the reactions of the halogens with water and alkalis. | Reactions of halogens with Water and Alkalis | Discuss the reagents, conditions and products formed when the halogens react with water and alkalis<br>Write balanced chemical equations to show how the reactions occur.<br>State the uses of the above reactions | |
| | 2.1.9 explain why there are differences in the acid strengths of hydrogen halides. | Acid Strengths of hydrogen halides | Discuss the acid strengths of hydrogen halides under the following:<br>* Relative bond strengths of HX, where X is F, Cl, Br and I.<br>* *Ka* values | |

<table>
<tr><th>UNIT</th><th>SPECIFIC OBJECTIVES</th><th>CONTENT</th><th>TEACHING AND LEARNING ACTIVITIES</th><th>EVALUATION</th></tr>
<tr>
<td>UNIT 2<br>TRANSITION CHEMISTRY</td>
<td>The student will be able to:<br><br>2.2.1 write detail electron configuration of the first row transition elements.<br><br>2.2.2 state and describe properties of transition elements.<br><br>2.2.3 demonstrate through experiment, the catalytic properties of transition elements and their compounds.<br><br>2.2.4 describe the bonding in complex compounds</td>
<td>Electron configuration of first row transition elements, ($_{21}Sc \rightarrow {}_{30}Zn$)<br><br>Properties of transition elements<br><br>Catalytic properties of transition elements and their compounds.<br><br>Bonding in complex compounds</td>
<td>Let students:<br><br>Discuss and list the names of the first row transition elements and explain what transition elements are.<br><br>Write the detailed electron configuration of the first row transition elements and discuss the existence of variable oxidation states in the elements.<br><br>List and explain the characteristic properties of transition elements:<br>* hardness<br>* variable oxidation states<br>* complex ion formation<br>* formation of coloured compounds<br>* catalytic properties<br>* paramagnetism<br><br>Perform simple experiment(s) to show the catalytic behaviour of transition elements or their compounds. In the experiment, the speed of a reaction should be measured, where various transition metals in solution are tested as possible catalysts.<br><br>Note:<br>You can use the reaction between iron (III) trioxonitrate(V) and sodium thiosulphate solutions. This is similar to the sodium thiosulphate and hydrochloric acid reaction.<br>Repeat the experiment but add one drop of catalyst to the iron (III) trioxonitrate(V) before mixing. Test the various catalysts and fill in the table.
<table>
<tr><td>No catalyst</td><td>Nickel (II) tetraoxosulphate(VI) catalyst</td><td>Copper (II) tetraoxosulphate(VI Catalyst</td><td>Iron (II) tetraoxosulphate(VI catalyst</td><td>Cobalt (II) tetraoxosulphate(VI catalyst</td></tr>
<tr><td>Time (s)</td><td></td><td></td><td></td><td></td></tr>
</table>
Discuss how complexes of d-block elements are formed. Discuss the characteristics of the chemical species involved in the formation of coordination compounds.<br>Explain the terms central ion and ligand and give examples.</td>
<td>Explain why Sc and Zn are not considered to be typical of the transition elements.</td>
</tr>
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| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The student will be able to: | | Let students: | |
| | 2.2.5 name complex compounds. | Nomenclature of complex compounds. | Discuss and write systematic names and formulae for neutral, cationic and anionic complex compounds.<br>Discuss the systematic names of some common ligands, $Cl^-$, $F^-$, $I^-$, $NO_3^-$, $NH_3$, $H_2O$ and $SO_4^{2-}$, $CN^-$ | Define a ligand and give two examples each of neutral and anionic ligands. |
| | 2.2.6 draw the shapes of complex compounds. | Shapes of complex compounds. Include:<br>* Tetrahedral<br>* Square planar<br>* Octahedral | Draw the shapes of some common complex compounds (tetrahedral, planar, square planar complex and octahedral) from given formulae. | Draw the shapes of the following complexes:<br>i. $[Cu(NH_3)_4]^{2+}$<br>ii. $[Ag(NH_3)_2]^{+}$<br>iii. $[Cu(CN)_4]^{2}$ |
| | 2.2.7 outline the similarities and differences between transition metals and representative(main group) metals. | Similarities and differences between transition metals and representative (main group) metals. | Discuss the similarities and differences between transition metals and representative (main group) metals in terms of<br>* Hardness<br>* Reactivity with water and acids<br>* variable oxidation states<br>* complex ion formation<br>* formation of coloured compounds<br>* catalytic properties | iv. $[Fe(CN)_6]^{3-}$ |

# SHS 2

## SECTION 3

## CHEMICAL KINETICS AND EQUILIBRIUM

General objectives: The student will:

1. Understand that chemical reactions proceed at different rates depending on the conditions set for the reaction to occur.
2. Design simple experiments to determine the effects of the various factors on rate of reactions and systems in equilibrium.
3. Apply the principles of rate of reaction and equilibrium systems in industrial processes.
4. Recognize that there is a balance of opposing reactions in chemical equilibrium systems and that chemical changes eventually attain equilibrium.
5. Perform simple calculations based on rate and equilibrium laws.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**RATE OF REACTIONS** | The student will be able to:<br><br>3.1.1 explain rate of reaction. | Meaning of rate of reaction | Let students:<br><br>Brainstorm to come out with the meaning of rate of reaction.<br><br>Write a hypothetical equation to show the relationship between the rate of reaction, concentration of reactants and time.<br><br>Discuss observable physical changes that indicate the progress of chemical reactions. These should include:<br>* Colour change<br>* Disappearance of reactant and appearance of product<br>* Change in mass (e.g. a gas evolved causing a loss of mass)<br>* Formation of precipitate<br>* Volume of gas evolved<br>* Change in pH<br>* Change in Temperature<br>* Change in concentration and pressure | Outline three physical changes that can be used to monitor the progress of a reaction. |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**RATE OF REACTIONS (cont)** | The student will be able to:<br><br>3.1.2 monitor the speed of a chemical reaction using a simple experiment. | Monitoring the rate/speed of a chemical reaction | Let students:<br><br>Perform a simple experiment to measure the rate of a chemical reaction.<br>**Note:**<br>* Use the reaction between $HCl$ acid and Mg(s) and measure the volume of hydrogen gas evolved with time.<br>* Plot a graph of volume of hydrogen gas collected at interval against time. | |
| | 3.1.3 describe the factors that affect the rate of chemical reaction. | Factors that influence the rate of chemical reaction. | Discuss the factors that affect the rate of chemical reaction. Include:<br>* Concentration<br>* Particle size and nature of reactant<br>* Pressure (for reactions involving gases)<br>* Temperature<br>* Light<br>* Presence of a catalyst<br>NOTE; Determine how changes in the concentration of the acid and nature of the magnesium metal affect the rate of the reaction. | |
| | 3.1.4 demonstrate experiment to show how changes in temperature affect the rate of a reaction. | Temperature change and reaction rate. | Perform a simple experiment to show how changes in temperature affect the rate of a chemical reaction.<br>**Note**: You will need<br>i. Alka-Seltzer tablets (should be fresh) or any antacid that fizzes in water. You can also use soluble aspirin<br>ii. Water: hot, room temperature and cold in three different containers.<br>iii. Stop watch<br>Alka-Seltzer is an antacid that dissolves in water with violent evolution of bubbles.<br>Dissolve one tablet in each of the three containers. Record the amount of time it takes for the violent evolution of bubbles to cease.<br>Record and explain your observation.<br>How does the rate relate to changes in temperature?<br>**Note**: Other experiments could be used to achieve the same purpose. | Explain how the rate of a given chemical reaction is dependent on temperature and activation energy. |
| | 3.1.5 analyse and interpret simple graphs on rate of reactions | Deductions from experimental data and graphs on rate of reaction | Discuss graphs obtained from experimental data and make as many deductions from the data based on changes in the various factors that affect rate of reaction. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**RATE OF REACTIONS (cont)** | The student will be able to:<br><br>3.1.6 describe the collision theory of reaction rates. | Collision theory and rate of reaction | Let students:<br><br>Discuss the relationship between collision theory and rate of reaction<br>Differentiate between collision and effective collision.<br><br>Use the collision theory to explain some of the factors that affect rate of reaction: concentration, temperature, pressure and nature of reactant. | Explain the relationship between catalyst and the activation energy of a reaction. |
| | 3.1.7 identify the role of activation energy in chemical reactions. | Transition State and chemical reactions. | Draw and discuss energy profile diagrams to illustrate activated complex or transition state and activation energy, $E_a$<br>Use the energy profile to explain reaction rate with and without catalysts<br>**Note**; Only qualitative treatment required | |
| | 3.1.8 deduce the rate law from a given data. | The Rate Law | Discuss the rate law and show how it can be deduced from a given data.<br>Explain the terms rate constant and order of a reaction.<br><br>Derive the rate expression from experimentally determined rate data.<br>i.e. $r = k[A]^x[B]^y$, where<br>k= rate constant<br>$[A] = \text{concentration of A in mol dm}^{-3}$<br>$[B] = \text{concentration of B in mol dm}^{3}$<br>X = order of reaction with respect to concentration A<br>y = order of reaction with respect to concentration B<br>X + y = overall order of reaction. | |
| | 3.1.9 draw and analyze graphical representation for zero, first and 2nd order reactions. | Zero, first and second order reactions. | Deduce, zero, first and second order reactions from a given data and graphs.<br>Calculate quantities in the rate law given appropriate data of information. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**RATE OF REACTIONS (cont'd)** | The student will be able to:<br><br>3.1.10 deduce half-life from first order reaction. | Half-life of a reaction. | Let students:<br><br>Deduce the equation for a half-life of a reaction from first order reactions and explain its significance.<br>Half-life, $t_{1/2} = 0.693/k$ | |
| | 3.1.11 describe the effect of temperature and catalyst on the rate constant. | The relationship between rate constant, temperature and catalyst | Discuss the qualitative effect of temperature and catalyst on rate constant. | |
| | 3.1.12 deduce the rate law from an experiment. | Experimental determination of the rate law. | Perform a simple rate experiment and use the data collected to derive the rate law.<br><br>Note:<br>**1.** Use the thiosulphate $S_2O_3^{2-}$ (aq) and dilute $HCl$ acid reaction. The reaction proceeds with the formation of a yellow precipitate of sulphur.<br>Monitor the progress of the reaction by changing the concentration of the thiosulphate while maintaining the concentration of the acid. Now maintain the initial concentration of thiosulphate and change the concentration of the acid. | |
| | 3.1.13 identify the rate determining step of a multi-step reaction. | Rate determining step of a multi-step reaction | Explain rate determining step in a multi-step reaction as the slowest step and that the speed of reaction depends on the rate determining step. | |
| **UNIT 2**<br>**CHEMICAL EQUILIBRIUM** | 3.2.1 explain reversible and irreversible reactions. | Reversible and irreversible reactions. | Discuss reversible and irreversible reactions and give examples and their chemical equations. | |
| | 3.2.2 explain that equilibrium is established when forward and reverse reactions are proceeding at the same rate. | Chemical equilibrium and the state of dynamic equilibrium | Discuss the characteristics of a reaction in a state of dynamic equilibrium for reversible reactions.<br>Discuss how the concentrations of reactants and products at equilibrium are determined. | |
| | | Equilibrium constant | Write a mathematical expression for the determination of equilibrium constant $K_c$ and $K_p$ for a given reaction. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2 CHEMICAL EQUILIBRIUM (cont)** | The student will be able to: | | Let students:<br><br>Write a mathematical expression to show the relationship between $K_c$ and $K_p$<br>Identify the factors that can cause a shift in equilibrium.<br><br>Discuss and predict the qualitative effect of changes in concentrations, pressure and temperature on the position of equilibrium and the value of the equilibrium constant. | Explain why catalyst does not affect a reaction that has attained equilibrium |
| | 3.2.3 describe how Le Chatelier's principle can be used to predict the effect of changes in concentration, temperature and pressure on equilibrium reaction. | Le Chatelier's principle and equilibrium disturbance | Use Le Chatelier's principle to predict the effect of change in concentration, temperature, pressure and volume on a reaction at equilibrium. | |
| | 3.2.4 identify the correct equilibrium constant expression and use it in computation. | Equilibrium constant calculations | Write and calculate equilibrium constant Kc and Kp<br>Calculate quantities present at equilibrium given appropriate data.<br>Differentiate between homogeneous and heterogeneous equilibrium systems | Calculate the equilibrium constant Kc and Kp for the following reactions.<br><br>i. $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$ |
| | 3.2.5 establish equilibrium for a chemical reaction from an experiment. | Experimental determination of equilibrium. | Perform a simple experiment to establish the concept of equilibrium.<br>Note<br>**A**<br>Use a 0.2M $K_2CrO_4$ solution, 2M $HCl$ acid and 2M NaOH solution.<br>The chemical reaction occurring is<br>$2CrO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)} \rightleftharpoons 2Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)}$<br>(yellow) (orange) | ii. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3$ |

# SHS 2

## SECTION 4
## ACIDS AND BASES

General objectives: The student will:

1. Understand the behaviour of acid and base solutions based on their physical and chemical properties.
2. Explore acidic and basic solutions qualitatively and quantitatively
3. Describe acids and bases and classify substances as acids and bases based on Arrhenius, Bronsted-Lowry and Lewis concepts.
4. Show knowledge of how to test for anions and cations.
5. Use the principles and practice of titration to solve analytical problems.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | Let students: | |
| **THE CONCEPTS OF ACIDS AND BASES** | 4.1.1 outline the characteristic properties of acids and bases in aqueous solutions. | Properties of Acids and Bases | Discuss the general properties of acids and bases.<br>Discuss the reactions of acids with bases and metals and trioxocarbonate(IV).<br>Discuss the effects of acids on indicators.<br>Identify bases which are not hydroxide e.g. $NH_3$ , soluble trioxocarbonate(IV) and hydrogen trioxocarbonate(IV). | List the general properties of acids and bases. |
| | 4.1.2 describe Arrhenius, Bronsted-Lowry and Lewis concepts of acids and bases. | Arrhenius and Bronsted-Lowry and Lewis concepts of acids and bases | Discuss Arrhenius, Bronsted-Lowry and Lewis concepts of acids and bases with illustrative examples.<br><br>Arrhenius theory of acids and bases in terms of the presence of $H_3O^+$ and $OH^-$ ions in water.<br><br>Bronsted-Lowry theory of acids and bases in terms of proton donor and proton acceptor.<br><br>Lewis theory as lone pair electron donor and acceptor.<br><br>Identify whether or not a compound could act as a Bronsted-Lowry acid and base.<br>Identify the conjugate acid base pairs in a given acid-base reaction.<br><br>Define and apply the terms Lewis acid and Lewis base. | Why are Bronsted-Lowry's definitions more useful in describing acid-base properties than Arrhenius'? |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The students will be able to: | | Let students: | |
| **UNIT 2**<br>**PROPERTIES OF ACIDS, BASES AND ACID-BASE INDICATORS** | 4.2.1 state the physical properties of Acids and bases. | Physical properties of Acids and bases. | Discuss the physical properties of acids and bases under the following: pH, feel, indicators/litmus papers (effect), taste dilute weak acids and bases | |
| | 4.2.2 explain the chemical properties of acids and bases and write balanced equations for the reactions. | Chemical properties of Acids and Bases | Discuss the reaction of acids with metals such as Zn, Fe and Mg. Write balanced chemical equations for reactions that take place.<br><br>Discuss also the reaction of bases with ammonium compounds and test for the gas that evolves with the appropriate reagent.<br><br>Discuss the process of acid-base neutralization. For example;<br>i. the reaction of acids (HCl, $HNO_3$, $H_2SO_4$) with trioxocarbonate(iv), $C0_3^{2-}$ or hydrogentrioxocarbonate(iv), $HC0_3^-$ or a mixture of $C0_3^{2-}$ and $HC0_3^-$.<br>ii. reactions of acids (HCl, $HNO_3$, $H_2SO_4$) with bases: Na0H(aq), KOH(aq), $Ca(OH)_2$ (Neutralization) | |
| | 4.2.3 describe qualitatively how acid-base indicators work. | Acid-Base indicators | Determine an appropriate indicator for a titration given the equivalence point for the titration.<br>Discuss the effects of acids and bases on indicators.<br>Discuss some common laboratory acid-base indicators and their pH working ranges.<br>Discuss how to extract dyes from flowers as a way of preparing indicators.<br>Discuss Phenolphthalein and methyl orange indicators and their suitability for use as indicators for certain acid-base titrations. | |
| | 4.2.4 determine the quantity of an analyte in solution using titration. | Acid-Base titration experiments | Perform acid-base titration experiments involving the acids (HCl, $HNO_3$, $H_2SO_4$) and bases (trioxocarbonate(IV), $C0_3^{2-}$, hydrogentrioxocarbonate(IV), $HC0_3^-$, or a mixture of $C0_3^{2-}$ and $HC0_3^-$, Na0H(aq), KOH(aq), $Ca(OH)_2$ using methyl orange and phenolphthalein as indicators.<br><br>Discuss titre values, end point, equivalence point, precise titre values and average titre.<br>From the data collected, determine mole ratios, concentrations, volume of gas evolved, mass of salt produced, molar mass of compounds and number of entities | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The students will be able to: | | Let students: | |
| | 4.2.5 draw graphs for acids-Base titrations. | Graphs for acids-Base reactions and their indicators | Discuss the nature of the graph when the following pairs of compounds are used:<br>1. strong acid and strong base $(NaOH_{(aq)} + HCl_{(aq)})$<br>2. Strong acid and a weak base $(NH_{3(aq)} + HCl_{(aq)})$<br>3. Strong base and a weak acid $(NaOH_{(aq)} + CH_3COOH_{(aq)})$<br><br>Perform double indicator titrations (continuous and discontinuous) and back titration and learn the calculations that go with them e.g. finding concentrations, composition and % purity, etc. of analytes.<br><br>**Note**: Assist students to acquire the following skills:<br>Observation, manipulation of equipment and handling of reagents, recording, analysis of data, calculation and communication of results.<br><br>Provide examples of processes and products that use knowledge of acid and base chemistry, e.g.<br>(1) air pollution analysis<br>(2) food and beverage analysis<br>(3) water quality and environmental analysis<br>(4) in the soap industry<br>(5) acidity of edible oils<br>(6) analysis of antacids | |
| **UNIT 3**<br><br>**CLASSIFICATION OF ACIDS AND BASES** | 4.3.1 describe and explain the difference between strong and weak acids and bases in terms of the extent of dissociation reaction with water and conductivity. | Strong and weak acids and bases | Discuss strong and weak acids and bases and differentiate between them. Explain what makes an acid or base strong or weak.<br>Determine whether a given acid or base is strong or weak.<br>**Note**<br>* Specify that strong acids include HCl, $H_2SO_4$ and $HNO_3$<br>* Specify that weak acids include trioxocarbonate (IV) acid and ethanoic acid.<br>* Specify that Group1 hydroxides and Ba $(OH)_2$, are strong bases.<br>* Specify that organic bases and trioxocarbonate(IV) salts are weak bases | Distinguish between the following pairs:<br>Weak and strong acids<br>Weak and dilute acids<br>Strong and dilute acids<br>strong and concentrated acids |
| | 4.3.2 classify acids and bases into Strong and Weak | Strength of acids and bases | Discuss the process of dissociation and ionization. Indicate how they differ.<br>Discuss the differences between strong and weak acids and bases in terms of the extent of dissociation, reaction with water and conductivity. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The students will be able to:<br><br>4.3.3 explain the conduction of strong and weak electrolytes. | Conductivity of solutions. | Let students:<br><br><u>Strong acid</u><br>Dissociate/ionize completely in an aqueous solution<br>State examples of strong acids<br><br><u>Weak acid</u><br>Dissociate or ionize partially /incompletely. Equilibrium is established between the ions in solution and unionized compound.<br><br>Examples of weak acids: $H_2CO_{3(aq)}$ /aqueous carbon dioxide and $CH_3COOH(aq)$ (Organic acids)<br><br><u>Strong bases</u>: ionize or dissociate completely in aqueous solution. Examples are NaOH(aq) and KOH(aq).<br><br><u>Weak bases</u>: ionize or dissociate partially/incomplete e.g. $NH_3$ (aq).<br>Write appropriate equations for the Ionization of the acids and bases.<br><br>Discuss conduction of strong electrolytes:<br>More ions in solution for conduction. Give examples from strong acids and bases and salts.<br><br>Discuss the conduction of weak electrolytes<br>i.e. solutions from weak acids and bases: few ions available for conduction.<br><br>Perform simple experiments to distinguish between weak and strong electrolytes:<br>Use lemon and battery acid (lead-acid accumulator) and electric bulb for the experiment.<br><br>Review the following dilute and concentrated solutions from section 4 unit 2 of SHS 2.<br><br>Carry out conductivity experiment using simple electric circuit with an incandescent bulb on the following aqueous solutions:<br>i. dil. $NH_3$<br>ii. dil. $CH_3COOH$<br>iii. mixture of dil. $NH_3$ and $CH_3COOH$<br>Explain your observations | Identify each of the following substances in aqueous solution as a strong electrolyte, weak electrolyte, or non-electrolyte:<br>$H_2O$<br>$KCl$<br>$NH_3$<br>$CH_3COOH$<br>$C_{12}H_{22}O_{11}$ |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The students will be able to: | | Let students: | |
| **UNIT 4**<br><br>**CONCEPT OF pH AND pOH** | 4.4.1 distinguish between solutions that are acidic, neutral or basic using the pH scale. | Acidic, neutral and basic solutions; The pH scale. | Discuss the expression for the ionic product constant of water($K_w$) $K_W = [H^+_{(aq)}][OH^-_{(aq)}] = 1.0\times10^{-14}\,mol^2dm^{-6}$ at 298K<br><br>Discuss the concept of pH, and pOH<br><br>Deduce $[H^+_{(aq)}]$ and $[OH^-_{(aq)}]$ and hence the pH and pOH from specified concentrations of acids and bases.<br>$pH = -\log [H_3O^+]$<br>Measure pH of solutions using pH meter, colorimetric methods, or universal indicator.<br><br>Discuss the significance of the values of pH in everyday life e.g. acid rain and its effect, pH of soil, blood, urine and saliva; shampoo and pharmaceutical products. | What is the pH of 0.1M $H_2SO_4$ acid? |
| | 4.4.2 explain $pK_a$ and $pK_b$ of weak acids and bases. | Partial lionization of weak acids and bases | Discuss the incomplete or partial ionization of weak acids and bases e.g. Weak acids:<br>$H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$<br>$CH_3COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-{}_{(aq)}$<br><br>e.g. Weak bases<br>$NH_{3(aq)} + H_2O_{(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$<br>Discuss acid and base ionization constants, $K_a$ and $K_b$ respectively.<br>Discuss $pK_a$ of weak acids and $pK_b$ of weak bases.<br>State and explain the relationship between $K_a$ and $pK_a$ | |
| **UNIT 5**<br><br>**BUFFER SOLUTIONS** | 4.5.1 describe a buffer solution in terms of ite composition and behaviour. | Buffer Solutions | Discuss what a buffer solution is and how it acts as a buffer.<br>Explain that a buffer resists change in pH when a small amount of base or acid is added.<br><br>Explain the role of common ion effect in buffer solution<br>Discuss the preparation of buffer solutions: Weak acid and weak base and their conjugate bases and conjugate acids.<br>Examples of buffer, are $NH_4Cl / NH_3$ solution,<br>$CH_3COOH / CH_3COONa$ solution. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 5 (cont)** | The students will be able to: | | Let students:<br><br>Give specific examples of the application of buffer in every day life.<br>* In living systems<br>* In industries | |
| **UNIT 6 SOLUBILITY OF SUBSTANCES** | 4.6.1 explain the term solubility. | Solubility | Brainstorm to come out with the meaning of the term solubility<br>Explain the solubility rules of common ionic compounds in water at $25^0$C.<br>Examples:<br>(i) Soluble compounds. Compounds containing alkali metal ions ($Li^+$ , $Na^+$, $K^+$) and ammonium ion ($NH_4^+$)<br>Nitrates ($NO_3^-$), Halides ($C1^-$) Sulphates ($S0_4^{2-}$)<br><br>(ii) Insoluble compounds.<br>* Carbonales of $Ca^{2+}$ , $Pb^{2+}$, $Ba^{2+}$, $Zn^{2+}$<br>* Hydroxides of $A1^{3+}$ and $Zn^{2+}$, $Pb^{2+}$<br>* Halides of Ag+, $Pb^{2+}$<br>* Sulphates of $Ba^{2+}$ , and $Pb^{2+}$ | Which indicator is most appropriate for the reaction between<br>$NaOH_{(aq)} + CH_3COOH_{(a}$ |
| | 4.6.2 describe factors that affect solubility of substances. | Factors that affect solubility of substances | Discuss factors that affect solubility of substances: temperature, nature of solvent, charge density of ions<br>Discuss the drawing and uses of solubility curves. | A liter of a solution saturated at $25^oC$ with calcium oxalate $CaC_2O_4$, is evaporated to dryness, giving a 0.0061g residue of $CaC_2O_4$. Calculate the solubility product constant for this salt at $25^oC$. |
| | 4.6.3 determine the solubility and solubility product of sparingly soluble substances. | Solubility and solubility product of sparingly soluble ionic compounds | Discuss the determination of the solubility (in $g/dm^3$ or $mol/dm^3$) of sparingly soluble ionic compounds in solution at specified temperatures.<br>Explain solubility products (Ksp) of sparingly soluble Ionic compounds.<br>Calculate the solubility of a compound given the solubility product and also calculate the solubility product given the solubility | |
| | 4.6.4 describe an experiment to determine the solubility product constant for $Ca(OH)_2$. | Experimental determination of the solubility product constant of $Ca(OH)_2$ | Perform a simple experiment to establish the solubility product constant (Ksp) for $Ca(OH)_2$ in water.<br>$Ksp = [Ca^{2+}][OH^-]^2$<br><br>**Note**<br>You may use 0.05M solution of HCl or $HNO_3$ acid. Titrate against $25cm^3$ of a saturated solution of $Ca(OH)_2$ using phenolphthalein as indicator. | Explain the term solubility product.<br>Explain why in the solubility product constant expression for $Ca(OH)_2$, the solid compound does not appear in the expression. |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| | The students will be able to: | | Let students: | |
| **UNIT 6 SOLUBILITY OF SUBSTANCES (Cont.)** | 4.6.5 describe the precipilation of sparingle soluble substances. | Precipitation of insoluble salts. | Discuss the use of precipitation reactions in the identification of cations ($Pb^{2+}$, $Ca^{2+}$, $Zn^{2+}$, $Al^{3+}$, $Cu^{2+}$, $Fe^{2+}$, $Fe^{3+}$,) and anions ($Cl^-$, $Br^-$, $I^-$, $S^{2-}$ $S0_4^{2-}$, $SO_3^{2-}$ and $CO_3^{2-}$ ) in solution using appropriate reagents. | A liter of a solution saturated at 25°C with calcium oxalate $CaC_2O_4$, is evaporated to dryness, giving a 0.0061 residue of $CaC_2O_4$,. Calculate the solubility product constant for this salt at 25°C |
| | | Identification of anions and cations in solution | Perform preliminary and confirmatory tests to qualitatively identify the ions ($Pb^{2+}$, $Ca^{2+}$, $Zn^{2+}$, $Al^{3+}$, $Cu^{2+}$, $Fe^{2+}$, $Fe^{3+}$,) and ($Cl^-$, $Br^-$, $I^-$, $S0_4^{2-}$, $S^{2-}$ and $CO_3^{2-}$ ) in solution using appropriate reagents( $HCl_{(aq)}$, $NaOH_{(aq)}$, $NH_{3(aq)}$, $BaCl_{2(aq)}$, $AgNO_{3(aq)}$ etc. Test for any gas that evolves. | |
| **UNIT 7 SALT AND CHEMICALS FROM SALT.** | 4.7.1 explain the meaning of salt. | Meaning of salt | Brainstorm to come out with the meaning of salt.<br>Differentiate among normal, acidic, basic, double and complex salts. | |
| | 4.7.2 state and explain how salts form acidic, alkaline and neutral aqueous solutions. | Salt hydrolysis | Discuss salts formed from the four possible combinations of strong and weak acids and bases.<br>Discuss the effect of charge density of some cations and anions on the hydrolysis of their ions in aqueous solution. Use examples from group1, group 2, group 3 and the d-block elements<br><br>Write equilibrium equations to illustrate hydrolysis of cations and anions to show the acidic, basic and neutral nature of salt solutions. | Classify the following as basic or acidic salt<br>i. $AlCl_3$<br>ii. $Na_2CO_3$<br>iii. $NaHSO_4$<br>Give reasons for your answer. |
| | 4.7.3 describe the laboratory and industrial production of salt. | Laboratory and industrial production of salt | Discuss the production of salts in the laboratory and the Industrial Mining of Salts. For example mining of impure sodium chloride and its conversion into pure granulated and iodated salts. | Distinguish between hydrolysis and hydration. |
| | 4.7.4 describe the process of obtaining chemicals from brine (sea water) | Sources and chemicals from sodium chloride | Discuss the sources of NaCl in Ghana (coastal and inland) and chemicals obtained from concentrated sodium chloride solution (brine) by electrolysis.<br>**NB**: Review the electrolysis of brine thoroughly in SHS 2 section 4 unit 5<br>Discuss the uses of NaCl. e.g.<br>* Food preservative<br>* Food flavouring agent<br>* Production of $Cl_2$, $H_2$, NaOH and Na metal<br>* Soap production<br>* Crude oil refining<br><br>Uses of NaOH: Soap, extraction of Al from bauxite, paper dyes and textiles<br>Uses of $Cl_2$ : Water purification, bleaching property, raw material for variety of products e.g. PVC<br>Uses of $H_{2(g)}$ filling balloons for weather searchlight, production of ammonia, fuel for space crafts | Explain with the help of equations why a solution of $NH_4Cl$ is acidic and that of $CH_3COONa$ is basic. |

# SHS 2

## SECTION 5
## REDOX REACTIONS

General objectives: The student will:

1. Understand the nature of oxidation-reduction reactions and apply its principles to electrochemical cells.
2. Show awareness of corrosion as an oxidation-reduction process and its economic cost.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | | |
| **OXIDATION – REDUCTION PROCESSES AND OXIDIZING – REDUCING AGENTS** | 5.1.1 describe Oxidation and Reduction Processes. | Oxidation and Reduction processes | Discuss oxidation number (or oxidation state) rules<br>Discuss oxidation – reduction in terms of:<br>* Addition and removal of hydrogen and oxygen<br>* Loss and gain of electrons<br>* Change in oxidation state (oxidation number) | Define oxidation and reduction in terms of electron transfer and in terms of oxidation number. |
| | 5.1.2 describe the types of redox reactions. | Types of Redox reactions | Discuss some common oxidation-reduction reactions. These should include:<br>i) Combination reactions<br>ii) Decomposition reactions<br>iii) Combustion reactions<br>iv) Displacement reactions such as:<br>* Hydrogen displacement<br>* Metal displacement<br>* Halogen displacement | Why must oxidation and reduction occur together in a reaction? |
| | 5.1.3 describe half reactions. | Half reactions | Discuss the activity series of metals and anions.<br>Discuss oxidation reaction with reference to the half – reaction that involves loss of electrons. For example.<br>$Zn \rightarrow Zn^{2+} + 2e^-$<br>$2Cl^- \rightarrow Cl_2 + 2e^-$<br>Discuss Reduction reaction with reference to the half reaction that involves gain of electrons. For example<br>$Cu^{2+} + 2e^- \rightarrow Cu$<br>$Cl_2 + 2e^- \rightarrow 2Cl^-$ | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 1**<br><br>**OXIDATION – REDUCTION PROCESSES AND OXIDIZING – REDUCING AGENTS** | The students will be able to:<br><br>5.1.4 describe an experiment to illustrate reactivity of metals. | Reactivity of metals | Perform an experiment to illustrate the reactivity of metals.<br>Note:<br>**A**. *You will need*<br>* Iron nails<br>* Copper metal<br>* Aluminium<br>* 3.0M HCl . Take 250ml of HCl stock solution and dilute to 1.0L<br><br>**B.** *Help students to acquire the following skills*:<br>* Collection of gases<br>* Observation<br>* Timing an event<br>**C**<br>* Avoid skin contact with conc. HCl acid<br>* Do not inhale the vapour of the acid | |
| | 5.1.5 perform an experiment to illustrate the reactivity of halogens. | Reactivity of the halogens | Carry out a simple experiment to illustrate the relative reactivity of halogens (group 17) and the method of separating them from solution.<br><br>**Note**<br>Use the displacement reactions of the halogens. You will need 0.1M solutions of NaCl, NaBr, NaI and $Ca(NO_3)_2$. You will also need 3.0M $NH_3$ (aq), chlorine water, silver nitrate and chloroform.<br>Write equations for pair wise reactions e.g.<br>$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ | Give one example of a displacement reaction. What is the oxidizing agent? What is the reducing agent? |
| | 5.1.6 describe oxidizing and reducing agents. | Oxidizing and reducing agents. | Discuss oxidizing agents as substances that accept electrons or decrease in oxidation number during redox processes.<br>Examples should include:<br>$KMnO_4$, $K_2Cr_2O_7$, $H_2O_2$<br>$Cl_2$, $I_2$ and $Fe^{3+}$ | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1 (CONT'D)** | The students will be able to: | | Let students: | |
| | | | Discuss reducing agents as substances that donate electrons or increase in oxidation number during redox processes. Examples should include: $SO_2$, $H_2S$, halides, metals, $Fe^{z+}$ and $H_2$ | Identify the reductant and oxidant from the following redox reactions<br>$2H_2S + SO_2 \rightarrow 3S + 2H_2O$<br>$Cl_2 + H_2O \rightarrow HCl + HOCl$ |
| **UNIT 2** | | | | |
| **BALANCING REDOX REACTIONS** | 5.2.1 explain the steps involved in balancing redox equations | Steps involved in balancing redox equations | Discuss the steps involved in balancing Redox equations in both acidic and basic solutions (rules). Emphasize the importance of mass and charge balance in redox reactions | |
| | | | Discuss the techniques used to break equations into half reactions. Explain how the half reactions can be put together to give the overall reaction. | Balance the oxidation-reduction reaction below in acidic medium.<br>$Cr_2O_7^{2-} + Fe^{2+} \rightarrow$<br>$Cr^{3+} + Fe^{3+}$ |
| **UNIT 3** | | | Use the techniques studied above to balance sets of redox equations. | What is a spectator ion? Illustrate with a full ionic equation. |
| **OXIDATION-REDUCTION TITRATIONS** | 5.3.1 describe and explain the processes involved in carrying out redox titrations. | Processes involved in carrying out redox titrations | Discuss the actions/internal indicator systems in some redox titrations. Such as in Potassium dichromate $K_2Cr_2O_7$ and Potassium permanganate, $KMnO_4$. | |
| | 5.3.2 describe an experiment to determine the end point of redox titration. | Experiment on redox titrations | Perform an experiment to determine the end point of the following oxidation-reduction titrations<br>* $MnO_4^-$ versus $Fe^{2+}$<br>* $I_2$/KI versus $S_2O_3^{2-}$<br>**NB**<br>Assist students to acquire the following skills;<br>* Design of redox titration<br>* computations involved in the titrations above. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 4**<br><br>**ELECTROCHEMICAL CELLS** | The students will be able to:<br><br>5.4.1 describe the interconversion of chemical energy and electrical energy in redox reactions.<br><br>5.4.2 describe and explain the function of the standard electrode potential in redox reactions.<br><br>5.4.3 describe how standard electrode potentials can be used to produce the electrochemical series.<br><br>5.4.4 describe and explain the functions of a simple electrochemical cell. | Electrochemistry<br><br>Standard Hydrogen Electrode $(E^{\theta})$<br><br>Electrochemical series and the $E^{\theta}$<br><br>Electrochemical cells | Discuss and demonstrate how a redox reaction can generate electrical energy and how electrical energy can also be used to bring about redox reactions (electrolysis)<br><br>Discuss the use of half equation to introduce redox couples including $H^+/H_2$ and a selection of couples from the electrochemical series.<br><br>Discuss how electrode potentials develop between an element and its aqueous solution<br>Discuss and state the meaning of the standard electrode potential $(E^{\theta})$<br>Discuss function of the Standard Hydrogen Electrode (SHE).<br><br>Discuss the term cell potential. Calculate cell potentials using $E^{\theta}$<br><br>Relate the magnitude of $E^{\theta}$ of ions to its position on the activity series and use it to predict the oxidizing and reducing powers of a given series.<br><br>Design a simple electrochemical cell and explain how to measure the emf.<br><br>Draw a cell diagram and explain the cell notation of a given cell.<br><br>Discuss the $E^{\theta}$ sign and emf of an electrode and cell<br><br>Relate the sign of emf to the feasibility of a redox reaction.<br><br>Explain and write half and overall equations for an electrochemical cell.<br><br>Discuss and indicate the direction of flow of electrons, the sign and name of the electrode | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 4 (CONT'D)**<br><br>**ELECTROCHEMICAL CELLS**<br>(cont) | The students will be able to: | | Let students:<br><br>Solve problems on cell potential or emf from a given data<br>Set up a simple electrochemical cell in the Laboratory involving $Zn^{2+}/Zn$ and $Cu^{2+}/Cu$ with a salt bridge containing KCI(aq) | Draw a cell diagram and write the overall cell equation for the diagram. Show direction of flow of electrons. |
| | 5.4.5 explain some applications of electrochemical cells | Applications of electro-chemical cells | Discuss the generation of electricity from the following:<br>(i) Lead acid battery (wet cell)<br>(ii) Alkaline cells (dry)<br>(iii) Fuel cells | |
| | | Primary and secondary Cells | Distinguish between a primary and a secondary cell and give examples of each. Write simple half and overall reaction equations for the cells above | |
| **UNIT 5**<br><br>**ELECTROLYTIC CELL** | 5.5.1 explain the operation of electrolytic cells. | Electrolytic cells | Discuss the mechanism involved in electrolytic cells<br>Set up an electrolytic cell involving the following; electrolyte, electrodes, power source and connecting wires.<br>Discuss the electrolysis of **brine** and copper(II)tetraoxo-sulphate(VI) solution.<br>Discuss the factors that influence the discharge of species at the electrodes during electrolysis. | Draw a diagram showing the essential components of an electrolytic cell.<br>Describe how current is conducted through the cell. |
| | 5.5.2 illustrate the electrolysis of brine experimentally. | Experimental illustration of the electrolysis of brine | Carry out a simple experiment to illustrate the electrolysis of brine in the laboratory.<br>**Note1**<br>You will need the following materials:<br>* U-shaped test tubes/beakers<br>* carbon electrodes<br>* sodium chloride salt<br>* deionized water/distilled water/tap water<br>* 9 volt batteries<br>* Universal indicator (to help follow what happens during the reaction)<br>* Electrical leads with crocodile clips.<br>**Note 2**<br>Do not inhale any gas<br>Keep reaction away from naked fire<br>Wear eye protection.<br><br>Let student observe closely and explain the chemistry of what happens. Predict the products of the reaction. | Concentrated solution of sodium chloride is electrolyzed using carbon electrodes.<br>Predict the products at the cathode and anode and the pH of the final solution. |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 5** | The students will be able to: | | Let students: | |
| **ELECTROLYTIC CELL (CONT'D)** | 5.5.3 distinguish between electrolytic and electrochemical cells. | Comparison of electrolytic and electrochemical cells | Compare the mechanisms involved in electrochemical cells using specific examples. | |
| | 5.5.4 describe some uses of electrolysis in everyday life. | Applications of electrolysis | Discuss the applications of electrolysis: extraction of reactive metals and purification and electroplating of metals.<br>Perform an experiment to show electroplating e.g. using $Zn / Zn^{2+} // Cu^{2+} / Cu$ | |
| | 5.5.5 demonstrate an experiment to determine the quantity of metal deposited on an electrode. | Electroplating | Perform experiment to demonstrate the process of electroplating using $CuSO_4$ solution.<br>**Note**;<br>Use electrolyte solution made of 200g $CuSO_4.5H_2O$ plus 25.0 ml conc. $H_2SO_4$ acid in enough distilled water to make 1.00L of solution. Use pure copper metal as anode.<br>Assist students to design, measure and record masses before and after the experiment and the current passed. Compare masses. | The electrolysis of molten magnesium chloride is carried out with a current of $8.00 \times 10^{-4}$ A. What masses of magnesium and chlorine are produced in exactly 1hour? |
| | 5.5.6 state and explain Faraday's Laws of Electrolysis . | Faraday's Laws of Electrolysis | Discuss the laws of electrolysis and use them to solve problems based on the laws. | |
| **UNIT 6** | | | | |
| **CORROSION OF METALS** | 5.6.1 explain the concept of corrosion of metals. | Corrosion of metals | Discuss the process of corrosion of metals as oxidation – reduction process;<br>Explain rusting of iron as example of wet corrosion. | Explain why certain metals do not corrode but iron rusts. |
| | 5.6.2 state and describe methods of preventing rusting. | Prevention of corrosion | Discuss the methods of preventing rusting: galvanizing, alloying, ectroplating, tin plating, cathodic protection/sacrificial protection and redox methods.<br>Painting, greasing/oiling and lamination with plastics are non-redox methods. | Explain why stainless steel is preferred to iron in many instances. |

# SHS 2

## SECTION 6

## CHEMISTRY OF CARBON COMPOUNDS

**General objectives**: The student will

1. Show general awareness of source and preparation, structure and naming, physical properties and chemical reactions of carbon compounds.
2. Apply chemical principles learnt to explain observed properties.
3. Demonstrate knowledge of the characteristic tests to detect functional groups.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | Let students: | |
| **BONDING IN CARBON** | 6.1.1 describe the electron structure of carbon. | Electron structure of carbon | Discuss the detailed electron configuration of carbon and use the Lewis dot structure to describe it.<br>Define hybrid orbital e.g. sp, $sp^2$ and $sp^3$ and discuss sigma ($\sigma$) and ($\pi$) pi-bond formation( refer to Year 1, section3). | |
| **UNIT 2**<br>**CLASSIFICATION OF ORGANIC COMPOUNDS** | 6.2.1 classify organic compounds. | Classification of organic compounds | Classify organic compounds into aliphatic, alicyclic, heterocyclic and aromatic using specific examples from real life situation. | Give one example each of aliphatic, alicyclic, heterocyclic and aromatic compounds. |
| **UNIT 3**<br>**IDENTIFICATION OF ELEMENTS IN ORGANIC COMPOUNDS** | 6.3.1 determine the components of a given organic compound. | Components of organic compounds | Discuss and demonstrate the experimental determination of the elements: C, H, O, N, S and halogens in a given organic compound.<br>Use given data to determine the empirical and molecular formulae of organic compounds. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 4**<br><br>**SEPARATION AND PURIFICATION OF ORGANIC COMPOUNDS** | The students will be able to:<br><br>6.4.1 describe the methods of separation and purification of an organic compound from a mixture of compounds. | Separation and purification of organic compounds | Let students:<br><br>Demonstrate the separation of organic mixtures by the processes of distillation, solvent extraction, crystallization and chromatography.<br><br>Use the methods of recrystallisation, drying and distillation to purify a given impure organic compound.<br><br>Use the methods of melting and boiling point to determine the purity of given organic compounds. | State two effects impurities have on the melting point of an organic sample. |
| **UNIT 5**<br>**ALKANES** | 6.5.1 describe the sources and characteristics of Alkanes. | Sources and characteristics of alkanes | Discuss the sources of alkanes.<br><br>Discuss the physical properties of alkanes e.g. melting point, boiling point, solubility volatility and states. | |
| | 6.5.2 outline the nomenclature and isomerism of alkanes. | Nomenclature of alkanes and structural isomerism. | Discuss the steps involved in the naming of alkane compounds.<br><br>Define homologous series.<br>Explain isomerism and write structural isomers for $C_4H_{10}$ and $C_5H_{12}$ | Give the systematic names for the following compounds.<br>1. $CH_3CH_2CH(CH_3)CH_3$<br>2. $CH_3C(CH_3)_2CH_3$ |
| | 6.5.3 describe the preparation, physical and chemical properties of alkanes. | Preparation, physical and chemical properties of alkanes | Discuss the laboratory preparation of alkanes<br>Explain the terms, Free radicals, homolytic fission, heterolytic fission, nucleophiles and electrophiles.<br><br>Discuss the; combustion and substitution (halogenations) reactions of alkanes. | Write the structures and names of three compounds with the same molecular formula $C_5H_{12}$. |
| | 6.5.4 identify the uses of alkanes and their contribution to the greenhouse effect. | Uses of alkanes | Discuss the uses of alkanes in<br>* fuels<br>* lubricating oil<br>* making of Vaseline<br>* plastic bowls<br>* surfacing roads (bitumen)<br>* wax<br>* protective coating on leaf surface<br>* contribution of alkanes to the greenhouse effect | Name two greenhouse gases and outline their effect on the environment |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| | The students will be able to: | | Let students: | |
| **UNIT 6 ALKENES** | 6.6.1 describe the sources and characteristics of alkenes. | Sources and characteristics of Alkenes. | discuss the sources of alkenes e.g. latex from rubber tree and cracking of hydrocarbon compounds.<br><br>Discuss the physical properties of alkenes mpt, bpt, solubility volatility, states. | |
| | 6.6.2 outline the nomenclature and isomerism of alkenes. | Nomenclature and alkene isomers | Discuss homologous series of alkene and the steps involved in naming the structures of alkene compounds<br>Write the structures for named alkenes<br><br>Discuss isomerism in alkenes (structural and stereo isomers) for butene and pentene<br><br>Write the names and structures for the isomers of given alkenes. | Write the structural formula for 2-methylbut-2-ene. |
| | 6.6.3 describe the preparation and chemical reactions of alkenes. | Preparation and chemical reactions of alkenes | Discuss the preparation of alkenes from alkanes, haloalkanes and alkanols.<br><br>Outline the reaction of symmetrical and unsymmetrical alkenes with hydrogen, bromine, halogen halides, water and $KMnO_4$(cold dilute)<br><br>Hydrogenation is used in the production of margarine; hydration of alkenes is used in the manufacture of ethanol.<br><br>Bromination can be used to distinguish between alkane and alkene. | |
| | 6.6.4 Outline the uses of alkenes. | Uses of alkenes | Discuss the uses of alkenes for<br>* fruit ripening<br>* flower maturation<br>* seed germination<br>* production of alkanols<br>* polymers synthesis<br>* production of antifreeze(ethylene glycol for use in automobile radiators). | |
| **UNIT 7 ALKYNES** | 6.7.1 describe the sources and characteristic properties of alkynes. | Sources and characteristic properties of Alkynes | Discuss sources of alkynes. i.e. from carbides<br><br>Discuss the physical properties of alkynes, i.e. m.pt, b.pt, solubility, volatility and states. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 7 (Cont)** | The students will be able to: | | Let students: | |
| | 6.7.2 outline the nomenclature and isomerism in alkynes. | Nomenclature and isomerism in alkynes | Discuss the steps involved in naming structures of alkyne compounds<br>Discuss the alkyne homologous series.<br>Write the structures for named alkynes<br>Write the names for given alkyne structures<br><br>Discuss isomerism in butyne and pentyne, i.e. terminal and non-terminal alkynes.<br>Discuss acidity of terminal alkynes. | Identify the hydrocarbons with the following general formulae:<br>$C_nH_{2n+2}$<br>$C_nH_{2n-2}$<br>$C_nH_{2n}$ |
| | 6.7.3 describe the preparation and chemical reactions of alkynes. | Preparation and chemical reactions of alkynes. | Discuss the preparation of ethyne from calcium cabide and water.<br>Discuss chemical reactions of alkynes<br>* Halogenation-terminal and non-terminal<br>* Combustion of alkyne(oxy-ethyne flame)<br>* Hydrogenation reactions of terminal alkynes<br>* test for terminal alkynes. | Describe the test for terminal alkynes. |
| | 6.7.4 outline the uses and test for alkynes. | Uses of alkynes | Discuss the uses of ethyne in welding. | |
| **UNIT 8 BENZENE** | 6.8.1 describe the structures and stability of benzene. | The structure and stability of benzene | Discuss benzene as a hydrocarbon<br>Discuss the special stability of the benzene ring<br>Draw the structures of benzene (Kekule)<br><br>Explain the resonance structures of benzene by Kekule | |
| | 6.8.2 outline the reactions of benzene. | Reactions of benzene | Discuss the formation of mono substituted benzene compounds by:<br>* Halogenation reaction using Lewis acid catalyst<br>* Alkylation reaction using Lewis acid catalyst<br>* The addition reaction of benzene by hydrogenation reaction using Ni/Pt/Pd catalyst<br>* Halogenations reaction using heat/sunlight | Draw the structures of<br>* chloro benzene<br>* 3-phenylpropane<br>* cyclohexane |
| | 6.8.3 explain the differences between the reactivity of benzene and alkene towards certain reagents. | Comparison of reactions of benzene and alkenes | Discuss and perform simple tests with benzene and alkene using the following reagents: cold dilute $KMn0_4$ , $Br_2/H_2O$ or $Br_2/CHCl_3$ in the dark | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 9**<br>**ALKANOLS** | The students will be able to:<br>6.9.1 describe the preparation and properties of alkanols. | Preparation and properties of alkanols<br><br>Physical properties of alkanol | Let students:<br>Discuss the preparation of alkanols from alkenes and haloalkanes, palm wine, sugar cane juice, maize, millet and fruit juice.<br>Discuss the physical properties of alkanols, i.e. boiling point and solubility in water. | |
| | 6.9.2 write the names and structures of given alkanols. | Nomenclature of alkanols<br><br>Primary, Secondary and tertiary alkanol | Write the structure of a named alkanol<br>Write the name for the structure of given alkanols<br><br>Classify alkanols as primary secondary and tertiary for given alkanols | Draw the structures of<br>* chloro benzene<br>* 3-phenylpropane<br>* cyclohexane |
| | 6.9.3 describe the chemical reactions of alkanols. | Chemical reactions of alkanols | Discuss the dehydration of alkanols to form alkenes.<br>Determine the products formed by the oxidation of primary, secondary and tertiary alcohols using acidified $K_2Cr_2O_7$ /$KMnO_4$ solution. | |
| | 6.9.4 state some uses of alkanols | Uses of alkanols | Discuss the uses of ethanol in the home, hospital, pharmaceutical industries and research work in chemistry and science related laboratories. | |
| **UNIT 10**<br>**ALKANOIC ACID** | 6.10.1 describe the sources, preparation and properties of alkanoic acids | Sources, preparation and properties of alkanoic acids. | Discuss and state the main sources of alkanoic acids, i.e. methanoic acid from insects, ethanoic acid from vinegar, fruits, sugars and carbohydrates.<br><br>Discuss the laboratory preparation of alkanoic acids e.g. oxidation of alkanols and other examples.<br>Discuss the effects of substituent groups on the acid strengths of alkanoic acids<br>Explain the terms inductive effect, mesomeric effect and resonance.<br>Discuss the physical properties of alkanoic acid i.e. b.pt and solubility<br>Discuss why alkanoic acids have higher boiling points than alkanes with comparable masses | Explain why alkanoic acids have higher boiling points than alkanes with comparable masses. |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 10 ALKANOIC ACID (cont)** | The students will be able to: | | Let students:<br><br>Discuss the chemical properties of alkanoic acid. Reactions of alkanoic acids with<br>i. Active metals, Zn, Mg<br>ii. Na0H<br>iii. $NaHCO_3$ and $Na_2CO_3$<br>iv. NH3<br>v. Alkanol/$H^+$ | |
| | 6.10.2 write the systematic names and structures of given alkanoic acids. | Nomenclature of alkanoic acids | Discuss the structure of the functional group C00H (carboxyl group) acid.<br><br>Explain that functional groups can exist as isomers, for example, ethanoic acid ( $CH_3COOH$ ) and ( $HCOOCH_3$ )<br>Write the systematic name for given structure of alkanoic acids | |
| | 6.10.3 describe the uses of alkanoic acids. | Uses of alkanoic acids | Discuss the uses of alkanoic acids:<br>Ethanoic acid and phenylmethanoic acids. | |
| **UNIT 11 ALKANOIC ACID DERIVATIVE ALKYL ALKANOATE (ESTERS)** | 6.11.1 describe the sources, preparation and properties of alkyl alkanoates. | sources, preparation and properties of alkyl alkanoates | Discuss the sources of alkyl akanoates: flavours of fruits and flower.<br><br>Outline the condensation reaction of an alkanol with a alkanoic acid to form an ester. | |
| | 6.11.2 describe the nomenclature and structure of alkyl alkanoates. | Nomenclature and structure of alkyl alkanoates | Discuss the nomenclature of alkyl alkanoates: RC00R<br><br>Discuss the physical properties: Solubility, b.pt, m.pt<br>Discuss the chemical properties: hydrolysis with alkali and acids | |
| | 6.11.3 outline the uses of alkyl alkanoates | Uses of alkyl alkanoates | State the uses of esters in soap production, as flavouring agent, plasticizers, as solvents and in perfumes. | |

# SHS 3

## SECTION 1
## CHEMISTRY, INDUSTRY AND ENVIRONMENT

**General Objectives:** The students will

1. Recognize the important role chemical industries play in the lives of people.
2. Be aware of chemical industries in Ghana and understand what they do.
3. Be aware of the mineral resources in Ghana and understand how they are exploited and used.
4. Recognize that chemical industries have implications for society and the environment

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | | |
| **CHEMICAL INDUSTRY** | 1.1.1 explain the terms 'industry' and 'Chemical Industry'. | Industry and Chemical Industry | Brainstorm to come out with the meaning of the term 'Industry, placing emphasis on chemical industry. | |
| | 1.1.2 explain what a chemical plant is. | Chemical plants | Discuss chemical plants and distinguish between a chemical plant and chemical industry.<br><br>Discuss some chemical plants in Ghana and what they do.<br>For example.<br>* Crude Oil refinery<br>* Cement production<br>* Soap making<br>* Salt making<br>* Gold refinery<br>* Steel Production<br>* Aluminium production<br>* Brewing<br><br>Explore the raw materials they use and state their sources (local or foreign)<br>Explain why some chemical plants in Ghana use foreign raw materials.<br><br>Discuss the major and by-products of the chemical plants listed above. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1**<br><br>**CHEMICAL INDUSTRY (CONT)** | The students will be able to: | | Let students:<br><br>Outline the basic chemical reactions or processes employed to transform raw materials to products, e.g.<br>* saponification,<br>* electrolysis,<br>* solvent extraction<br>* fermentation<br>* precipitation<br>* decomposition etc<br><br>Visit a chemical industry plant in Ghana, write a report on the kind and sources of raw materials; finished products, by-product and the basic chemical process/or processes used to convert raw materials into products, sources of energy to the chemical plants and benefits the industry gives to the community in which the plant is cited.<br><br>In groups present reports to class for discussion | |
| **UNIT 2**<br><br>**EXTRACTION OF METALS** | 1.2.1 outline the properties and reactivity of metals<br><br>1.2.2 explain the term mineral/ore.<br><br>1.2.3 identify the different types of mineral deposits in Ghana | Properties and Reactivity of metals.<br><br>Meaning of mineral or ore<br><br>Mineral deposits in Ghana | Review properties and reactivity series of metals ( Year 2, section 5, Unit 4, SRN 5.1.4)<br><br>Brainstorm to come out with the meaning of the term 'mineral or ore.<br><br>Discuss the various mineral deposits and their locations in Ghana. e.g.<br>(1). *Metallic minerals*<br>* Gold<br>* Bauxite<br>* Manganese<br>* Iron ores<br>(2). *Precious stones*<br>* Diamond<br>(3). *Industrial minerals*<br>* Limestone, clay, kaolin<br>* Solar salt<br>* Crude oil | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 2 (CONT'D)** | The students will be able to: | | Let student: | |
| | 1.2.4 identify ores of gold, aluminium, iron and manganese. | Metals and their ores. | Discuss the ores/minerals from which gold, aluminium, iron and manganese are extracted.<br><br>Identify any elements or compounds that co-exist with the metals in question and their compounds in the ore. | |
| | 1.2.5 outline the extraction of gold and aluminium from their ores. | Extraction of Gold and Aluminium. | Discuss the extraction of Gold and Aluminium from Quartz and Bauxite respectively.<br>Outline the extraction processes using chemical equations. | |
| | 1.2.6 outline the economic importance of Al and Au to the people of Ghana. | Importance of Al and Au metals | Discuss the domestic and industrial uses of Al and Au and their alloys.<br>Discuss why duralumin an alloy of Al is preferred to the pure metal in many instances. | |
| **UNIT 3 EXTRACTION OF CRUDE OIL AND PETROLEUM PROCESSING** | 1.3.1 outline the formation of crude oil from biological sources | Formation of Crude Oil | Discuss the theory of the formation of crude oil from zooplankton, algae, diatoms, foraminifera and radiolaria millions of years ago | |
| | 1.3.2 identify the chemical elements and compounds found in crude oil. | Elements and compounds in Crude oil<br>* H, N, O, S<br>* Hydrocarbons<br>* aromatic hydrocarbons | Discuss the chemical composition of crude oil. | |
| | 1.3.3 Classify crude oil by their density, geographic location and sulphur content. | Classification of crude oil by<br>* Geographic location<br>* API gravity<br>* Light, heavy<br>* Sulphur content(sweet and sour) | Discuss the classification of crude oil (on the world market) and explain why light and sweet crude oils are preferred to heavy and sour crude oils. | Explain why there are differences in price for the same quantity of crude oil from different sources. |
| | 1.3.4 describe how crude oil is extracted from an oil well. | Extraction of crude oil from an oil well. | Discuss crude oil extraction from an oil well by the primary (natural gas pressure) and the secondary (Gas lift and gas injection) recovery processes. | |
| | 1.3.5 describe the fractional distillation of crude oil. | Distillation of crude oil | Discuss the physical and chemical methods of separation of organic compounds in crude oil | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| | The students will be able to: | | Let students: | |
| **UNIT 3**<br><br>**EXTRACTION OF CRUDE OIL AND PETROLEUM PROCESSING** (**Cont)** | 1.3.6 explain cracking and reforming of organic compounds. | Cracking and Reforming of organic compounds | Discuss cracking and reforming of organic compounds and state their importance to the crude oil refining process. | What is cracking? How important is cracking to the petroleum industry? |
| | 1.3.7 outline the uses of the fractions obtained from crude oil distillation. | Uses of crude oil fractions | List and discuss the uses of the fractions obtained from crude oil distillation. | |
| | 1.3.8 outline the sources and uses of petrochemicals. | Petrochemicals<br>• Sources<br>• Uses | Discuss the term petrochemicals, their sources and uses (of some named examples) as raw materials for many industrial processes. | Name three petrochemicals and state their sources. |
| | 1.3.9 explain octane number and its importance to the petroleum industry. | Octane number | Discuss the term '*Octane number*' and its importance in the petroleum industry.<br>Discuss addition of anti-knocking agents to enhance octane number.<br>Discuss why Lead tetraethyl has been faced out as an additive to gasoline | What is knocking? Explain the significance of cracking in improving the quality of gasolin |
| **UNIT 4**<br>**ENVIRONMENTAL POLLUTION** | 1.4.1 explain pollution. | Pollution of the environment | Discuss the various systems that can be polluted. For example:<br>* Air<br>* Water<br>* Land | |
| | 1.4.2 describe natural air Pollution. | Natural air pollution | Discuss the three types of natural air pollution as:<br>* Wildfires – which increase $CO_2$ in the air through burning<br>* Windblown dust or wind storms in the West African sub-region | |
| | 1.4.3 describe human activities that cause air pollution. | Human activities that cause air pollution. | Discuss the composition of Fossil fuels such as:<br>* burning of Octane, $C_8H_{18}$ in an excess of oxygen to produce $CO_2$ and $H_2O$ and limited amount of oxygen to produce soot, CO and $H_2O$.<br>* combustion of sulphur containing substances to produce $SO_2$<br>* Oxidation of Nitrogen, which is also an impurity in fossil fuel to produce $NO_2$.<br>Discuss pollutants that result from roasting – heating an ore in the presence of air for example, metal sulphides to produce free metal and $S0_2$ | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 4**<br><br>**ENVIRONMENTAL POLLUTION** | The students will be able to:<br><br>1.4.4 describe atmospheric events such as Acid rain, Greenhouse Effect and ozone depletion. | Acid rain<br><br>Green house Effect<br><br>Ozone Depletion | Let students:<br><br>Discuss air pollution that results from the release of Arsenic oxide ($As_2O_3$) into the air from Gold mining processing plants.<br><br>Discuss Acid Rain in terms of the conversion of $S0_2$ and $NO_2$ into $H_2SO_3$ and $HNO_3$ in the atmosphere and its subsequent precipitation as acid rain onto the earth.<br><br>Discuss greenhouse effect as the trapping of heat near Earth's surface by gases in the atmosphere, particularly $CO_2$<br><br>Discuss the conversion of Ozone to Oxygen by UV light. Discuss CFCs and their contribution to ozone depletion. | Explain why lakes with limestone experience less adverse effect from acid rain. |
| | 1.4.5 describe the effects of air pollution. | Environmental effects of air pollution. | Discuss the consequences of acid rain, Greenhouse effect and ozone depletion on vegetation, water, and general wellbeing of humans. | |
| | 1.4.6 describe the sources of water pollution. | Sources of Water Pollution | Discuss the sources of water pollutants such as<br>* Human Waste<br>* Industrial chemical waste<br>* Agricultural waste chemicals such as pesticides, weedicides, insecticides, fertilizers<br>* Leaches from urban solid wastes<br>* oil spillage | |
| | 1.4.7 describe the sources of land pollution. | Common soil pollutant | Discuss urban solid waste and its effect on land and humans. This should include;<br>• Degradable and<br>• Non-degradable substances | |

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| **UNIT 5 BIOTECHNOLOGY** | The students will be able to:<br>1.5.1 describe the concept of biotechnology. | The concept of Biotechnology | Let students:<br>Discuss the concept of Biotechnology and its applications in the following industries<br>* Food and drink<br>* Treatment of waste<br>* Genetic Engineering<br>* Medical Products/pharmaceuticals<br>* Mining<br>* Fuel | |
| | 1.5.2 outline biotechnology processes that give products for human use. | Biotechnology products | Discuss some products obtained using biotechnology. This should include:<br>(i) Chemicals<br>* Food<br>* Ethanol<br>* Polymers<br>(ii) Fuel<br>* Biogas (methane)<br>* Gasohol (ethanol-gasoline) | |
| | 1.5.3 outline biotechnology services useful to humans. | Biotechnology Services | Discuss service delivery to humans using Biotechnology. This should include:<br>(i) Mining<br>* Extraction of metals by bioleaching<br>(II) Treatment of Waste<br>* Oil spills<br>* Domestic waste<br>* Sewage treatment | |
| | 1.5.4 visit a traditional (indigenous) industrial facility. | Traditional (indigenous) industrial facility<br>Gari, kenkey, 'koobi' local gin (akpeteshie), production. | Discuss and write a report on a visit to an indigenous technology facility. This should include:<br>* Raw materials<br>* Stages in the production process using a flow chart<br>* Source of energy<br>* Chemical transformation in the raw material to products (No chemical reaction required)<br>* Main products and by-products<br>* Management of waste from the production process<br>* Health risk factors and safety precautions | |

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| **UNIT 5 BIOTECHNOLOGY (cont)** | The students will be able to: | | Let students: | |
| | 1.5.5 describe an industrial visit. | Industrial visit: mining, brewery, drug production, Food processing facility. | Visit some industries and observe how biotechnology is applied in extraction of gold, brewery, drug production and food processing. Write a report and discuss in class. | |
| **UNIT 6 CEMENT AND ITS USES** | 1.6.1 describe raw materials used in clinker and cement production | Raw materials for clinker production | Discuss the raw materials for clinker production. This should include:<br>* Limestone<br>* Clay | |
| | 1.6.2 describe the process of cement production | Cement Production | Explain that the limestone and clay are mined and processed. That is,<br>(i) Physical treatment:<br>* Crushing and grinding, drying of the limestone,<br>* Drying and milling of the clay<br>* Mixing of the powdered limestone and clay<br>(ii) Chemical treatment<br>* Roasting of clay-limestone mixture in a kiln at about $1600^{o}C$ to produce clinker<br><br>Discuss the processes involved in cement production from clinker. Explain that the raw materials are:<br>(i) Clinker<br>(ii) Gypsum, which are mixed, milled and packed for sale. | |
| | 1.6.3 describe the uses of cement | Uses of cement | Discuss the uses of cement in the building and construction industry: This includes<br>- Bridges<br>- Roads<br>- Buildings<br>- Asbestos(highly carcinogenic) | |
| | 1.6.4 describe the environmental impact of cement production and usage. | Environmental pollution associated with cement production. | Discuss the environmental pollution of clinker/cement production. This includes:<br>(i) Discharge of cement dust into the air<br>(ii) Reaction with the skin on direct contact with cement dust.<br>(iii) Dissipation of heat<br>(iv) Noise | |

# SHS 3

## SECTION 2
## BASIC BIOCHEMISTRY AND SYNTHETIC POLYMERS

1. Recognize important applications of functional group chemistry in the manufacture and use of organic compounds.
2. Show awareness of the general impact of organic products on our lives and the environment e.g. medicines, clothing, shelter, plastics and detergents.

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
|---|---|---|---|---|
| **UNIT 1** | The students will be able to: | | Let students: | |
| **FATS AND OILS** | 2.1.1 identify sources and properties of Fats and Oils | Sources and properties of Fats and Oils | Discuss the sources of Fats and Oils<br>* Plants, Animals<br>Discuss the composition of fats and oils.<br>Discuss the physical properties such as solubility and states.<br><br>Discuss the acidic and alkaline hydrolysis of Fats and Oils using dilute mineral acid, NaOH and KOH<br>* Hydrogenation(Margarine production)<br><br>Discuss the test for fats and oils | |
| | 2.1.2 describe fats and oils as alkylalkanoates. | General Structure of Fats and Oils | Discuss and write the general structure for fats and oils<br>* Palm oil, coconut oil<br>Discuss fats and oils as mono-, di-, and tri-esters of propan-1,2,3-triol(glycerol) | |
| | 2.1.3 describe the preparation of soap from Fats and Oils. | Preparation of soap (saponification) from Fats and Oils | Outline the saponification reaction for making soap using local oils and fats and alkali from burnt cocoa husks, plantain peel/caustic soda. | Describe the preparation of soap from plantain peels.<br>What is salting out in the soap production process? |
| | 2.1.4 compare soapy and soapless detergents | Soap and Soapless detergents | Describe the hydrolysis of fats and oils to form soap | |
| | 2.1.5 outline some uses of fats and oils. | Uses of Fats and Oils | Discuss the difference between soapy and soapless detergents in terms of<br>* Raw material sources<br>* Structure<br>* Effect on hard water | |

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| | The students will be able to | | Let students:<br><br>Demonstrate the test for soapy and soapless detergents on hard water and soft water.<br><br>Discuss the uses of fats and oils as:<br>* Food preparation<br>* Lubrication of machine parts<br>* Medicinal use.<br>List the major functions of fats and oils in the body i.e. energy sources, insulation and cell membrane | |
| **UNIT 2**<br>**PROTEINS** | 2.2.1 describe the sources, and properties of proteins. | Sources and properties of proteins | Discuss the sources of protein.<br>Meat, Fish, Eggs, Beans, Milk, Groundnuts, Soya bean, peanuts, Cashew nut.<br>Discuss the solubility of proteins in water<br>Discuss the hydrolysis of proteins to give amino acids | |
| | 2.2.2 describe the general structure of alpha amino acids. | General structure of alpha amino acids | Discuss the general structure of alpha amino acids using glycine, tyrosine as examples.<br><br>Explain that there are approximately 20 common 2-amino acids (alpha-amino acids) obtained from the proteins of organisms | |
| | 2.2.3 describe proteins as a natural polymer. | Protein as a natural polymer | Discuss formation of protein from amino acids.<br>Describe the condensation reaction of amino acids to form polypeptides.<br>Discuss the peptide linkage as an amide bond. | |
| | 2.2.4 describe the uses of proteins. | Uses of proteins | Discuss the uses of proteins for food.<br>List the major functions of proteins in the human body, i.e. structure, biological catalyst, hormones and genetic materials and energy sources. | |
| **UNIT 3**<br><br>**CARBOHYDRATES** | 2.3.1 identify the sources and properties of carbohydrates. | Sources and properties of carbohydrates | Discuss the sources of carbohydrates<br>Sugars, cereals, tubers, fruits, honey.<br><br>Discuss the solubility of sugars.<br>Explain the hydrolysis of disaccharides into monosaccharide or simple sugars.<br>Discuss the test for reducing sugars using sugar strips, Fehling's or Benedict's solution, and Tollen's reagent. | |

| UNIT | SPECIFIC OBJECTIVES | CONTENT | TEACHING AND LEARNING ACTIVITIES | EVALUATION |
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| **UNIT 3 CARBOHYDRATES (cont'd)** | The students will be able to:<br>2.3.2 describe the classes and names of carbohydrates. | Classes and names of carbohydrates | Let students:<br>Discuss the classes and names of the components of the various classes of carbohydrates<br>Monosaccharide – glucose, galactose and fructose.<br>Disaccharides -- lactose, sucrose,<br>Polysaccharide – starch, cellulose, glycogen | |
| | 2.3.3 describe carbohydrate as a natural polymer. | Polymers of carbohydrate | Discuss starch as a polymer made up of glucose units i.e. an example of carbohydrate<br>Discuss the hydrolysis of disaccharides and polysaccharides to form monosaccharides. | |
| | 2.3.4 describe the uses of carbohydrate | Uses of carbohydrates | Discuss the uses of carbohydrate.<br>Industrial, commercial, medicinal, domestic and pharmaceutical uses.<br>List the major functions of polysaccharides in the body i.e. energy sources, energy reserves (glycogen) and precursors for other biologically important molecules. | |
| **UNIT 4 SYNTHETIC POLYMERS** | 2.4.1 describe synthetic polymers. | Synthetic polymers | Brainstorm to come out with the definition of the terms polymer and polymerization<br>Classify synthetic polymers based on monomers and comonomer units<br>* Polystyrene, synthetic rubber<br>* Polythene, PTFE, orlon, nylon<br>* Bakelite | |
| | 2.4.2 describe addition and condensation polymerization. | Addition and condensation polymerization | Outline the polymerization of alkenes. Polythene and polyvinyl chloride should be cited as addition polymers.<br>Outline condensation polymerization of e.g. – urethane to polyurethane | Differentiate between addition and condensation polymers. |
| | 2.4.3 describe how the properties of polymers depend on | Effect of heating on polymers | Discuss the properties of polymers as dependant on heating.<br>Differentiate between thermoplastics and thermosets | |

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| **UNIT 4**<br><br>**SYNTHETIC POLYMERS** | The students will be able to:<br><br>2.4.4 explain the chemical Tests for plastics.<br><br>2.4.5 state the uses of polymers | Chemical tests on plastics<br><br>Uses of Polymers | Let students:<br><br>Discuss chemical tests on plastics using.<br>* heat<br>* acids<br>* alkalis<br><br>Discuss polymer chemistry as a part of the larger discipline of materials science, which involves creation of new materials to replace metals, glass, ceramics, wood, cardboard and paper.<br><br>Discuss the advantages and disadvantages of synthetic polymers<br>Consider strength, density, insulation, lack of reactivity, use of natural resources, disposal and biodegradability use polyethene, polyurethane foams, polyvinyl chlroride and phenol-methanal plastics as examples.<br>Discuss Teflon as a special polymer. | |

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