A' LEVEL

CHEMISTRY

ASSESSMENT GUIDELINES 2026

WITH SAMPLE ASSESSMENT ITEMS AND LEVELS OF COMPETENCE

ASSESSMENT GUIDELINES FOR ADVANCED LEVEL CHEMISTRY

1.1 INTRODUCTION

Chemistry in the Advanced Secondary Curriculum (ASC) is assessed at school and at the End of the Cycle examinations which is administered by the Uganda National Examinations Board (UNEB).
Assessment of Chemistry at school level will be formative and summative. Formative assessment will be done through observation (watching learners working), conversation (asking questions and talking to learners) and appraising the learners' work (product). While summative assessment will be done through an examination at the end of the year.
The end of cycle assessment for Chemistry for the Advanced Secondary Curriculum will be guided by assessment objectives based on the constructs. A construct is an abstract representation of a unifying theme that brings coherence to an assessment task. It serves as a generalized concept that combines a cluster of related learning outcomes or competencies—each contributing to a common learning ability. Acquisition of learning outcomes/ competencies in a construct enables the learner to demonstrate mastery in a way that supports real-life functionality and application.

1.2 ASSESSMENT OBJECTIVES

The end of Cycle assessment for Chemistry will be guided by three assessment objectives focusing on the learner's ability to:
AO1:
Demonstrate understanding of atomic and molecular structures, periodic trends and patterns of chemical reactivity across the Periodic Table.
AO2:
Analyse the structure, reactivity, and transformation pathways of organic compounds to predict chemical behaviour, explain natural processes, and propose solutions in real-world and innovative chemical contexts.
AO3:
Apply fundamental physical and chemical principles to analyse, model, and predict the behaviour of chemical systems and their transformations under different conditions.

1.3 LINKAGE BETWEEN ASSESSMENT OBJECTIVES, CONSTRUCTS AND SYLLABUS

The table below shows a linkage between the assessment objectives, the constructs and the topics that contribute to the construct.

Table 1: Table showing relationship between assessment objectives, constructs and the topics in the syllabus

ASSESSMENT OBJECTIVE	CONSTRUCT	CONSTRUCT DESCRIPTION	TOPICS IN THE SYLLABUS
AO1: Demonstrate understanding of atomic and molecular structures, periodic trends and patterns of chemical reactivity across the Periodic Table.	Foundations of atomic structure, bonding and periodicity of elements.	Applying knowledge of atomic and molecular structures to interpret periodic trends and chemical reactivity	***Atomic and electronic structure*** ***Bonding and structure*** ***Periodicity I*** ***Periodicity II***
AO2: Analyse the structure, reactivity, and transformation pathways of organic compounds to predict chemical behaviour, explain natural processes, and propose solutions in real-world and innovative chemical contexts.	Structure, reactivity and applications of organic molecules	Explore, predict, and apply the structure, reactivity, and transformation pathways of organic compounds to explain natural processes and support innovation in real world chemical contexts	***Organic chemistry I*** ***Organic chemistry II*** ***Organic chemistry III***

AO3: Apply fundamental physical and chemical principles to analyse, model, and predict the behaviour of chemical systems and their transformations under different conditions.	Molecular interactions and systems dynamics	Use fundamental physical and chemical principles to interpret, model, and predict the behaviour of chemical systems and transform as conditions change.	***Moles and equations*** ***Thermochemistry*** ***Equilibria I*** ***Equilibria II*** ***Electrochemistry*** ***Reaction Kinetics***

2.0 TABLE OF CONSTRUCTS

The table below details the constructs for Chemistry i.e. the competencies/learning outcomes that make up the construct, the expected learner abilities and what assessor should look out for in the learner's work as evidence of achievement of the intended learning outcomes (indicators of mastery).

CONSTRUCT	**COMPETENCIES** THE LEARNER:	**ABILITIES**	**INDICATORS OF MASTERY**	**LEVEL OF COMPLEXITY**
FOUNDATIONS OF ATOMIC STRUCTURE, BONDING AND PERIODICITY OF ELEMENTS: Applying knowledge of atomic and	2. deduces electronic configurations, evaluates their implications for chemical properties and bonding, and synthesises models to predict	• Apply the Aufbau principle, Pauli exclusion principle, and Hund's rule. • Deduce electronic configurations of atoms and ions. • Use electronic configurations to predict reactivity. • examine the nature and types of radioactive decay	1. Writing electronic configurations for elements across the periodic table. 2. Explaining how electronic configurations influence chemical properties and types of bonding 3. Recognising types of radioactive decay and their properties 4. Explaining how factors affecting nuclear stability can be used to predict atomic behaviour. 5. Explaining specific applications of radioactivity in different fields.	2-High

molecular structures to interpret periodic trends and chemical reactivity	atomic behaviour in various contexts. 3. analyses the types of chemical bonds and molecular structures, and relates them to the properties and uses of substances in real-life contexts. 4. analyses the trends and periodic properties of elements, to explain and predict the reactivity and properties of elements in the Periodic Table.	• apply this knowledge to predict decay rates and half-life in specific elements • evaluate the principles of radioactivity in real-life applications, such as in medicine, industry, and environmental science • evaluate the associated health, environmental, and ethical implications of radioactive materials. • justify the formation of ionic and metallic bonds based on electron transfer and electrostatic forces. • evaluate the properties of ionic and metallic compounds in relation to bond strength and structural composition. • Analyse the formation of covalent bonds including dative covalence • Explain molecular structures by applying VSEPR theory to predict molecular shapes and bond angles	6. Explaining benefits and limitations of radioactivity 7. Assessing the health, environmental and ethical implications of using radioactive materials in real-world contexts assessed 8. Constructing models to represent atomic structure and bonding. 9. Relating the behaviour of compounds in different chemical contexts. 10. Differentiating between ionic, covalent, and metallic bonds using examples of substances 11. Modelling molecular shapes using VSEPR theory and explains how molecular geometry affects physical properties (e.g., polarity, boiling point). 12. Explaining how bonding types and structures are related to properties such as solubility, conductivity, and hardness in real-world materials (e.g., graphite vs. diamond). 13. Relating use of particular materials is to their bonding and molecular structure. 14. Explaining trends in atomic radius, ionization energy, electro negativity, and metallic character across periods and down groups. 15. Interpreting data on periodic properties of elements in the periodic table. 16. Comparing reactivity of elements based on their position in the Periodic Table, particularly within groups such as alkali metals and halogens. 17. Comparing chemical behaviour of elements from different groups and periods using trend data.	3-High 4-High
	11. analyses the trends in the physical and chemical			11-High

	properties of Group 14 elements, Group 17 elements and d-block elements and relates these trends to their applications in industrial and environmental contexts.	• Analyse the Polarity of molecules based on molecular structure and electron distribution • Analyse periodic trends and electronic structure • Interpret and analyse periodic data for trends in properties of elements in the periodic table • Evaluate the properties of elements in the periodic table across the period and down the groups • Apply knowledge of element chemical and physical properties in real-world contexts	18. Applying periodic trends to justify selection of elements for specific functions or reactions (e.g., selecting catalysts or reducing agents). 19. Explaining the physical and chemical properties (e.g. melting points, reactivity, oxidation states) of elements within Group 14, Group 17, and the d-block. 20. Explaining the environmental or industrial relevance of these elements (e.g., halogens in water purification, transition metals in catalysts). 21. Recognising progressive changes in properties within each group or block and relating them to their electron configurations. 22. Evaluating advantages and limitations of using specific elements from the groups in industrial applications (e.g., silicon in semiconductors , platinum in catalytic converters),	

CONSTRUCT	COMPETENCIES The learner:	ABILITIES	INDICATORS OF MASTERY	LEVEL OF COMPLEXITY
STRUCTURE, REACTIVITY AND APPLICATIONS OF ORGANIC MOLECULES Explore, predict, and apply the structure, reactivity, and transformation pathways of organic compounds to explain natural processes and support innovation in real-world chemical contexts	6. analyses the structures, functional groups, and reactivity of organic compounds, and applies knowledge of organic reactions and organic reaction mechanisms to synthesise organic molecules. 9. analyses reaction mechanisms, evaluates reaction pathways and conditions, and designs multistep syntheses to achieve target compounds (considering alcohols, phenols, carbonyl compounds). 12. analyses the chemical properties, industrial applications, and environmental impacts of amines and polymers, evaluates their social and ecological implications, and proposes innovations and sustainable solutions for addressing challenges in their use and disposal.	• analyses structures of organic compounds • predicts reactivity of organic compounds • explains transformation pathways of organic reactions. • applies the knowledge of structure and reactivity to synthesis. • carries out projects relating natural processes in real-world chemical contexts to societal problems.	i. Recognising functional groups and compound ii. types in organic molecules, including alcohols, phenols, carbonyls, amines, and polymers. Predicting products of organic reactions predicted by applying knowledge of reaction types, functional group behaviour, and principles of writing reaction mechanisms. iii. Writing reaction mechanisms, using appropriate conventions (e.g., curved arrows) to show electron movement and intermediates. iv. Designing logical multi-step synthetic pathways to produce target organic compounds, justifying reagent selection and reaction conditions. v. Explaining real world applications of organic compounds (e.g., pharmaceuticals, plastics, industrial chemicals) and their impacts on health, society, and the environment. vi. Proposing sustainable and innovative solutions for reducing environmental harm from the use and disposal of organic compounds, particularly polymers and industrial chemicals.	6-High 9-High 12- High

CONSTRUCT	COMPETENCIES The learner:	ABILITIES	INDICATORS OF MASTERY	LEVEL OF COMPLEXITY
MOLECULAR INTERACTIONS AND SYSTEMS DYNAMICS Apply fundamental physical and chemical principles to interpret, model, and predict the behaviour of chemical systems and their transformations under varying conditions	1. analyses stoichiometric relationships, evaluates experimental methods, and synthesises solutions to complex chemical problems. 5. analyses and evaluates thermodynamic principles and processes to predict the spontaneity and feasibility of chemical reactions and processes. 7. analyses principles of chemical equilibrium and applies them to explain and solve problems related to industrial processes, ionic equilibria, buffer systems, and solubility equilibria in various chemical and real-world contexts. 8. applies principles of physical equilibria and colligative properties to analyse and predict changes in physical systems, including phase	• performs stoichiometric analysis, • interprets experimental data • solves quantitative chemical problems. • applies analytical principles to solve real world problems • Construct and analyse energy profile diagrams Apply Hess's law in multistep chemical reactions • Use thermochemical equations to solve enthalpy problems • Predict phase changes using knowledge of physical equilibria • Analyse colligative properties based on solute concentration • Apply Le Chatelier's principle to predict equilibrium shifts • Solve equilibrium problems involving Kc and Kp • Solves quantitative problems involving pH and buffer capacity	i. Calculating quantities of reactants and products using mole ratios in different contexts. ii. designing and performing, stoichiometric experiments. iii. Analysing experimental data to draw valid conclusions. iv. Solving chemical problems involving stoichiometry in real-life situations such as food preservation and water purification. v. Constructing and interpreting energy profile diagrams for exothermic and endothermic reactions. vi. Using thermochemical principles to analyse and solve enthalpy related problems. vii. Carrying out projects to solve real-life problems involving energy changes. viii. Explaining phase transitions using principles of physical equilibria. ix. Performing experiments to investigate effects of solute concentrations on colligative properties.	1-High 5-High 7-High 8-Moderate

	transitions and effects of solute concentration on solution behaviour, in scientific and real-world contexts. 10. analyses redox reactions, electrochemical processes and electrochemical cells, applies the principles of electrode potentials to predict reaction spontaneity and electrolysis outcomes. 13. evaluates factors influencing reaction rates, and applies the principles of reaction, mechanisms and rate laws to predict the speed of chemical reactions under various conditions.	• Solve problems involving redox equation and EMF of cells • Determine reaction rates and propose mechanisms • for reactions	x. Applying theoretical principles of physical equilibria to predict changes in real world systems. xi. Analysing and interpreting scientific data on solution behaviour in different physical conditions. xii. Solving quantitative problems involving equilibrium constant (Kc, Kp) calculations and predicts shifts using Le Chatelier's Principle. xiii. Explaining how changes in temperature, pressure, and concentration affect equilibrium in industrial processes such as the Haber or Contact process. xiv. Calculating pH and predicting buffer capacity, and changes in pH upon the addition of acids or bases to buffer systems. xv. Balancing complex redox reactions in acidic and basic media using the half-reaction method. xvi. Calculating standard cell potentials (E°cell) and predicting spontaneity and direction of redox reactions. xvii. Determining the amount of products of electrolysis in various electrolytic cells.	10-High 13-High

			xviii. Explaining the industrial applications of redox reactions in batteries, metal extraction, and corrosion control. xix. Determining rate laws from experimental data and calculating orders of reaction and rate constants. xx. Carrying out experiments to investigate the effect of temperature, catalysts, concentration, and surface area on reaction rate using collision theory and activation energy concepts. xxi. Proposing plausible reaction mechanisms consistent with experimental rate laws and recognising the rate determining step.	

3.0 STRUCTURE OF THE EXAMINATION PAPERS

There will be two examination papers for Chemistry at ASC. Each examination paper will be divided into two sections, with each section addressing an assessment objective.

Paper 1 (Theory Paper) will contain two sections A and B.

Section A:

- **Items in Section A** will come from construct 3 ***(Molecular Interactions and Systems Dynamics***) addressing assessment **objective 3**

Section B will have **two parts**:

- **Part I two items will come from construct** ***1*** *(Foundations of Atomic Structure, Bonding and Periodicity of Elements)* where the candidate responds to any one item addressing ***assessment objective 1***.

- **Part II of Section B will come from Construct 2** (*Structure, Reactivity and Applications of Organic Molecules*) where the candidate responds to any one item ***addressing assessment objective 2***.

The items in the paper will be scenario based and the entire paper will take **2hours:45min.**

Paper 2 (Practical Paper) will contain two compulsory items picked from any of the three constructs

The paper will test science process skills in the three assessment objectives. The entire paper will take of **3hrs:15min.**

SET 1 - SAMPLE ITEMS FOR CHEMISTRY

CHREMISTRY PAPER 1

Duration: 2hours 45 minutes

Instructions to candidates:

The paper consists of two sections A and B.

Sections A: consists of TWO **Compulsory** items**.**

Section B: consists of two parts 1 and II each having two items. Attempt any **ONE** item from each part of section B.

Section A:

Attempt ALL items in this section

ITEM 1: A renewable energy company is producing bioethanol from sugarcane molasses. The bioethanol is used to power rural micro-grids. The process involves fermenting glucose into ethanol and carbon dioxide using yeast, followed by fractional distillation. The following equilibria and thermochemical data are available:

Substance	**Equilibrium concentration (mol/L) at 37 °C**
Glucose	0.20

Ethanol	0.30
Carbon dioxide	0.30

To optimise yeast activity, the pH must be kept between 4.5 and 5.5. The team proposes using the acetic acid (CH_3COOH) / sodium acetate (CH_3COONa) buffer system (pKa = 4.74), prepared with 0.1 M acetic acid and 8.4 g sodium acetate in a total volume of 1.0 L.

However, current production suffers from low yield, energy inefficiency, and fluctuating reaction rates due to changing environmental conditions. Using 1.5 g of glucose as your starting feedstock, you are required to analyse the process and recommend improvements.

The table below provides additional kinetic data for glucose fermentation:

[Glucose] (mol/L)	**[Yeast] (g/L)**	**Initial Rate (mol/L·min)**
0.10	1	0.003
0.20	1	0.006
0.20	2	0.012
0.20	3	0.018

The management of the company has asked your school science club to carry out a pilot project to improve the yield, efficiency, and consistency of the fermentation process.

Task

As a member of the science club and chemistry student:

a. By applying the equilibrium law, predict how continuous removal of CO_2 would influence the ethanol yield.

b. Determine the suitability of the proposed buffer system to maintain optimal yeast activity during fermentation

c. From the kinetic data, determine the rate constant for fermentation and suggest scientifically sound methods to increase the rate constant.

d. Suggest ways by which the community members can utilise your findings to manage the fermentation process for their own benefit.

ITEM 2: Chemical industries producing dyes, pharmaceuticals, and other products rely on solvents like naphthalene and precise knowledge of molecular characteristics of additives and impurities. At the same time, the local water supply shows signs of contamination, with an unknown solute T affecting the freezing point of water in storage tanks.

The water treatment facility collected the following data on solute T:

Concentration of T (g dm^{-3})	0	30	60	90	120	150
Freezing point (°C)	0	-0.16	-0.32	-0.49	-0.65	-0.81

The Cryoscopic constant for water is 1.86 °C per 1000g per mole.

The same company is optimizing an industrial reaction: $A+2B \rightleftharpoons 2C+D$ $\Delta H^{\theta}=-50$ kJ mol^{-1}

Exp No.	[A] (mol/L)	[B] (mol/L)	Initial rate (mol L^{-1} min^{-1})
I	4.0×10^{-2}	4.0×10^{-2}	6.40×10^{-3}
II	4.0×10^{-2}	8.0×10^{-2}	1.28×10^{-2}
III	8.0×10^{-2}	4.0×10^{-2}	2.56×10^{-2}
IV	8.0×10^{-2}	8.0×10^{-2}	5.12×10^{-2}

The community depends on safe drinking water and efficient chemical production for economic growth. Your chemistry teacher has requested you to analyze the information to help solve these community problems.

Tasks

a. Construct a rate equation for the industrial reaction

b. Predict the behaviour of the reaction under different conditions of temperature and pressure

c. Determine the molecular mass of T so that the chemical company can accurately identify additives, ensure product quality and solve the water quality problem

SECTION B

Part I: Attempt any one item in this part

ITEM 3: Uganda faces persistent challenges in rural electrification. Many communities rely on unreliable and costly energy sources like diesel generators, kerosene lamps, and car batteries. A Ugandan company is developing solar-powered micro-grids and has invited your chemistry class to help identify suitable materials for solar batteries and wiring. These materials must be affordable, corrosion-resistant, and durable under Uganda's rural conditions. The company is investigating elements similar to those in Periods 2 and 3 of the Periodic Table. The measured properties of selected elements are shown below:

Element	Atomic Radius (pm)	First Ionization Energy (kJ/mol)	Electronegativity (Pauling)	Typical Bonding Type
Li	145	520	1.0	Metallic
Mg	130	730	1.5	Metallic
Al	110	1000	2.5	Metallic
Si	95	1250	3.0	Covalent
P	85	1500	3.5	Covalent

Task
As a chemistry learner;
Use your understanding of atomic structure, periodic trends, chemical bonding and the information provided to propose suitable materials for solar batteries and wiring in Uganda's rural micro-grid systems

ITEM 4: Your chemistry class has been invited by a chemical plant management near Lake Victoria to assist in identifying ways of optimizing the production of key industrial compounds including sodium oxide, magnesium oxide and silicon dioxide used in glassmaking and ceramics. The plant management has observed inconsistencies in melting points and reactivity, which are affecting product quality and safety. You are tasked with conducting a scientific investigation to analyze periodic trends of the elements, compound properties, and molecular structures to recommend improvements.
Important chemical data of the findings about the elements and their compounds is provided in the table below to assist in the analysis.

Element	**Atomic Number**	**Atomic Radius (pm)**	**Ionisation Energy(kJ/mol)**	**Melting Point (°C)**	**Oxide Melting Point (°C)**
Sodium (Na)	11	186	496	98	1275
Magnesium (Mg)	12	160	738	650	2800

Aluminium (Al)	13	143	578	660	2072
Silicon (Si)	14	118	786	1410	1710
Phosphorus (P)	15	110	1012	44	580
Sulphur (S)	16	104	1000	115	Gas/Sublimes
Chlorine (Cl)	17	99	1251	-101	Gas/Gas

Task

As a chemistry learner, write a report about the periodic trends of the elements and their oxides, and recommend improvements to the plant's production processes.

Part II: Attempt any one item in this part

ITEM 5: A certain town in central Uganda faces growing concerns over water pollution from agro-processing industries, especially during the cocoa harvest season. Wastewater from cocoa processing plants often contains organic matter including acids, and amines that can harm aquatic life if released untreated.

A group of entrepreneurs is setting up a small plant to process cocoa husks, a by product of cocoa bean production, into value-added products. Chemical analysis of the husks shows that they contain ethanol (from natural fermentation), ethanoic acid, small amounts of amines (from protein breakdown), and aromatic aldehydes such as vanillin(4-hydroxy-3-methoxybenzaldehyde).

To address the water pollution challenge and create additional revenue streams, the team plans to:

1. Determine the relationship between the structure of vanillin and ethanoic acid, and their solubility.
2. Convert ethanol into amines for use in water treatment and cosmetics.
3. React ethanoic acid with ethanol to produce an ester for fragrances, and study its reaction mechanism.
4. Evaluate the use of the esters and amines in producing fragrances and cosmetics

You have been tasked by your teacher to design feasible chemical processes, explain the underlying organic chemistry, and propose sustainable solutions to help the plant reduce environmental harm while maintaining profitability.

Tasks

As a chemistry learner, address the plans for the team and propose suitable solutions.

ITEM 6: In southwestern Uganda, a small cosmetics start-up is producing herbal skincare creams using locally sourced plant oils, such as shea butter and sunflower oil. The production process generates significant amounts of waste plant oils and fats. These wastes are currently disposed of into nearby drainage systems, causing blockages and foul smells, which has led to complaints from the community and environmental authorities.

The company has approached a team of A-level chemistry students in your school to:

- Analyse the composition of these waste materials, their functional groups and physical properties,
- Explore possible chemical processes to convert them into valuable products and their mechanisms,
- Design a synthetic route to convert compound C into compound D
- Propose a sustainable chemical process to convert waste A into a useful, marketable product that reduces environmental harm.

Analysis of a sample of the waste oil revealed the presence of a mixture of the following compounds:

Compound	**Structure (condensed)**
A	$CH_3(CH_2)_{14}COOCH_2CH(OH)CH_2OH$
B	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$
C	$CH_3CH_2CH_2OH$
D	CH_3COCH_3

Tasks:

As a chemistry learner, give written presentation that addresses the company's challenges and outlines scientifically sound, sustainable solutions.

END

<u>SET 2 - SAMPLE ITEMS FOR CHEMISTRY</u>

CHREMISTRY PAPER 1

Duration: 2hours 45 minutes

Instructions to candidates:

The paper consists of two sections A and B.

Sections A: consists of TWO compulsory items**.**

Section B: consists of two parts 1 and II each having two items. Attempt any **ONE** item from each part of section B.

Section A:

INSTRUCTION: Attempt ALL items in this section

ITEM 1: In several rural Ugandan universities, students rely on cheap portable power banks to charge their phones due to unreliable electricity. Recently, some of these power banks have overheated, swelled, and even caught fire in dormitories—causing panic among parents and school administrators. Your chemistry class has been invited to work with a team of investigators aiming to find solutions for the problem. Scientific investigations revealed that these power banks are assembled using a mix of zinc–carbon cells and discarded lithium-ion cells, charged by unregulated solar panels. Inside, zinc acts as the anode and copper wires as the cathode, forming uncontrolled galvanic cells. Regulators for these setups are not available locally.

The chemistry team collected the following data to understand the issue:

Standard electrode potentials:	**Thermochemical data:**	**Additional data:**
Zn^{2+}/Zn = −0.76 V	• Enthalpy of combustion of lithium = −598 kJ/mol	• Faraday’s constant = 96,500 C/mol
Cu^{2+}/Cu = +0.34 V	• Enthalpy of neutralisation (NaOH + HCl) = −57 kJ/mol	• Charging current = 2 A for 30 minutes
Li^{+}/Li = −3.04 V	• Specific heat capacity of water = 4.18 J/Kg	• Recommended safer alternative: iron–nickel cells (Fe^{2+}/Fe = −0.44 V; Ni^{2+}/Ni = −0.25 V)
Fe^{2+}/Fe = −0.44 V	• 80 g of leaked fluid rose from 25 °C to 60 °C during a fire	

Tasks

As a member of the chemistry class,

a) Explain using data provided how spontaneous redox reactions in the power banks can cause overheating and fires.

b) Assess whether iron–nickel batteries are a safer alternative for rural school

ITEM 2: You are a chemical engineer at a fertilizer production plant that manufactures Ammonium nitrate by the reaction of Ammonia (NH_3) and Nitric acid.

Ammonia is produced as a product of the Haber process with Kc = 0.16 at 500 K, ΔH = −92 kJ/mol.

The nitrogen used has isotopic abundances of 99.63% $^{147 N}$ and 0.37% $^{157 N}$. The plant aims to produce 1000 kg of Ammonium nitrate daily (O=16, H=1). Your employer has asked you to give ideas on the following:

- Constructing an energy profile diagram for the manufacture of Ammonia.
- Determining the moles of Ammonia and Nitric acid required to produce the daily amount of Ammonium nitrate and the volume of 2.0 M Nitric acid solution needed.
- Calculating the equilibrium concentrations starting with [N_2] = 0.5 M, [H_2] = 1.5 M, and [NH_3] = 0 M at 500 K.
- Devising a means of optimizing the process by while ensuring efficient use of resources.

Task

Make write up to address the concerns of the employer

SECTION B

Part I: Attempt any one item

ITEM 3: You are a chemistry student intern at a local environmental and health laboratory. Communities near several farms have reported to the laboratory management that wells and streams are being contaminated by runoff from chlorine and bromine containing pesticides, raising concerns for drinking water and irrigation. At the same time, hospitals face shortages of iodine-based antiseptics, and local authorities plan to disinfect municipal water supplies to prevent outbreaks. Your supervisor has asked you to use periodic trends and halogen chemistry to assess risks and recommend safe, practical solutions that balance public health, agriculture, and environmental protection.

Available laboratory data:

Element	Atomic Number	Electronegativity	Bond Energy (kJ mol^{-1})
F	9	3.98	158
Cl	17	3.16	243
Br	35	2.96	193
I	53	2.66	151

Chlorine also forms several oxoacids, including:

- Hypochlorous acid (HOCl) – used in water disinfection and bleaching.
- Chlorous acid ($HClO_3$) – used in herbicides and laboratory reagents.
- Perchloric acid ($HClO_4$) – used in rocket propellants and explosives.

Tasks

a) Use the data on electronegativity and bond energy to explain how the elements differ in chemical behavior and environmental impact.

b) Evaluate the risks of using compounds from these elements in water treatment and recommend safer alternatives to protect public health and the environment

ITEM 4: A rural community located near a mining and groundwater drilling site is experiencing unusual health problems of chronic fatigue, respiratory illness, and signs of radiation exposure. Preliminary investigations have revealed the presence of Radon222, a radioactive noble gas produced from the natural decay of uranium in the surrounding bedrock. Water analysis has also confirmed elevated levels of Lead (a group 14 element likely leached from mineral ores), as well as Calcium and Chlorine compounds such hypochlorous acid (HOCl), used in paper bleaching and found in geological formations. Table 1 below shows the comparison of the melting points of Lead with other group 14 elements:

Element	**C**	**Si**	**Ge**	**Sn**	**Pb**
Melting point (°C)	3500	1414	938	232	328

Local authorities have called upon your school's science team to conduct a chemical investigation that explains the situation in scientific terms. You are required to apply your knowledge of atomic structure, periodic properties, bonding, molecular behaviour, and radioactivity to analyze the contaminants and evaluate their implications for health, safety, and environmental management. Your goal is to explore and explain the underlying chemical concepts behind the contamination and offer insights that could inform safe water management strategies.

Tasks

a)Explain the chemical properties and environmental behaviour of the elements found in the bedrock.
b)Evaluate the health risks of the radioactive isotope and propose practical mitigation strategies.

Part II: Attempt to any one item

ITEM 5: In many rural Ugandan health centres, access to affordable and effective pain relief medication is limited due to the high cost of imported drugs. Some lowquality counterfeit painkillers on the market contain harmful additives and are poorly soluble in water, reducing their effectiveness and causing environmental harm when improperly disposed of. Concerned about this, a group of chemistry students is developing a painkiller inspired by paracetamol, a molecule with phenol and amine functional groups, as their project for exhibition during a science fair. However, they lack the knowledge of the structure, synthetic routes, mechanisms and how benzene can be used as a raw material in the process and have contacted you for help. They aim to create a painkiller that is effective and environmentally safe after use.

Tasks

As a chemistry learner,
a)Predict the solubility and acidity of the compound
b)Propose a synthetic route and a suitable mechanism for the first step in the production of the pain killer
c)Suggest suitable mitigations for the environmental risks of waste from production process.

ITEM 6: A certain town in central Uganda faces growing concerns over water pollution from agro-processing industries, especially during the cocoa harvest season. Wastewater from cocoa processing plants often contains organic matter including acids, and amines that can harm aquatic life if released untreated.

A group of entrepreneurs is setting up a small plant to process **cocoa husks**, a byproduct of cocoa bean production, into value-added products. Chemical analysis of the husks shows that they contain ethanol (from natural fermentation), ethanoic acid, small amounts of amines (from protein breakdown), and aromatic aldehydes such as vanillin(4-hydroxy-3-methoxybenzaldehyde).

To address the water pollution challenge and create additional revenue streams, the team plans to:
a)Determine the relationship between the structure of vanillin and ethanoic acid, and their solubility.

b)Convert ethanol into **amines** for use in water treatment and cosmetics.
c)React ethanoic acid with ethanol to produce an **ester** for fragrances, and study its reaction mechanism.
d)Evaluate the use of the esters and amines in producing fragrances and cosmetics

You have been tasked by your teacher to design feasible chemical processes, explain the underlying organic chemistry, and propose sustainable solutions to help the plant reduce environmental harm while maintaining profitability.

Tasks

As a chemistry learner, address the plans for the team and propose suitable solutions.

END

SET 1 – ASSESSMENT RUBRICS FOR SAMPLE ITEMS FOR CHEMISTRY ITEM 1:

Basis of evaluation	Exceptional	Outstanding	Satisfactory	Basic	Elementary
a. Determine Kc and explain CO_2 removal effect	• Correct balanced equation • All calculation s accurate • Correct units • Complete explanation of Le' Chatelier's principle and clear prediction of ethanol yield change.	• Correct balanced equation • All calculation s correct (minor error in units) • Wrong explanation	• Correct balanced equation • Some calculations incorrect with significant arithmetic or conceptual error • Incorrect explanation	• Correct balanced equation • Incorrect calculation • Incorrect explanation	No correct equation, calculation or explanation provided.
b. Calculate buffer pH and comment on suitability	• Correct molar mass, • Concentration of CH_3COONa, • Correct Henderson Hasselbalch calculation of pH • Interpretation of suitability clearly justified.	• Correct molar mass • Correct concentration of CH_3COONa • Correct Henderson Hasselbalch calculation of pH • suitability comment not reasonable.	• Correct molar mass • Correct concentration of CH_3COONa • Incorrect Henderson Hasselbalch calculation of pH, • suitability comment not reasonable.	• Correct molar mass • Incorrect concentration of CH_3COONa • Suitability comment missing or irrelevant.	• No molar mass • No calculation • No or wrong suitability comment provided.

c. etermine rate constant and suggest improvements	• Correct rate law application • Accurate k calculation with units; • At least three scientifically valid, clearly explained methods to increase rate constant.	• Correct rate law application • Accurate k calculation with units • At least one scientifically valid, clearly explained method to increase rate constant.	• Correct rate law application • Accurate k calculation with units • No valid method for increasing rate	• Correct rate law application • Incorrect k calculation • No valid method to increase rate	• No calculation or improvement suggestions provided.
d. Suggest community application of findings	• At least four realistic, context specific application s directly linked to findings, • Clear benefit to rural bioethanol production.	• Three realistic applications, mostly linked to findings.	• Two relevant applications but weak connection to findings.	• One relevant application, poorly connected to findings.	• No relevant application provided.

ITEM 2

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
a. Rate equation analysis	• Correctly determines order for both A and B with clear, step-by step working and correct reasoning • Calculate rate constant accurately with correct substitution, units, and shows working • writes a fully correct rate equation with correct powers	• Correctly determine s orders for both A and B but with minimal explanation. • Calculates rate constant correctly but omits units or minor working steps • Writes correct powers in the rate equation but omits or misstates units.	• Correctly determines one order but misstates or omits the other. • Shows correct • method for rate constant but has arithmetic or unit errors • Rate equation structure partly correct but with one wrong power.	• Attempts determination but with conceptual or calculation errors for both orders in correct application of formula for rate equation • Incorrect equation form.	• No correct determination of orders • No relevant calculation of rate constant • No equation provided.
b. Effect of conditions	• Fully explains Effect temperature on rate by linking kinetic energy, collision frequency, and activation energy. • Fully explains equilibrium shift direction using ΔH and Le Châtelier's • Correctly explains no change in equilibrium position with pressure change due to Δn=0.	• Correctly states temperature increases rate with brief reasoning • Gives correct equilibrium shift with partial explanation • States no change in equilibrium with brief explanation.	• States effects correctly but without scientific reasoning • Gives correct equilibrium shift direction without explanation • States no change in equilibrium without explanation.	• Incorrect or incomplete statements for temperature or equilibrium effects statement about pressure effect.	• No relevant statement s for any condition.

c. Molecular mass from freezing point	• Draws accurate graph with correct title, labelled axes, proper scale, and straight best-fit line • Calculate s slope accurately using triangle method with correct units • Correctly uses slope and Kf to compute MM with correct units.	• Graph mostly correct but with minor scale or line errors Correct slope with small arithmetic error • Correct formula for MM but minor arithmetic/ unit error.	• Graph drawn but missing one major element (title, labels, or best-fit line) • Method for slope correct but value largely inaccurate • Method for MM attempted but incorrect substitution.	• Graph present but incorrectly plotted or with wrong line Incorrect slope method • Incorrect MM method with value far from expected .	• No graph or unrelated diagram No slope, No attempt at molecular mass calculation.

ITEM3

Basis of Assessment	**Exceptional**	**Outstanding**	**Satisfactory**	**Basic**	**Elementary**
a. Relate trends in ionization energy and atomic radius to periodic table positions	• Correctly states both trends • Accurately explains both trends with clear reasoning linked to nuclear charge and shielding • Correctly identifies all periodic positions.	• Correctly states both trends • Partially explains both trends with correct reasoning • Correct periodic positions.	• Correctly states both trends • Incorrect reasoning incomplete or partially correct • Correctly identifies at least half of positions.	• Correctly states both trends or correctly identifies at least half of positions. • Incorrect reasoning • incomplete or partially correct	• No correct trends or periodic positions; • irrelevant or no explanation.

b. Using equation s, discuss reactions with air, water, and acids and influence on use	• Writes correct • equations • for all relevant reactions • Accurately describes reactivity differences • Clearly links to uses to all elements	• Writes correct • equations • for all relevant reactions • Accurately describes reactivity differences • Links reactivity to uses for most elements with reasonable justification	• Writes correct equations for at least half the reactions • Partial reactivity explanation • No clear linkage of • reactivity to uses	• Few correct equations; • Minimal explanation • Weak or no link to uses.	• No valid equations • No meaningful discussion of reactivity or uses.
c. Explain how bonding and structure determine real-life applications	• Correctly explains bonding type and structure for each element • Accurately links structure and bonding to specific • real-life application s.	• Correctly explains bonding and structure for most elements • Accurately links structure and bonding to specific • real-life application s for most elements	• Correctly explains bonding and structure for some elements • Linkage of structure and bonding to application inaccurate, vague or partially relevant.	• Minimal bonding/ structure explanation • Little or no application connection	• Inaccurate bonding or structure details • No link to application s.

ITEM 4

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
• Understanding of Periodic Trends	• Accurately explains the trend in atomic radius and ionization energy	• Accurately explains both trends clearly with relevant connections to	• Explains both trends but does not clearly link them to reactivity.	• States the trends with vague or inadequate explanations	• Misinterprets trends; lacks understanding of reactivity implications.

	and connects it to reactivity.	reactivity for one of the properties.			
• Analysis of Compound Properties	• Thorough comparison of melting points and bonding types with accurate chemical reasoning.	• Good comparison with mostly accurate explanations of bonding and melting points.	• Basic comparison; some • inaccuracies in bonding or melting point analysis.	• Limited comparison; explanations are vague or partially incorrect.	• Inaccurate or missing analysis of compound properties.
• Explanation of Molecular Structure	• Detailed and accurate description of • silicon dioxide's structure, bonding, and industrial relevance.	• Clear explanation of structure and bonding with relevant industrial links.	• Basic description; some relevant points about structure and use.	• Limited understanding of molecular structure and industrial relevance.	• Incorrect or missing explanation of structure and application.
• Recommendations for Optimization	• Innovative, feasible, and well-justified recommendations based on chemical evidence.	• Practical and justified recommendations with some chemical reasoning.	• Basic recommendations; • justification is present but limited.	• Few recommendations; weak or unclear justification.	• No clear recommendations • or justification provided.
• Scientific Communication	• Report is exceptionally well organized, uses precise terminology, and includes diagrams or data effectively.	• Report is well structured, uses appropriate terminology, and includes some visuals.	• Report is organized; terminology is mostly correct; visuals may be limited.	• Report lacks clear structure; terminology is inconsistent; visuals are minimal.	• Report is disorganized; terminology is incorrect or missing; no visuals used.

ITEM 5

Bases of assessment	**Exceptional**	**Outstanding**	**Satisfactory**	**Basic**	**Elementary**
a) Solubility and Acidity Prediction	• Correctly explains • Moderate solubility • (H-bonding in phenol and amines vs hydrophobic aromatic ring) • Correctly explains weak acidity of phenol and amine basicity.	• Correctly explains • Moderate solubility • (H-bonding vs hydrophobic aromatic ring) OR • Correctly explains weak acidity of phenol and amine basicity.	• Partially explains • Moderate solubility • (H-bonding vs hydrophobic aromatic ring) • Partially explains weak • acidity of phenol and amine basicity.	• Partially explains • Moderate solubility • (H-bonding vs hydrophobic aromatic ring) OR • Partially explains weak acidity of phenol and amine basicity	• Incorrect or no response.
b) Synthetic Route	• Correct route from benzene to compound with correct reagents and conditions	• Correct route from benzene to compound without correct reagents and conditions	• Two relevant steps from benzene compound	• One relevant step from benzene to compound	• Incorrect steps and no reagents
c) Mechanism	• Correct mechanism with all steps (generation of nitronium ion, electrophilic attack and re-organisation)	• Mechanism with correct first step and electrophilic attack.	• Mechanism with only formation of the nitronium ion	• Mechanism only starting at the electrophilic attack	• No relevant route or mechanism.
d) Environmental Risk Mitigation	• Two risks and their mitigations clearly explained	• One risk identified and clearly explained	• Risks and mitigations identified with no clear explanation	• One risk or mitigation identified	• None or irrelevant.

ITEM 6

Basis of assessment	**Exceptional**	**Outstanding**	**Satisfactory**	**Basic**	**Elementary**
• Understanding of composition and properties (A–D)	• Correctly identifies all functional groups; • Clearly explains physical properties with correct chemical reasoning; • Notes likely triglycerides in waste.	• Correctly identifies main functional groups; • Gives plausible explanations of properties and environmental impact.	• Identifies most functional groups; • Explanations are partial or imprecise.	• Identifies only one or two functional groups correctly; • Limited or inaccurate property discussion.	• Fails to identify groups correctly • No meaningful discussion of properties or impact.
• Chemical knowledge and mechanisms (waste conversion routes)	• Provides clear step by-step mechanisms for conversions • Correct catalysts and conditions; discusses pros/cons and green options.	• Describes reactions qualitatively with conditions • Mentions environmental/waste aspects.	• Gives basic description s of reactions • Mechanisms incomplete or missing key details.	• Writes the equations • for reactions but fails to write correct mechanisms or reagents.	• Incomplete reaction • No correct mechanism or meaningful chemical detail.

• Synthetic route: C → D	• Proposes efficient stepwise route (1-propanol → propene → 2-propanol → acetone); • Gives reagents, • conditions, mechanisms; • Explains sustainability and alternatives.	• Correct overall route and reagents with some mechanistic justification. • Misses some conditions • No sustainability alternatives	• Proposes a route but with missing • steps • Some reagents • incorrect • No conditions	• Incomplete route incomplete or chemically implausible • Major errors in reagents/conditions.	• No realistic route or conditions proposed.
• Sustainable process design (waste A → useful product)	• Presents detailed, realistic process: pretreatment, catalyst choice, reaction conditions, separation, coproduct • valorization, recycling, effluent treatment; shows environmental/regulatory awareness.	• Proposes biodiesel/soap process with catalysts, separations, and sustainability considerations.	• Mentions biodiesel/soap but lacks • process detail or sustainability justification.	• Suggests single simple option without detail or sustainability.	• No useful or sustainable process proposed.

• Presentation, safety and feasibility	• Well structured report; • Equations balanced; • Safety hazards • identified with mitigation; • Realistic next steps	• Well structured presentation • Balanced Equations • Safety hazards noted • Most steps not feasible steps included.	• Adequate structure but lacks clarity in parts • Most Equations not balanced • Safety not addressed • No feasible steps.	• Poorly organized report • Safety/feasibility missing; • Unrealistic suggestions.	• Incomplete or incoherent report • No safety or feasibility suggestions • No equations

SET 2 – ASSESSMENT RUBRICS FOR SAMPLE ITEMS FOR CHEMISTRY

ITEM 1 assessment rubric (columns in requested order)

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
• Electrochemical reasoning	• Correctly computes both E° values (Zn– Cu = +1.10 V; • Li–Cu = +3.38 V) and clearly identifies anode/cathode and electron flow; links mixed chemistries to crossdischarge and parasitic cycling.	• Computes both E° correctly; minor omission in flow or cross discharge explanation.	• Computes one E° correctly and infers spontaneity; basic anode/cathode identification.	• Recognises spontaneity qualitatively but no correct calculation.	• Incorrect or absent • electrochemical explanation.

• Thermochemical and quantitative support	• Correctly calculates all: charge (3600 C), moles e^- (~0.037), Zn mass (~1.22 g), heating of fluid (11.7 kJ), and compares to neutralisation (≈0.20 mol) and Li combustion (≈0.14 g Li), tying each to overheating risk.	• As above but misses one of the comparisons or rounds roughly.	• Gets two of the following right: charge/e^-, Zn mass, or fluid heating; shows how heat could arise.	• One correct calculation with limited linkage to overheating.	• No correct/useful calculation.
• Fe–Ni electrochemistry and comparison	• Computes E cell (Ni–Fe) =+0.19 V and contrasts clearly with Zn–Cu and Li systems (voltage, energy density, failure modes).	• Computes E° and offers partial comparison (misses one contrast).	• Qualitative statement that Ni–Fe is lower voltage/safer without computation.	• Mentions Ni–Fe but with errors or no comparison.	• Incorrect or off-topic.
• Safety evaluation and practicality	• Balanced evaluation: aqueous electrolyte, abuse tolerance, hydrogen/alkali hazards; practical low tech mitigations (blocking diode, series resistor, thermal fuse, vented case, matched cells) and clear, contextaware recommendation.	• Solid pros/cons and a recommendation; misses one mitigation or context detail.	• General pros/cons; • recommendation present but thin on feasibility.	• One-sided or generic safety claim; weak feasibility.	• No evaluation or recommendation.

ITEM 2

Bases of assessment	**Exceptional**	**Outstanding**	**Satisfactory**	**Basic**	**Elementary**
a) Energy profile diagram for NH_3 formation	• Correct, clearly labelled diagram with reaction coordinate and potential energy axes; • Correct relative energy positions for reactants/products; • correct ΔH arrow (−92 kJ mol^{-1}); • E_a forward/reverse marked accurately; • catalyst curve shown with correct annotation; all industrial context notes included.	• Diagram correct with all main features; • minor omission in annotation (e.g., catalyst curve missing or Ea reverse not labelled).	• Diagram mostly correct but missing ≥2 key elements (e.g., ΔH label incorrect, • catalyst curve omitted, un labeled) .	• Diagram present but poorly drawn, missing most required labels, unclear energy relationships.	• No correct diagram provided or completely wrong representation.
b) Stoichiometry: moles NH_3 and HNO_3, volume of 2.0M HNO_3	• All molar mass, mole, and volume calculations correct; • Correct stoichiometric reasoning;	• All correct except minor unit slip or omission of one step in reasoning.	• Partial correctness: at least one of molar mass, mole, or volume calculation correct, but other parts	• Attempt made but all values incorrect due to major stoichiometric misunderstanding.	• No relevant calculation or reasoning.

	• Accurate final answers: NH_3 = 12500 mol, HNO_3 = 12 500 mol, volume HNO_3 = 6250 L; • all units and working shown.		• have major arithmetic/ conceptual errors.		
c) Equilibrium concentrations (Kc calculation)	• Correct quadratic • Correct solution for x (0.135M); • final equilibrium concentrations: $[N_2]$ = 0.365 M, $[H_2]$ = 1.095 M, $[NH_3]$ = 0.270 M; • correct substitution in K_c expression; units omitted correctly as K_c is dimensionless.	• Correct setup and substitution; small arithmetic error but logic sound.	• ICE table partially correct but wrong Kc substitution or algebraic steps; equilibrium concentrations incorrect.	• Attempted but major misunderstanding of equilibrium concept; values unreasonable	• No attempt or completely irrelevant answer.
d) Process optimisation recommendations	• 6 well explained, scientifically valid strategies	• 4 valid strategies, mostly explained and linked to	• ≥2 valid strategies, some link to chemical principles	• 1 valid idea with minimal or no explanation of principle.	• No valid or relevant suggestions.

	• covering temperature /pressure compromise • , catalyst use, recycling gases, continuous product removal, heat integration, safety consideratio ns, and feed ratio control; • Correct link to the Le Chatelier's principle and kinetics; clear industrial feasibility noted.	• relevant chemical principles.	• but with weak explanation.		

ITEM 3

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
• Use of provided data (EN and BDE) and accuracy	• Correctly cites numerical electronegativities and bond energies; ranks F > Cl > Br > I (EN) and Cl–Cl >Br–Br > F–F > I–I (BDE); no errors.	• Gives correct trends with at least two correct numbers; minor rounding/ omission.	• States correct trends qualitatively; little or no numbers.	• Partly correct/ ambiguous trends; some inaccuracies.	• Trends mostly wrong or missing.

• Trend → chemical behaviour	• Clearly links EN/BDE to oxidizing power, bond stability, and reactivity; notes F–F anomaly; explains consequences for • organohalide formation/ breakdown.	• Solid linkage of trends to reactivity; • minor gaps (e.g., omits F–F anomaly).	• General cause–effect statements with limited depth.	• Vague or partly incorrect causal links.	• No meaningful connection to behavior.
• Environment al impact reasoning	• Differentiates likely persistence/toxicity/ DBPs across Cl/Br/I; ties mechanisms to trends (e.g., brominated DBPs, iodine– thyroid).	• Addresses at least two impacts with sound reasoning.	• Lists common • impacts with linkage to trends.	• Mentions impacts but speculative or off-target.	• Off-topic or incorrect.
• Water treatment risk evaluation	• Evaluates HOCl/OCl^- use with pH control and DBP trade-offs; explains when to avoid bromine (high bromide sources); rejects chlorate/perc hlorate for routine disinfection; • notes viable DBP controls (GAC/filtration, chloramination, UV).	• Strong evaluation with one minor omission (e.g., pH or DBP control detail).	• Basic pros/cons of chlorine vs bromine; generic DBP mention.	• One-sided or superficial evaluation; limited treatment context.	• Incorrect or absent evaluation.

Safer alternatives and feasibility	• Gives actionable recommendations: • optimized (dose/pH), pretreatment/ activated carbon, chloramination or UV where feasible; • prioritizes iodine for medical use; avoids bromine for drinking water; • addresses local practicality (cost, availability, operator skill).	• Clear, practical Recommendations feasibility discussed briefly.	• Reasonable alternatives named; • limited practicality discussion.	• Generic suggestions; • little regard for constraints.	• No clear • recommendations or unsafe advice.

ITEM 4

Basis of assessment	**Exceptional**	**Outstanding**	**Satisfactory**	**Basic**	**Elementary**
• Geochemical analysis of bedrock elements	• Accurately explains mineral hosts, weathering rates (carbonates vs silicates), pH/redox controls, and links to hardness, alkalinity, Fe/Mn release; • integrates sorption/ complexation.	• Same as Exceptional with minor omissions or less detail on one control (e.g., complexation)	• Correct overview of weathering and at least two controls (pH or redox) tied to water quality.	• General statements about "dissolving minerals" with weak links to outcomes.	• Off-topic or largely incorrect.
• Trace element behaviour	• Correctly explains the chemical forms and how easily they move for all two: F^-, Ra^{2+}. Clearly states when each moves or stays put	• Correctly explains the chemical forms and how easily they move for only one of F^-or Ra^{2+}. Clearly states when it moves or stays put.	• Correctly explains the chemical forms and how easily they move for only one of F^- or Ra^{2+}. No explanation of movement.	• Only mentions the chemical forms without any explanation.	• None treated correctly.

• Radioisotope health risk	• Clearly identifies Rn-222, Describes risk rationale; • Explains water contamination risk.	• Clearly identifies Rn-222, Describes risk rationale; • Mention water contamination risk.	• Clearly identifies • Rn-222, Describes risk rationale; • No reference to water contamination risk.	• Identifies Rn-222 as radioactive. • No linkage to health	• Incorrect risk characterization.
• Mitigation strategies	• Provides practical, prioritized actions (sealing, ventilation, aeration; • appropriate tech for Ra/U) and notes maintenance/ disposal considerations • matches method to pathway.	• Strong, practical set with small feasibility gaps (e.g., omits maintenance)	• Reasonable methods named; • some mismatch or missing prioritization.	• Generic advice (e.g., "filter more") with little specificity.	• Unsafe or infeasible suggestions.

ITEM 5

Bases of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
• Solubility and Acidity Prediction	• Correctly Moderate solubility (Hbonding in phenol and amines vs hydrophobic aromatic ring) • Correctly explains weak acidity of phenol and amine basicity.	• Correctly Moderate solubility (Hbonding vs hydrophobic aromatic ring) OR • Correctly explains weak acidity of phenol and amine basicity.	• Partially Moderate solubility (Hbonding vs hydrophobic aromatic ring) • Partially explains weak acidity of phenol and amine basicity.	• Partially explains Moderate solubility (H-bonding vs hydrophobic aromatic ring) OR • Partially explains weak acidity of phenol and amine basicity	• Incorrect or no response.
• Synthetic Route	• Correct route from benzene to compound with correct reagents and conditions	• Correct route from benzene to compound without correct reagents and conditions	• Two relevant steps from benzene to compound	• One relevant step from benzene to compound	• Incorrect steps and no reagents

• c) Mechanism	• Correct mechanism • with all steps (generation of nitronium ion, electrophilic attack and reorganisation)	• Mechanism with correct first step and electrophilic attack.	• Mechanism with only formation of the nitronium ion	• Mechanism • only starting at the electrophilic attack	• No relevant route or mechanism.
• Environmental Risk Mitigation	• Two risks and their mitigations clearly explained	• One risk identified and clearly explained	• Risks and mitigations identified with no clear explanation	• One risk or mitigation identified	• None or irrelevant.

ITEM 6

Bases of assessment	**Exceptional**	**Proficient**	**Satisfactory**	**Basic**	**Elementary**
• Structure and Functional Groups – Relating Structure to Solubility	• Provides accurate, complete structural descriptions for ethanoic acid and vanillin • Correctly identifies all functional groups • Explains solubility using hydrogen bonding, polarity, molecular size, and	• Provides accurate, complete structural • descriptions for ethanoic acid and vanillin • Identifies most functional groups correctly • Explains solubility mainly through polarity and hydrogen bonding, with minor gaps in relating aromatic hydrophobicity or molecular size.	• Provides structural descriptions for one functional group • Explains solubility partially, focusing mainly on polarity without deeper discussion of hydrogen bonding or non-polar regions.	• Gives incomplete structural identification • Confuses some functional groups • Solubility explanation lacks scientific detail.	• Incorrect or missing functional group identification • Incorrect scientific reasoning for solubility.

	aromatic hydrophobicity • Clearly relates structure and property.				
• Conversion of Ethanol to Amines	• Proposes feasible synthetic route • Clearly indicates reagents • Includes conditions for the reaction stages	• Proposes feasible synthetic route • Clearly indicates reagents • Some • conditions not correct	• Proposes feasible synthetic route • Clearly indicates reagents • Wrong • conditions.	• Gives a vague or impractical route • minimal or incorrect reaction details.	• No relevant process for ethanol to amine conversion provided.
• Esterification of Ethanoic Acid and Ethanol	• Correctly writes reaction equation • Correct mechanism with clear steps (protonation nucleophilic attack, elimination, deprotonation)	• Correctly writes reaction equation • Correct mechanism with at least one incorrect or missing	• Correct reaction • Description of • mechanism misses at least two stages	• • Correct equation • Wrong mechanism	• Incorrect esterification reaction presented.

• Application of Esters and Amines in Fragrance /Cosmetics	• Provides correct roles with pros and cons, and connection to product performance • Links chemistry to sustainability and safety.	• Provides correct roles with pros and cons • Partial linkage of sustainability and performance factors.	• Gives one or two valid uses partially addresses advantages/l imitation • Partial links to chemistry to sustainability and safety	• Provides uses with little or no supporting explanation • No linkage to chemical properties.	• No valid roles or applications given.

PRACTICAL ASSESSMENT ITEMS

Chemistry Paper 2 (Practical Paper)

Duration: 3 hours:15min.

Instruction to Candidates:

The paper consists of two ITEMS. Attempt both questions.

ITEM 1

In an industrial town, a number of small-scale factories near a river have been reported to discharge wastewater containing various chemicals, including hydrochloric acid, into nearby drainage channels. Recently, environmental supervisory body observed milky cloudiness and poor visibility in parts of the river, believed to be due to chemical reactions.

The supervisory body suspects that the cloudiness could be a result of a reaction between sodium thiosulphate ($Na_2S_2O_3$), commonly used in some textile industries and hydrochloric acid (HCl). The reaction produces elemental sulphur, which appears as a white precipitate and causes turbidity. To understand how this reaction contributes to pollution, it is important to study how varying concentrations of sodium thiosulphate affect the rate of reaction, and thus, the extent of pollution. You have been contacted to give recommendations based on your investigations.

You are provided with the following reagents:

- FA1 which is0.1M Sodium thiosulphate solution
- FA2 which is 2M hydrochloric acid
- Distilled water
- A variety of laboratory apparatus and materials

Task

Design an experiment to determine the order of reaction with respect to the concentration of sodium thiosulphate in the reaction and write a report of your findings.

ITEM 2

In a certain town, community members have raised concerns about a recent increase in stomach-related illnesses. Investigations by local health authorities linked the issue to the improper handling and storage of water treatment chemicals. A water committee member handed over a solid sample suspected to be part of the treatment residue contaminating drinking water sources.

Your chemistry teacher has brought the sample labelled W from the treatment plant suspected to contain two cations and one anion. You are tasked to systematically investigate and identify the ions present using the reagents provided.

Task:

Design and carry out a systematic investigation to solve the problem and write a report of your findings

PRACTICAL SET 2

Chemistry Paper 2 (Practical Paper)

Duration: 3 hours:15min.

Instruction to Candidates:

The paper consists of two ITEMS. Attempt both questions.

ITEM 1

Your school clinic has bought a batch of "Fe(II) supplement" tablets labelled 65 mg elemental Fe per tablet. Before recommending them to students with iron deficiency, the nurse asks you to verify the label claim.

Design and carry out an investigation in which you verify the actual Fe^{2+} content per tablet so as to advise the school nurse accordingly. Your design should include; (aim, hypothesis, variables), apparatus and materials, procedure, risks and their mitigations)

Task:

Write an advisory report to the nurse that clearly states your decision and evidence.

ITEM 2

A consignment of fortified flour has been imported into the country, and there are concerns that one of its additives, labelled X, may not meet the required food safety standards. Before the product can be approved for distribution, it must be analysed to confirm whether it is suitable for human consumption. One of the required tests is to identify the functional group in the active ingredient in X.

Your school has been contacted to participate in the analysis. As a member of the group selected by your school in this activity, you are required to design and carry out a systematic investigation so as to determine the functional group present in substance X**.**

Task:

Design and carry out a systematic investigation to solve the problem and write a report of your findings

CHEMISTRY PRACTICAL ASSESSMENT RUBRIC

ITEM 1: ASSESSMENT RUBRIC

Basis of Assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
Aim, Variables and Hypothesis	• Aim is precise, linked to theory; • correctly Variables • Hypothesis is testable	• Aim is precise, linked to theory; • Identifies all variables with minor gaps • Hypothesis is testable with sound rationale and qualitative prediction.	• General aim understandable but broad; • Incomplete identification of variables • hypothesis is plausible but generic with limited rationale.	• Vague/ambiguous aim with important elements missing; • Partial or misclassified variables with controls largely unspecified; • hypothesis vague.	• Aim incorrect/irrelevant/ missing; • variables not identified or incorrect; • hypothesis missing or scientifically invalid.
Materials and Reagents	• Complete, accurate list with correct spelling and relevance to all planned tests; no unnecessary items.	• Mostly complete list; minor omissions or small inaccuracies.	• List contains most essential items but with notable omissions.	• List incomplete or inaccurate (important reagents missing).	• Very minimal or irrelevant list of materials.
Methodology	• Detailed, logical sequence of tests; • Steps clear, replicable, and systematic; • Safety/accuracy.	• Detailed, logical sequence of tests; • Steps clear, replicable, and systematic • Safety/accuracy not catered for.	• Detailed, logical sequence of tests; • Steps provided but some incomplete, disorganize d, or lacking clarity. • Safety/accuracy not catered for.	• No logical sequence of tests; • Steps provided but some incomplete, disorganize d, or lacking clarity. • No safety/accuracy catered for.	• Method absent or incoherent. • No safety/ accuracy catered for.

Risks and Mitigations	• Identifies chemical/ physical/ biological hazards; cites GHS where relevant; specifies PPE, controls, spill/first aid and disposal steps compliant with policy.	• Major hazards and PPE listed; reasonable mitigations; minor gaps.	• Basic hazards acknowledged ; generic PPE; limited mitigation detail.	• Few hazards noted; mitigations insufficient or inappropriate.	• Hazards not addressed; unsafe practice evident.
Presentation of Data	• Tables/graphs are well formatted • with titles, labels, units, correct significant figures; appropriate graph type; error bars/uncertain ty shown where relevant.	• Mostly correct formatting; minor unit/significant figues; graph type appropriate.	• Basic table/graph with titles/units; no error representation; formatting inconsistent.	• Disorganized layout; missing labels/units; inappropriate or confusing display.	• Data not presented or unreadable.
Data Analysis and Interpretation	• Correct calculations; shows working; includes uncertainty/percentage yield/error; accounts for anomalies with theoretical reasoning; interprets against hypothesis.	• Calculations correct; basic error/percentages; sound interpretation; minor slips.	• Essential calculations done; limited error treatment; interpretation reasonable but superficial.	• Calculation errors and/or misinterpretation; ignores anomalies; weak linkage to theory.	• No analysis or fundamentally incorrect.
Conclusion and Recommendation	• Conclusion directly supported by data; addresses hypothesis; acknowledges limitations; gives feasible improvements and real-world applications/implications.	• Supported conclusion; notes some limitations; offers sensible improvements	• States conclusion; loosely tied to data; generic improvement notes.	• Weak or contradicted by data; no limitations or next steps.	• Missing, incorrect, or copy pasted conclusion.

ITEM 2 ASSESSMENT RUBRIC

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
Research focus (Aim, Hypothesis and Variables)	• Aim is precise, hypothesis is clearly linked and justified, and variables • (independent, dependent, controlled) are clearly identified and relevant.	• Aim and hypothesis clearly stated; variables mostly • identified and relevant.	• Aim and hypothesis present but somewhat vague; variables • incomplete or • partly relevant.	• Aim or hypothesis weakly stated; variables mostly • missing or unclear.	• Aim, hypothesis, and variables absent or incorrect.
Materials and Reagents	• Complete, accurate list with correct spelling and relevance to all planned tests; no unnecessary items.	• Mostly complete list; minor omissions or small inaccuracies.	• List contains most essential items but with notable omissions.	• List incomplete or inaccurate (important reagents missing).	• Very minimal • or irrelevant list of materials.
Methodology	• Detailed, logical sequence of tests; Steps clear, replicable, and systematic; Safety/accuracy.	• Detailed, logical sequence of tests; • Steps clear, replicable, and systematic • Safety/accuracy not catered for.	• Detailed, logical • sequence • of tests; • Steps provided but some incomplete, • disorganize d, or lacking clarity. • Safety/accuracy not catered for.	• No logical sequence • of tests; • Steps provided but some incomplete, • disorganize d, or lacking clarity. • No safety/accuracy catered for.	• Method absent or incoherent. • No safety/ accuracy catered for.

Observations	• All • observations recorded accurately with correct detail (colour, precipitate, odour, changes); systematic and well presented.	• Most observations correct; a few details missing but overall accurate.	• Observations recorded but some inaccuracies or incomplete details.	• Observations vague, partially incorrect, or not systematic.	• Observations largely missing, incorrect, or inconsistent.
Deductions	• Logical deductions for each test, clearly linked to observations and consistent with science process skills.	• Most deductions correct and linked to observations; only minor errors.	• Some correct deductions but with noticeable errors or gaps.	• Deductions mostly inaccurate or poorly linked to observations.	• Deductions missing or completely incorrect.
Conclusion/Comment	• Conclusion integrates all evidence, and reflects on hypothesis validity.	• Conclusion correct and consistent with most evidence; minor omissions.	• Conclusion • partially correct	• Conclusion vague or inconsistent with evidence.	• Conclusion missing or contradicts data.

PRACTICAL PAPER ASSEMENT RUBRICS – SET 2

ITEM 1: ASSESSMENT RUBRIC

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
Aim, Hypothesis and Variables	• Measurable aim; Justified ± tolerance; • Hypothesis tied to method capability; • Variables well identified.	• Measurable aim; Justified ± tolerance; • Hypothesis tied to method capability; • Variables not well identified.	• Measurable aim; • Tolerance not justified; • Hypothesis tied to method capability; • Variables not well identified.	• Aim measurable • Hypothesis vague; • Controls incomplete /incorrect.	• Missing/incorrect aim– hypothesis • variables confused.
Apparatus and Materials	• Complete, list of • correct materials • Correct specifications and quantities	• Complete, list of • correct materials • Most specifications and quantities correct	• Adequate, list of correct materials • No specifications and quantities	• List lacks Important items • No specifications • Questionable suitability.	• Inappropriate items/incomplete list; • unsafe or unworkable.
Investigation Design and Procedure	• Correct plan for standardisation + tablet; • Correct acid choice; • Endpoint defined.	• Correct plan with minor omissions; • Correct acid choice; • Endpoint defined.	• Correct plan with minor omissions; • Wrong acid choice; • Endpoint defined.	• Correct plan with major omissions; • Wrong acid choice; • Endpoint not clearly defined.	• Unusable plan; • major chemical errors.
Risks and Mitigations	• Specific hazards mapped to workable controls (PPE, acid → water, spill/waste) ; lab appropriate and feasible.	• • Appropriate hazards and mitigations listed.	• Generic hazards; some • mitigations vague;	• Incomplete hazards; weak/irrelevant mitigations	• Little/no safety consideration.

Data collection and Presentation	• All raw readings • (initial/final burette) with units and sig • figs; ≥3 • concordant • titres; • Anomalies noted; clear tables and concise summary (mean ± SD).	• Most raw readings • (initial/final burette) with units and sig • figs; ≥ 2 • concordant • titres; • Some anomalies noted; clear tables and • concise summary (mean ± SD).	• Adequate records; • some inconsisten cies; basic tables/sum mary.	• Sparse/inco nsistent records; • poor formatting; missing units/summ ary.	• Disorganis ed or absent data; • unreadable tables.
Calculations, Stoichiometry and Accuracy	• Correct equation; 5:1 ratio applied; ($KMnO_4$) and mg Fe/tablet computed with tidy units and working; rounding sensible.	• • Correct overall; minor slips; units mostly clear.	• • Mostly correct; a few logic/roundi ng issues.	• Multiple errors in • ratios/units; working unclear.	• • Incorrect or absent calculation s.
Conclusion and Recommendation to Nurse	• Clear recommen • dation tied to numbers • vs acceptanc e range; accessible • language • for a • clinician; pragmatic next steps.	• • Decision supported by data; mostly accessible.	• • Conclusion broadly aligned to data; terse.	• • Weak/uncle ar link to data; audience not considered.	• No conclusion or contradicts data.

ITEM 2: ASSESSMENT RUBRIC

Basis of assessment	Exceptional	Outstanding	Satisfactory	Basic	Elementary
Research focus (Aim, Hypothesis and Variables)	• Aim is precise, hypothesis is clearly linked and justified, and variables (independent , dependent, controlled) are clearly identified and relevant.	• Aim and hypothesis clearly stated; variables mostly identified and relevant.	• Aim and hypothesis present but somewhat vague; variables incomplete or • partly relevant.	• Aim or hypothesis weakly stated; variables mostly missing or unclear.	• Aim, hypothesis, and variables absent or incorrect.
Materials and Reagents	• Complete, accurate list with correct spelling and relevance to all planned tests; no unnecessary items.	• Mostly complete list; minor omissions or small inaccuracies.	• List contains most essential items but with notable omissions.	• List incomplete or inaccurate (important reagents missing).	• Very minimal or irrelevant list of materials.
Methodology	• Detailed, logical sequence of tests; Steps clear, replicable, and systematic; • Safety/accuracy.	• Detailed, logical sequence of tests; • Steps clear, replicable, and systemmatic • Safety/accuracy not catered for.	• Detailed, logical sequence of tests; • Steps provided but some incomplete, disorganize d, or lacking clarity. • Safety/accuracy not catered for.	• No logical sequence of tests; • Steps provided but some incomplete, disorganize d, or lacking clarity. • No safety/accuracy catered for.	• Method absent or incoherent. • No safety/accuracy catered for.

Observations	• All observations recorded accurately with correct detail (colour, precipitate, odour, changes); systematic and well presented.	• Most observations correct; a few details missing but overall accurate.	• Observations recorded but some innaccuracies or incomplete details.	• observations vague, partially incorrect, or not systematic.	• Observations largely missing, incorrect, or inconsistent.
Deductions	• Logical deductions for each test, clearly linked to observations and consistent with science process skills.	• Most deductions correct and linked to observations; only minor errors.	• Some correct deductions but with noticeable errors or gaps.	• Deductions mostly inaccurate or poorly linked to observations.	• Deductions missing or completely incorrect.
Conclusion/Comment	• Conclusion integrates all evidence, and reflects on hypothesis validity.	• Conclusion correct and consistent with most evidence; minor omissions.	• Conclusion partially correct	• Conclusion vague or inconsistent with evidence.	• Conclusion missing or contradicts data.

CHEMISTRY SUBJECT GRADING

Chemistry learning outcomes and competencies have been amalgamated to form the three constructs aligned to Assessment Objectives:

AO1: (Atomic Structure, Bonding, Periodicity)

AO2: (Organic Chemistry)

AO3: (Physical and Chemical Principles)

The candidates' overall performance per construct will be identified and recognised using five letter grades from A to E in a descending order and are meant to differentiate achievement levels as follows;

GRADE	(AO1: Atomic Structure, Bonding, Periodicity)	(AO2: Organic Chemistry)	(AO3: Physical & Chemical Principles)
A	Clearly explains atomic structure, bonding, and periodic trends, accurately predicts reactivity using strong reasoning, and confidently applies this knowledge to new and unfamiliar problems.	Accurately interprets organic structures, correctly predicts reactions and mechanisms, and independently applies organic chemistry to real-life situations.	Accurately solves complex calculations and equilibrium problems, confidently predicts system changes, and effectively interprets graphs, models, and data.
B	Gives clear explanations of bonding and periodic trends, predicts reactivity accurately in most cases, and applies knowledge effectively in familiar situations.	Understands most reactions and mechanisms, predicts outcomes with few errors, and applies these ideas to familiar real world situations.	Handles most calculations correctly, predicts system behaviour accurately under standard conditions, and interprets data and models with some support.

C	Shows a good basic understanding of atomic structure and periodicity, correctly predicts simple trends, but needs support with unusual or complex patterns.	Understands basic organic structures and reactions, predicts simple outcomes fairly well, and can apply ideas to straightforward examples with guidance.	solves routine calculations and predicts the behaviour of simple systems accurately, but still require guidance when working with graphs or multi-step problems.
D	Shows limited understanding of bonding and periodic trends, can recall facts but struggles to apply them, and often gives incomplete or incorrect predictions.	Recognizes basic organic reactions but struggle to explain them, often make unclear or incorrect predictions, and require support to apply their knowledge.	Solves only simple calculations but often with errors, struggles to predict how systems behave, and finds it difficult to interpret models or data.
E	Shows very little understanding of atomic structure or periodicity, frequently misinterprets trends and reactivity, and requires significant teacher support.	Struggles to understand organic structures and reactions, is unable to reliably predict outcomes, and requires step-by-step guidance.	Makes frequent errors in calculations and predictions, is unable to model or interpret chemical systems, and requires continuous support.