S.6 CHEMISTRY SCENARIO COLLECTIONS EDITION 2026

NOTE; Thanks very much for trusting Ngambo Wilson's resources from the start to the end, kindly be informed that this set of chemistry collections is a NEWLY compiled edition which is in line with the new adopted Advanced level curriculum Assessment strategies. I hope it's of great help to you as it comes into your hands.

VERY IMPORTANT:

1. STRUCTURE OF UACE CHEMISTRY THEORY PAPER 1

- ✓ Paper 1(Theory paper)
- ✓ 2 sections A and B
- ✓ Section A(2 compulsory items)
- ✓ Item 1 from assessment area 3
- ✓ Item 2 from assessment area 4
- ✓ Section B(2 Parts I and ii)
- ✓ Each part has 2 items (answer only one item from each part)
- ✓ Part I from assessment area 1
- ✓ Part ii from assessment area 2

2. ELEMENTS OF CONSTRUCT, ASSESSMENT AREAS AND RELATED TOPICS

Element of construct	Assessment area	Related topics
Foundations of atomic structure, bonding and periodicity of elements	**A01**- demonstrate understanding of atomic and molecular structures, periodic trends and patterns of chemical reactivity across the periodic table	1. Atomic & electronic structure 2. Bonding & structure 3. Periodicity 1 & II
Structure, reactivity and applications of organic molecules	**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 innovate chemical contexts	1. Organic chemistry 1, II, & III
Stoichiometry, thermochemistry and reaction kinetics	**AO3-** Apply quantitative chemical principles to analyse, model and predict the amounts of substances , energy changes and reaction rates in chemical systems under varying conditions	1. Moles & Equations 2. Thermochemistry 3. Reaction kinetics
Chemical equilibria and electro chemical systems	**AO4**- Apply principles of chemical and physical equilibria and electrochemistry to interpret, predict and evaluate the behaviour of chemical systems in industrial and real-world contexts.	1. Equilibria 1 & II 2. Electrochemistry

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

1. Ngambo, an oil pipeline engineer made a mistake while attempting to locate a leak on an oil pipeline. He accidentally added 78g of radioactive substance at a pumping station. This set off alarms indicating the levels of radioactivity in the oil were very dangerous. The pipe had to be shut down. The facility and the nearby community was vacated due to the dangerously high levels of radiation.

The environmental authorities then set up meters that measured the levels of radioactivity in the area.

They got the data below:

Time (days)	0	10	20	30	40	50
Activity (counts per second)	21	8.9	3.8	1.6	0.7	0.3

The government is claiming that the area will be safe again if the amount of the radioactive substance in the oil reduces to 5% and that this will happen in two weeks.

Task; As a student of Chemistry and showing clear working, using the information provided, respond to the claims of the government. (***Use the graph paper)***

2. Your class has been invited by a chemical plant management near late 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 analyse periodic trends of the elements, compounds 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)**	**I.E(KJmol^{-1})**	**Melting point(^{o}C)**	**Oxide melting point(^{0}C)**
Sodium(Na)	11	186	496	98	1275
Magnesium(Mg)	12	160	738	650	2800
Aluminum (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/ sublime
Chlorine(Cl)	17	99	1251	-101	Gas / gas

Task; As a chemistry student, write a report about the periodic trends of the elements and their oxides, and recommend improvements to the plant's production process.

3. In an effort to promote the production of cleaner and more efficient fuels, EcoFuel Ltd, a chemical company, has been converting long-chain alcohols into hydrocarbons through dehydration reactions. During laboratory analysis, one of the gaseous hydrocarbons Q was found to contain 14.3% hydrogen by mass. When its vapour density was determined, it was found to be 28. Before scaling up the process, the company's research department seeks to understand the composition, structure, and potential applications of this compound. They have contacted you, a chemistry student, to help in the investigation.

Task.; As a chemistry learner;

Help the company's research department to;

a) Know the molecular formula of the compound and enlighten them about the structural formulae and IUPAC names of all possible isomers of compound Q.
b) Identify the homologous series to which the compound belongs, giving a reason for your response.
c) The company also wishes to produce but-2-yne for making polymers and 2-methylpropan- 2-ol for fuel use, each from the best isomer of Q. Advise the manager on how this can be achieved (In your advice, describe the reaction process giving appropriate reaction conditions required, equation(s) and mechanisms for the reaction(s) involved in formation of each compound from its suitable isomer of Q).
d) In a bid to manufacture a good fuel additive, the company research team reacted one isomer of Q in a (i) above with hydrogen gas in presence of a suitable catalyst. Compound W with molecular formula of C_4H_{10} was formed. Further analysis of W, revealed it existed in two different isomeric forms but the company would like to use the isomer with lower boiling point in order to optimize combustion frequency. Advise the company on the most suitable isomer to be used and justify your choice.

4. Uganda Agro-Fertilizer Company Ltd, situated near Jinja Industrial Area, synthesizes ammonia for fertilizer manufacture using the Haber process, as expressed in the equation;

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) + \text{Heat}$$

Due to recent decline in ammonia yield, a diagnostic experiment was performed. It involved the introduction of 4.0 moles of nitrogen and 12.0 moles of hydrogen into a 2.0 litre sealed vessel at high temperature of 400^0C and experiment left for some time. At equilibrium, analysis revealed that 20 % of the nitrogen had reacted. Later, the production engineers attempted to improve yield by raising the temperature further, reducing pressure, and removing the iron catalyst. Surprisingly, ammonia production dropped even more. Management now seeks your expert chemical analysis and advice.

Task; As a chemistry learner;

a) Explain the characteristics of the chemical equilibrium established during the production process.
b) Help the management to know the equilibrium constant for the reaction.
c) Using Le Chatelier's Principle, explain to the production engineers why ammonia yield deviated from their expectations due to their alteration in temperature, pressure and catalyst for the reaction.
d) Suggest three practical ways the company can improve ammonia yield economically.
e) During the third trial to improve ammonia production, the initial amount of nitrogen was increased by 12%, keeping other conditions unchanged. Help the company determine the mass of ammonia at the new equilibrium formed.

5. A product development team at a small chemical factory in Mukono district, Uganda, is designing new low-cost polyethene packaging films for local farmers to replace expensive imported plastics. They have isolated a gaseous hydrocarbon Q from a petroleum C-4 fraction supplied by the oil refinery in Kenya. Combustion analysis shows that when 40 cm^3 of Q are exploded with 300 cm^3 of excess oxygen, and the mixture allowed to cool back to room temperature, a reduction in volume of 120 cm^3 occurs; a further reduction in volume of 160 cm^3 occurs when the mixture is then shaken several times with a concentrated potassium hydroxide solution. Further analysis of the fraction resulted in the isolation of three compounds of the same molecular formula but had different boiling

point temperatures . The product development team needs to understand this, before they can work. The team plans to convert Q into ethene as the monomer for polyethene production, and have been advised that for the process to work, Q must give a single product in an ozonolysis followed by

reduction reaction. So they must first confirm its identity, understand why several compounds share the same molecular formula yet behave differently, and select the safest conversion route that avoids toxic by-products and supports sustainable local manufacturing.

Task; As a chemistry student invited to the factory product-development meeting, write a concise technical report you would present to the team.

6. A local pharmaceutical company is developing a new cough syrup. During quality control, several organic compounds are detected as possible impurities. As part of your internship with the quality assurance team, you are asked to identify and name these compounds using IUPAC nomenclature.

You are provided with the following molecular structures (or condensed formulas), and your task is to ensure they are correctly identified and named according to IUPAC rules to avoid any dangerous mix-ups during drug formulation.

List of Detected Compounds (in condensed form):

$CH_3CH_2CH(CH_3)CH_2CH_3$

CH_3CH_2COOH

$CH_3CH_2CH_2OH$

$CH_3COCH_2CH_3$

$ClCH_2CH_2CH_3$

Task

a) Identify and name each compound using IUPAC rules.
b) Which functional groups are present, and how do they affect naming and numbering?
c) One of the detected compounds has similar structure to a known narcotic. How would you use structural information and IUPAC naming to distinguish between a harmless and a harmful compound in a lab report?

7. A company specializing in manufacturing aviation fuel additives is researching a new compound with a molecular formula C_5H_{12} suitable for improving fuel efficiency. After conducting further studies, they discovered that the compound exists in different isomeric forms, all having similar chemical properties but differing in physical characteristics.

Since the ideal fuel additive should have the lowest boiling point to optimize combustion efficiency, the company seeks expert advice on which isomer would be most suitable for their formulation.

Task: Write a message:

a) Enlightening the company on the different isomers and any similar chemical properties they exhibit.
b) Advising and explaining which isomer would be best suited for their fuel additive formulation.

8. A report from Kabong Chemical Works (U) Ltd revealed that the company is improving its sulphuric acid production process, an essential raw material used in fertilizers and lead acid batteries.

In one of the experiments, the company's chemists reacted 0.425 moles of sulphur dioxide with 0.294 moles of oxygen gas in a 1.60 dm³ sealed vessel. The gases were heated in the presence of a catalyst, and equilibrium was established according to the reversible reaction:

Equation 1: $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3$

After analysis, it was discovered that 52% of the oxygen gas had reacted this made the management curious how operating conditions influence both the position of equilibrium and rate of attainment of equilibrium in the process, and environmental effects of emissions.

Sulphur trioxide, is always converted to sulphuric acid, the plant's key product. For quality control, 25 cm³ of 0.05 M sulphuric acid was diluted with 750 cm³ of pure water, and the resulting solution was tested for acidity. To confirm whether the product meets safety and concentration standards, the manager must know the pH of diluted acid sample.

The acid is used to produce lead(II) sulphate used in battery plates. The company's environmental unit reported that only 0.035g/dm³ of it dissolves water at 17 °C, and the manager sought to know its solubility product, so as to predict the effects of waste discharge on nearby water sources. Concerned about these findings, the Plant Manager has invited you.

Task; As a learner of Chemistry, help the company to know;

a) The equilibrium constant for the gaseous reaction (Kc).
b) Explain effect on the position of equilibrium, the value of Kc, and the rate of attainment of equilibrium by:
   (i) adding more Sulphurdioxide gas.
   (ii) introducing a catalyst.
   (iii) increasing temperature.
   (iv) increasing pressure.
c) Calculate the pH of the solution obtained.
d) Determine the solubility product of lead(II) sulphate.
e) Environmental impacts of the gaseous or aqueous equilibria and their mitigations.

9. AgroTech Minerals Ltd. has developed a new inorganic fertilizer labeled X in Hydrated Form. Laboratory analysis shows that the solid contains 9.37% magnesium, 10.93%nitrogen, and 42.18% water of crystallization and rest being oxygen. Molar mass of X is 256g. 5.0 kg of the fertilizer was available for sale, the manager sought to know the amount in mass of nitrate nutrient in X that would be delivered to maize. Keen to know about environmental hazards, X was burnt in absence of air and decomposed with brown gas of nitrogen dioxide according to equation:

Equation 1: $2\ Mg(NO_3)_2(s) \rightarrow 2\ M(s) + 4\ NO_2(g) + O_2(g)$

The company sought to know the volume at s.t.p of the brown gas produced from burning 1.0 kg of the fertilizer and assess the environmental impacts of the emissions and mitigations.

Due to available rocks containing magnesium in the area, the company manager further seeks to evaluate the industrial synthesis of the fertilizer X from magnesium oxide:

Equation 2: $Mg\ (s) + 2\ HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l).$

The supplier reported that he would potentially supply 10.0 kg of magnesium oxide per day,and the manager intends to know how much fertilizer would be available in one month and also possible environmental impacts of using the fertilizer and mitigations.

Task ; As a learner of Chemistry, help the company to know;

(a)The molecular formula of compound X

(b) Mass of nitrate nutrient in X that would be delivered to maize.

(c) (i)The volume at s.t.p of the brown gas produced from burning the fertilizer.

(ii) The environmental impact of the brown gas emissions and mitigation.

(d) (i)Mass of the fertilizer produced in one month.

(ii) Possible environmental impact of using the fertilizer and their mitigations

10. An aluminium smelting company in Jinja uses a substance called aluminium fluoride as aflux to lower the melting point of cryolite during aluminium extraction. However, the production unit is facing high energy costs, and the environmental team reportschallenges in dissolving waste AlF_3 residues before disposal. The research chemist istasked to analyse the thermochemical feasibility of both forming and dissolving AlF_3 using available thermodynamic data to determine whether these processes are spontaneous or energy-intensive.

Across a certain article the following data was discovered by the researcher:

Standard enthalpy of formation of $AlF_3(s)$ -1301 kJ mol^{-1}

Enthalpy of atomization of aluminium $+314$ kJ mol^{-1}

Bond dissociation energy of fluorine $+158$ kJ mol^{-1}

First, second, and third ionization energies of Al $+577$, $+1820$, and $+2740$ kJ mol^{-1} respectively

First electron affinity of fluorine -348 kJ mol^{-1}

Hydration enthalpies aluminium and fluoride Ions -4690 , -364 kJ mol^{-1} respectively

The researcher struggles to use this information to construct and interpret an energy cycle diagram,perform calculations, evaluate the feasibility of the key processes and properties that suit aluminium fluoride for use in the process. You have been contacted for help.

Tasks; As a student of chemistry, help the researcher;

a) Analyse the data to construct an energy cycle diagram for the formation of solid substance

(b) Know the lattice energy of substance.

(d) Evaluate whether the dissolution of the substance in water is thermodynamically feasible and spontaneous under standard condition

(i) State the properties that make the substance suitable to serve the above purpose

(ii) Suggest the possible impact and mitigation of the substance to the environment.

11. A chemical company in Kampala manufactures halide compounds in disinfectants. To improve production efficiency,the company is studying the first ionization energied(I.E) of elements.

The ionization energy of an element indicates the amount of energy required to remove one mole of electronsom one mole of gaseous atoms to form one mole of positively charged gaseous ions.

Elements with low ionization energy lose electrons easily and thus form positive ions readily,making them more suitable for halide formation with group(VII) elements.Those with high ionization energy are less reactive and less suitable for this purpose.

The company is analyzing period 3 elements to identify the most suitable for halide production.

ELEMENT	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
Atomic number(nm)	11	12	13	14	15	16	17	18
First I.E (kJ mol^{-1})	496	738	578	786	1012	1000	1251	1521
Melting point(°C)	98	650	660	1414	44	115	-101.5	-189.4

The manager seeks to analyse the data to make informed decisions by plotting a graph of first ionization energy against atomic numbers for period 3 elements.He is also interested in understanding the variations in the melting points of some elements.

You are required to;

a) Describe and explain the trend and irregularities in the first ionization energies across period 3
b) Evaluate which element is the most suitable for industrial halide production,giving reasons.
c) State and explain the trend the melting points of the non-metals in the table above.

Task; As a learner of chemistry,make a write-up you will use to help the company.

12. A chemical research laboratory in Uganda is investigating a gaseous hydrocarbon X obtained from a petrochemical facility. Elemental analysis shows that X contains 11.11% hydrogen by mass, its vapour density is 27 and on treatment withTollens' reagent gave positive test.Hydrogenation of X with 1 mole of hydrogen and 1 mole of X over a lindlar's catalyst produced a carbon–carbon double bond. When the resulting compound of hydrogenation is treated with concentrated sulphuric acid and water, it forms Y,which is further oxidized using hot acidified potassium dichromate to yield a compound Z. Z gives a negative test with Tollens' reagent.

Multi-step synthesis from but-1-ene, propene, and ethene are explored to generate X and its derivatives,which are important for producing alcohols, carbonylcompounds, and polymer intermediates in Uganda's chemical industry, while safetyconsiderations such as flammability and waste management are observed.

An analyst, wishes to know molecular formula X, all structural isomers of X with IUPAC names, identity of X, Y, and Z, write equations to be involved, mechanisms for formation ofY, propose multi-step synthesis of X from but-1-ene, propene, and ethene, and discuss theindustrial applications, environmental impact, andmitigations of X, Y, and Z. You have been contacted for your help.

Task: As a student of Chemistry, prepare a presentation you will use to help the firm.

13. Sharon,An industrial chemist converts a halogenoalkane M into an alcohol N using aqueous sodium hydroxide.

However, inspection reports show that elimination products are also formed, reducing the yield of N. The chemist insists the process cannot be improved.

You are consulted as an expert in organic synthesis.

Task ; Help the inspector to:

a) Identify the reaction type involved in the conversion of M to N. (3 scores)
b) Explain the conditions that favour substitution over elimination. (4 scores)
c) Describe the mechanism involved in the formation of N. (4 scores)
d) Explain why elimination occurs under certain conditions. (3 scores)
e) Suggest process modifications to maximize the yield of N. (5 scores)

14. It is common knowledge in Chemistry that elements in a group of the Periodic Table have the similar physical and chemical properties. A closer study of properties of elements in the first three groups reveals that the first element in each group is similar in physical and chemical properties to the element in the next group to the right but in the next period below:

Tasks; Using your knowledge of periodic trends in the Periodic Table,

a) Identify the phenomenon described above.
b) Describe the similarities in physical and chemical properties between any two elements that show the phenomenon you have identified in (a) above.
c) Describe any two ways in which the implications of the phenomenon you have identified in (a) above are applied in industry.

15. Dr. Abraham, a radiotherapist at the Uganda Cancer Institute, is preparing a dose of radium-223 for a patient with advanced prostate cancer and bone metastases. Radium-223 is a radioactive isotope used in targeted alpha therapy to treat bone metastases. It has a half-life of 11.4 days and decays by emitting an alpha particle. Before administration, a small sample of the isotope was analysed using a mass-based analytical technique; mass spectrometry to confirm its identity and purity. On the treatment day, he administered to the patient an initial dose containing 150 µg of radium-223 at 9:00 a.m. The patient is scheduled to receive a follow-up dose 20 days later. Dr. Kalule would like to express the decay of radium-223 in a nuclear equation and also know how much of the isotope remains as a function of time. You are contacted for help.

Task: As a chemistry student,

a) Help him express the nuclear decay reaction of radium-223 using a balanced equation.
b) Explain how a mass spectrometer was used to confirm the presence and purity of this isotope.
c) Determine the amount of the Radium that will have decayed from the initial administration date to the time of follow-up dose.
d) Describe three likely health challenges associated with the use of radium-223 and suggest possible mitigations that Dr. Kalule and his team must implement to ensure safety.

16. Cipla Quality Chemical Industries Ltd, located in Luzira Kampala, uses controlled amounts of heat during the purification stage of Artemether–Lumefantrine production. This heat is obtained from the exothermic combustion of ethanol. Recently, company purchased ethanol from a new supplier. Production engineers later observed that the reaction system was not reaching the expected temperature, suggesting a possible variation in the energy released during the combustion of the new ethanol batch. To verify, the Quality Control team carried out a calorimetry experiment using a spirit burner of the new ethanol sample and obtained the following textbook-standard data:

Mass of water used: 250 g

Initial temperature of water: 22.0 °C

Final temperature of water: 36.5 °C

Mass of ethanol before burning: 92.41 g

Mass of ethanol after burning: 91.21 g

Specific heat capacity of water: 4.18 J g^{-1} K^{-1}

Heat capacity of calorimeter: negligible

Task;

a) Explain what is meant by exothermic reaction and standard enthalpy of combustion.
b) Using a labelled diagram, describe how the experiment above was carried out to obtain the temperature rise.
c) Using the data provided, calculate the heat released when 1 mole of ethanol is completely burnt.

(Relative atomic masses: C=12, H=1, O=16)

(i) Draw an energy profile diagram for the combustion of ethanol when the reaction is catalyzed.

(ii) Explain the effect of the catalyst on the above reaction.

17. Roofing Rolling Mills Ltd., located in Namanve Industrial Park, manufactures electrical cable components, heat-resistant furnace linings, and chemical-storage metallic tanks. Recently, the company began receiving serious complaints from clients:

- Some metallic tanks used to store sodium hydroxide solution were corroding rapidly, leading to leakage.

- A furnace-lining material in one of their workshops was found to melt at unexpectedly low temperatures, creating safety and maintenance concerns.

- The waste-management unit requested a metallic tank that can safely store acidic waste without undergoing corrosion.

In response to these challenges, the company decided to explore the use of locally sourced Period 3 elements as potential replacements for some imported raw materials. Their goal is to select elements that have suitable melting points and acceptable chemical resistance toward

commonly encountered substances such as water, sodium hydroxide solution, and dilute sulphuric acid. The Research and Testing Department compiled melting point data for selected Period 3 elements, but the production engineers remain uncertain about the physical trends shown by the data; chemical reactivity of these elements and hence cannot confidently determine which metal is suitable for each industrial application. Because the company must choose the correct metal for furnace linings, chemical-storage tanks, and electrical cable components, they have contacted you to help interpret the data and provide appropriate recommendations.

Support material.

The table below shows the melting points of the selected elements.

ELEMENT	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
Atomic number	11	12	13	14	15	16	17	18
MELTING POINT (^{0}C)	98	650	660	1414	44	115	-102	-189

Task

a) Help the analyse the presented data by plotting a graph of melting point against atomic number for the Period 3 elements.
b) Explain the variation in melting points across Period 3 and recommend the most suitable Period 3 element for heat-resistant furnace linings, giving reasons.
c) Explain to the company the chemical reactivity of the elements with commonly encountered substances stated by the company.
d) Recommend the most appropriate element for each of the company's needs while identifying any element(s) unsuitable for structural or industrial use. In each case, justify your choice with relevant reasons.

18. At Kawoko Materials Ltd, engineers discovered that magnesium metal ribbon stored in an open container had developed a dull surface. When the metal was cleaned and heated strongly in air, it burned with a bright white light and formed a white solid powder. This white substance is widely used in making heat-resistant bricks for lining furnaces and incinerators. To ensure the material is pure oxide of the metal, the company requested the school's chemistry class to assist in determining its molecular formula using laboratory data and to verify its chemical reactivity with common acids.

The following experimental data were obtained:

Mass of empty crucible = 32.40 g

Mass of crucible + magnesium ribbon before heating = 33.60 g

Mass of crucible + product after heating = 34.40 g

Vapour density for gaseous oxide of the metal is= 20.0

Tasks; As a chemistry learner, help the company determine the;

a) Name and formula of the white solid formed.
b) Molecular formula of the white solid formed.

c) Explain to the company reactivity of the metal with air, old water, and dilute hydrochloric acid and it's oxide with dilute hydrochloric acid and sulphuric acid. (In each case, include the equations and appropriate conditions for the reaction that occurred.)
d) Explain why this white substance is suitable for making heat-resistant bricks. (05 scores)

19. Cipla Quality Chemical Industries Ltd; a pharmaceutical manufacturer; is currently working on expanding the production of local Active Pharmaceutical Ingredients (APIs) used in anti- infectives, analgesics, and sedatives. To reduce dependence on imported raw materials, the company has started a project to localize the synthesis of certain organic intermediates used in; Analgesic and antipyretic drugs and Solvent and extraction systems used during API purification. During process development, the research and development team identified two key building blocks, 1-bromobutane and 2-bromobutane used as alkylating agents in side-chain construction. The company currently has only two raw materials available for the project, but- 1-ene and but-2-yne. However, the production team is stranded and uncertain about, the correct industrial processes, reagents, and appropriate conditions needed for the reactions to occur, mechanisms of reaction, the reactivity of the building blocks with alcoholic potassium hydroxide, sodium cyanide and aqueous sodium hydroxide solution and the associated environmental and health impacts of using and disposing of alkyl bromides in a pharmaceutical industry. Because of this uncertainty, the manager has contacted you, to provide scientific guidance so production can begin.

Task

a) Help the company know the production process that involves obtaining of 1-bromobutane from a suitable alkene and 2-bromobutane from a suitable alkyne depending on available raw materials. (In your description reaction equations, including appropriate conditions and mechanisms for the reaction)
b) Explain the reactivity of 1-bromobutane with alcoholic potassium hydroxide, sodium cyanide and aqueous sodium hydroxide solution. (In your description reaction equations, including appropriate conditions and mechanisms for the reaction)
c) Discuss real environmental and health impacts associated with large-scale handling of brominated organic compounds and suggest how they can be mitigated.

20. A water treatment plant uses chlorine, an isotopic gas for disinfection. A chemist was instructed to confirm the composition of chlorine using a mass spectrometer. The results were obtained as follows;

isotope	Isotope mass	Percentage abundance(%)
Cl-35	34.97	75.8
Cl-37	36.97	24.2

Task; as a chemistry student,

a) Explain briefly what is meant by;
   i) Isotopes (02 scores)
   ii) Relative atomic mass (02 scores)
   iii) Help the chemist determine the relative atomic mass of chlorine based on the data provided.(03scores)

21. Ugandan scientists in the energy sector are planning to develop a nuclear plant in Hoima. They consulted with the Russian experts , who shared the following reactions involving Uranium for guidance.

i. $^{235}U(n,\gamma) \longrightarrow {}^{236}U$

ii. $^{236}U \longrightarrow {}^{133}Ba + {}^{99}Tc + 3n + \text{energy}$

Task, as a learner of chemistry with knowledge of nuclear chemistry, help the Ugandan scientists to;

i) Complete and explain the meaning of each equation in the report, including the role of each component.(04 scores)

ii) Identify the category of the reaction represented by the equations above.(02 scores)

iii) Explain how the process in the category in b(ii) above occurs using Uranium-235 and describe how it releases energy.(03 scores)

iv) Advise the Ugandan scientists on the environmental impacts brought about by the above reactions and how they can be solved.(02 scores)

22. Ngambo, the forensics scientist has been entrusted by the Kabale police department to recreate a crime scene material involving a metallic alloy used in a suspicious device. The alloy is suspected to be a reactive but relatively stable material, crafted from elements in the alkali group and the alkaline earth metals. However, it's believed that the suitable elements needed is chosen depending on its atomic radius which varies from one element to another.

Ngambo now needs your expertise in understanding the variation in atomic radius down the groups in the periodic table to select an appropriate element for reconstructing the alloy.

Task; using your knowledge of the periodic table, help Ngambo,

a) Select an element from either the alkali group or the alkaline earth metals to form a reactive but relatively stable alloy.
Explain how the variation in atomic radius down each group influences the choice and predict how the atomic radius affects the alloys reactivity and stability for forensic reconstruction.
(05 scores)

b) Compare the reactivity of your chosen elements, explaining how the difference in atomic radius impacts the alloys properties.
(04 scores)

c) Briefly explain to Ngambo why the atomic radius increase down the group.(03 scores)

23. A research company developing new cosmetic aerosols is working with a hydrocarbon compound of molecular formula C_4H_{10}. Laboratory tests reveal the compound has structural isomers, each with differing boiling points.

The team wants to select the most volatile (lowest boiling point) form for effective aerosol dispersion and you have been identified as the suitable person for consultation.

Task: As a learner who is well equipped with the knowledge of organic chemistry,

Write a brief report:

a) Describing the different structural isomers of C_4H_{10} and their similar chemical behavior.

b) In your report, include a recommendation for which isomer is most appropriate for use in the product and justifying your answer.

24. A beverage company is developing a new energy drink designed to stay liquid even in cold weather. A chemist suggests adding an appropriate amount of glucose to the formula to lower its freezing point without affecting taste.

To estimate how much glucose to use, they test a sample containing 180 g of glucose ($C_6H_{12}O_6$) dissolved in 1 kg of water. They observe a decrease in freezing point by 1.86°C.

Task: As a chemistry student who has studied about colligative properties of solutions, help the company chemist,

a) Calculate the molality of the glucose solution.

b) Use the freezing point depression constant (Kf = 1.86°C·kg/mol) to confirm the freezing point depression.

c) Why does the identity of the solute (glucose vs. NaCl) matter for the magnitude of freezing point depression?

25. A S.5 science student mixes 5.0 g of calcium carbonate ($CaCO_3$) with hydrochloric acid. A gas is released, and a fizzing reaction occurs. The student is concerned on how much gas is released and as a senior student, you have been contacted for help

Task: As a senior student,

a) Write the balanced chemical equation for the reaction.

b) Calculate the number of moles of calcium carbonate used.

c) Determine the volume of carbon dioxide gas evolved at room temperature and pressure (molar gas volume = 24 dm^3/mol).

26.Barium fluoride and magnesium fluoride have various applications in optics due to their transparency over a wide range of wavelengths. A company is to synthesize one of these compounds to be used as a raw material for other optics related devices. The design of their manufacturing process requires that they select to produce the compound that gives out the less heat as it forms from its gaseous component ions.

Task; As a student of Chemistry consider the data below

MgF_2 : Standard heat of formation = −1124 kJ/mol; standard heat of sublimation of magnesium = +148 kJ/mol, IE_1(Mg) = +738 kJ/mol, IE_2(Mg) = +1451 kJ/mol, Bond dissociation energy (F_2) = +159 kJ/mol, First electron affinity (F) = −328 kJ/mol.

BaF_2 : Standard heat of formation = −1207 kJ/mol, Standard heat of sublimation (Ba) = +180 kJ/mol; IE_1(Ba) = +503 kJ/mol; IE_2(Ba) = +965 kJ/mol, EA(F) = −328 kJ/mol.

Task:

a) Use your knowledge of energy cycles and determine which of the two compounds will be the more suitable.

b) Help the company chemical engineer understand the stability difference between the two compounds to address durability concerns in optical devices they are to make.

27. Study the data below about the first ten successive energies (in kJ per mole) required to remove the first ten electron from the gaseous atom and then ions of an element X and another one Y.

X 495.8 4562 6910.3 9543 13354 16613 20117 25496 28932 141362

Y 577.5 1816.7 2744.8 11577 14842 18379 23326 27465 31853 38473

Tasks; As a student of Chemistry,

a) Explain the category of the process involved in the removal of the first electron and state any two factors that can affect the amount of the energy required.
b) Suggest the acceptable formulae of the chlorides of these elements and explain your reasons
c) Which of the chlorides you have given in (b) above is more likely to dissolve in paraffin? Give a concise explanation of your reasons.

28. A factory plans to produce small amounts of carbon dioxide by thermally decomposing the any one of the carbonates : magnesium carbonate, calcium carbonate or barium carbonate in an electric heater. They need to achieve this with the least expenditure on electricity and minimum side effects from handling.

Tasks

Consider the data below:

Cation	**Size (pm)**	**Carbonate**	**Decomposition temperature (°C)**
Mg^{2+}	72	$MgCO_3$	350
Ca^{2+}	100	$CaCO_3$	840
Ba^{2+}	135	$BaCO_3$	1350

a) (i) Help the factory management make a choice.
(ii) Understand the chemistry principles of bonding and structure that make the choice you have made in (i) the most suitable.
(iii) Describe the possible environmental impacts of this industrial process and suggest mitigation measures.

29. A fertilizer company produces ammonia (NH_3) by reacting nitrogen with hydrogen under controlled conditions. In a trial experiment, 10.0 g of nitrogen is combined with 3.0 g of hydrogen. After 1 hour, only 2.5 g of hydrogen has reacted. The company observes that the reaction rate doubles when the temperature is raised from 298 K to 318 K. The enthalpy change of the reaction is measured as -92 kJ/mol.

Task: Write a detailed scientific report analyzing:

a) Which reactant is limiting.
b) The expected quantity of ammonia formed.
c) The efficiency of the reaction compared to the theoretical maximum (percentage yield).
d) How temperature affects the reaction rate, referencing kinetic principles.

30. A laboratory investigates a solution containing 0.50 M Fe^{2+} and 0.10 M Fe^{3+} in acidic medium. A platinum electrode is immersed and connected to a standard hydrogen electrode. The reduction potential for Fe^{3+}/Fe^{2+} is +0.77 V.

Task: Prepare a scientific report that:

a) Determines the electrode potential using the Nernst equation.
b) Explains the effect of changing ion concentrations on the potential.
c) Predicts how equilibrium shifts when additional Fe^{2+} is added.
d) Suggests one real-life application of this redox system in industry.

31. A chemical plant produces metal oxides used in ceramics. They observe varying melting points, solubilities, and reactivities for BeO, MgO, CaO, and Al_2O_3. They request an analysis of periodic trends to optimize product quality.

Task: Write a report analyzing:

a) Trends in atomic radius and ionization energy. Differences in melting points of oxides.
b) The nature of bonding in BeO, MgO, and Al_2O_3.
c) Recommendations for production improvement based on periodic properties.

32. A laboratory studies group 17 elements (halogens) for potential use in disinfectants. Observations include differences in reactivity, solubility, and bond strengths across fluorine to iodine.

Task: Write a report that:

a) Explains the trend in reactivity down the group.
b) bond strengths and their effect on chemical behaviour.
c) Suggests which halogen is most suitable for industrial applications and why.

33. A chemist synthesizes butan-2-ol by reducing butan-2-one with sodium borohydride. The alcohol is then dehydrated using concentrated H_2SO_4 to produce but-2-ene.

Task: Write a detailed report covering:

a) The mechanism of reduction of butan-2-one to butan-2-ol.
b) The formation of cis and trans but-2-ene during dehydration.
c) Suggested test to distinguish butan-2-ol from butan-1-ol.
d) Industrial relevance of the reaction.

34. A pharmaceutical company investigates the synthesis of phenylmethanol from benzaldehyde. They plan to convert it into other derivatives for medicinal applications.

Task: Prepare a scientific report that:

a) Shows the synthesis pathway from benzaldehyde to phenylmethanol.
b) Explains the reaction mechanism for each step.
c) Discusses possible functional group transformations.
d) Recommends safety and efficiency improvements in the process.

35. A group of researchers used a mass spectrometer to determine the relative atomic mass of chlorine. In their findings, chlorine had three isotopes Cl-35 and Cl-37 and mass spectrum had three significant peaks at 70,72 and 74. The report shows that the relative atomic mass of chlorine is 35.5.

Juma a new comer in senior five science is inquisitive about this machine and the mass spectrum obtained.

Task: Using the knowledge of chemistry, you have obtained;

(a)Explain to him:

i) The mode of operation of the machine

ii) Why only three peaks were observed on the mass spectrum

iii) One other use of the machine in daily life

iv)Calculate the percentage abundance of each isotope of chlorine from the data and hence sketch the mass spectrum of chlorine.

36. On analysis by senior five chemistry students on compound K, it was discovered that compound K contains 39.9% Copper, 21.3% Sulphur and the rest being Oxygen. Husina a senior four student finds this information strange and she has approached you for help about substance K.

Task; As a chemistry student help her to understand compound with its:

a) Empirical formula of K.

b) Molecular formula of K provided 0.05 moles of X weighs 8.006 g.

c) IUPAC name compound K

37. While in the laboratory, an argument rose up between two senior three students after seeing certain information on one of the bottles in the laboratory. This information is for compound D which is an organic acid whose formula is: $H_xC_y O_z .nH O$. On its bottle its written that D contains 26.7% Carbon, 2.2% hydrogen and 71.1% oxygen by mass. On the same bottle its written that it has a vapour density of $5.625X10\text{-}3gcm^{-3}$ at s.t.p.

Your chemistry teacher has requested you to help the senior three students under the issue at hand. In your message include the following:

a) Determine empirical formula of the anhydrous form of Q.
b) Deduce the values of x, y and z.
c) Determine the value of n and hence the formula of the hydrated D.
d) Write the IUPAC name of D.
e) Determine the percentage of water of crystallization in D.

38. In the rural district of Luweero, central Uganda, a community-led water treatment initiative operates a small filtration plant drawing water from local underground water sources and boreholes to supply clean drinking water to over 500 households. This water is hard due to high levels of calcium ions (Ca^{2+}) from dissolved limestone, leading to scale build-up in pipes and kettles, which increases maintenance costs and reduces water flow efficiency. To address this, the plant uses sodium carbonate (Na_2CO_3) to soften the water by precipitating calcium carbonate ($CaCO_3$) .However, inconsistent dosing of the water with sodium carbonate has resulted in incomplete removal or excessive sludge formation. This has led to clogging of filters and raising operational expenses.

Water samples show initial concentrations: $[Ca^{2+}] = 0.005$ M, and the water engineer has proposed to add 1.5g of sodium carbonate for each liter of the water.

The solubility product at 25°C of calcium carbonate is 3.8×10^{-9}.

Tasks; As a student of Chemistry, use your knowledge of equilibria to

a) Determine the core problem or challenge in the water treatment process proposed by the water engineer.
b) Explain how the additive, sodium carbonate, functions in treating the water.
c) Identify dangers, or side effects of the current approach, where the amount of sodium carbonate used per liter of water keeps changing and hence suggest mitigations.

39. A small chemical factory set up in Mbalala – Mukono district, is developing an ammonium chloride gel for use in a new dry cell designed for durability. The ammonium chloride has to be in gel, not solid form, to act as a conductor in the dry cell. To produce this gel, they are reacting aqueous ammonia with hydrochloric acid;

$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$

The reaction is however producing heat in inconsistent amounts. This heat is causing structural and design problems in the production process. To get to solving this problem, they need to first know the heat of this reaction.

An intern was tasked with determining the heat of this reaction. She carried out experiments in two parts as described below.

In the first part, 25 cm^3 of 2M sodium hydroxide solution were added to an equal volume of 2M hydrochloric acid in a styroform cup lagged with cotton wool and nested in a plastic beaker.

The reaction was, $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

The time – temperature, T ,data that were obtained are in table 1 below:

Table 1

Time (s)	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
T(°C)	20.4	20.4	20.4	24.3	26.7	27.7	28.2	28.2	28.2

In the second part of the experiment, the procedure in the first part was repeated but 25 cm^3 of 2M ammonium chloride solution were added to an equal volume of 2M sodium hydroxide.

The reaction was, $NH_4Cl(aq) + NaOH(aq) \rightarrow NH_3(aq) + NaCl(aq) + H_2O(l)$

Table 2 shows the results

Table 2

Time (s)	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
T(°C)	20.5	20.5	20.5	21.1	21.2	21.4	21.4	21.4	21.4

Tasks; As a student of Chemistry

Explain

a) The heat change that occurs in this reaction.
b) Why ammonium chloride has to be in gel form.
c) Show the intern how this data can be used to determine the heat change for the reaction and hence do it.

[Use graph paper and assume that the density of all solutions is $1gcm^{-3}$ and the specific heat capacity of all solutions is $4.2\ Jg^{-1}K^{-1}$]

40. A product development team of an upstart medium sized chemical factory is faced with the need to quickly decide on which element combination will give two different compounds. One being the most stable ionic compound to be used in high temperature settings; the other, to have the highest solubility in cyclohexane – a covalent solvent.

These elements with corresponding atomic numbers are: Q, 13; W, 17; T, 16; G, 15; X, 12 and Z, 20.

They have put together the data in Table 3 below to help them decide though they do not have a clear understanding of the data.

Table 3

Element	**Atomic size (pm)**	**First ionisation energy ($kJmol^{-1}$)**	**Electronegativity (Pauling Scale)**
Q	118	578	1.61
W	79	1251	3.16
T	88	1000	2.58
G	98	1012	2.19
X	145	738	1.30
Z	194	590	1.00

Task

Provide a write up of the discussion you would have with the product development team at a workshop to help them understand their data and with reasons the choices they should make.

41. A group of students are designing a single-use self-heating meal pack for emergency rations to be used in the refuge camp in Bidi – bidi, rhino camp and kyangwali regions. The pack uses a chemical reaction with water to generate heat without flame or electricity.

The are seeking to choose from a shortlist of four Group 2A metals - Be, Mg, Ca, and Ba to react with water. They need help with understanding the reactivity of these elements with water and hence a guide in selecting the best metal for use taking into account, personal and environment safety.

Task

As a student of Chemistry provide a brief write up of the speech you would give the group of students, including an application of the data in table 4 below.

Table 4

Element	Atomic size (pm)	First ionisation energy ($kJmol^{-1}$)	Electronegativity (Pauling Scale)
Beryllium	112	895	1.57
Magnesium	155	738	1.31
Calcium	195.5	590	1.00
Barium	253	503	0.89

42. A chemical firm has been contracted by another chemicals production firm to scavenge their by-products for an organic compound X with molecular formula, C_4H_6. They need this compound because theoretically it can be converted to ethanal, a very useful and profitable compound. Physical methods have revealed that a sample of X has two different compounds with different boiling points and different reactions with certain reagents. This has caused a lot of concern.

The engineering department of the contracted firm, needs to understand:

(i) why a sample of X has two different compounds with the same atom composition;
(ii) how to chemically distinguish between the compounds;
(iii) how each of the compounds in a sample of X can be converted to ethanal.

You have been contacted for help in this matter.

Task

As a student of Chemistry produce a write up of the speech you would deliver a meeting with members of the engineering department.

43. Agroil Ltd extracts avocado oil using a cycloalkane B has solvent. However of recent it had mistakenly been using a different compound with unsatisfactory results. So they decided to dump this compound, after failing to find a way to convert B to A. They did the dumping irresponsibly, bringing the company under investigation for illegal dumping of chemicals. These chemicals have polluted the local underground water supply. An environmental protection activist group is suing the avocado oil manufacturer. They have collected a sample of the industrial chemical and labelled it “exhibit A". For prosecution purposes, they need information such as the identity of exhibit A , its reactivity, compared to B since this would provide information about how it interacts in nature and with the human body.

They used a government laboratory to analyse substance A and where given the following results:

A is 87.8% carbon and 12.2% hydrogen by mass.

A decolourises bromine water and 0.1g of A absorb 27.3 cm^3 of hydrogen measured at s.t.p to form B. B does not react with hydrogen.

Your help as a student of Chemistry has been sought.

Task

Provide a write up of the speech you would give to a meeting of the technical members of Agroil Ltd and the environmental activist group. You should clearly show how you arrive at your assertions.

44. The mass spectrum below was presented in a class plenary session by the teacher to your study group:

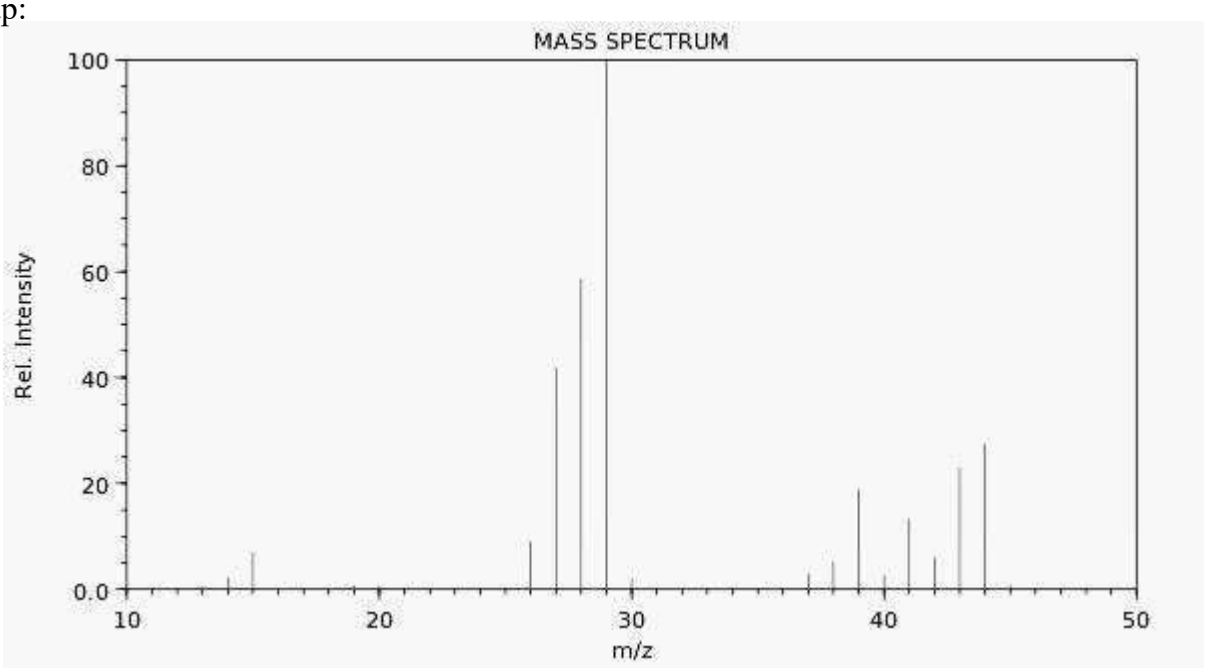

Fig 1 : mass spectrum of hydrocarbon Q

Q is a hydrocarbon that is 81.818% carbon by mass and is commonly used as a fuel gas that comes in canisters of 13 kg each.

Tasks; As a leader of your study group, the teacher requires you to

a) Explain the mechanism of the analytical method that produces the mass spectrum in figure 1 and; explain the main features on the mass spectrum.
b) Use the information off figure 1 and work out the mass in kilograms of carbon dioxide that gets let into the atmosphere when 13 kg of Q burn completely as a fuel gas.

(Take atomic masses, C = 12; H = 1; O = 16)

45. During a plenary session in class, you lead a study group, tasked with evaluating elements for their suitability for use in advanced technologies. Your group is exploring the use of Group II(A) (alkaline earth) main group elements—specifically Beryllium (Be, atomic number 4), Magnesium (Mg, atomic number 12), and Calcium (Ca, atomic number 20)—for applications in stable compound formation , electrical conductivity , and construction materials.

Task

You are required to analyse their electron configurations, relate these to their chemical and physical properties, and recommend their suitability for the specific industrial applications.

46. A National medical stores (NMS) van had an accident on a high way through a community called Buloba. The accident cracked open a sealed can containing radium – 223, a radioisotope used in the treatment of prostate cancer. It targets alpha radiation to kill cancer cells in bone metastases while minimising exposure for healthy tissue. The radioisotope leaked into a local natural water source. As a response the government forced people to not use the water and to evacuate the immediate area. It advised the residents to stay away for atleast six months when the activity of the radioisotope will have reached the safe level of 0.037 counts per second (cps).

Tasks; As a student of Chemistry

a) Use the information in the table below and evaluate the government's advice to residents to stay away for at least six months

Table 1 : time – activity data for radium – 223 taken in Buloba.

Time (days)	0	5	10	15	20	25
Activity (cps)	2.50	1.84	1.36	1.00	0.741	0.547

b) Produce a brief write up educating the community members about the dangers of radioisotopes and how these should be mitigated.

47. A water engineering firm uses anhydrous sodium carbonate that comes in 12kg bags each 65000 UgX, to remove calcium ions from hard water by the process:

$Na_2CO_3(aq) + Ca^{2+}(aq) \rightarrow 2Na^{+}(aq) + CaCO_3(s)$

A procurement officer has been tasked to estimate the cost of sodium carbonate that will be required to complete a job of softening 550,000 liter of a hard water containing 35.8mg of calcium ions per 200 cm^3.

The procurement officer has sought after your help.

Task

a) Showing a clear working, help the procurement officer estimate the number of bags of anhydrous sodium carbonate the job will require. (1 mg = 10-3g: Na =23, C = 12, O = 16 and Ca = 40)
b) If the National Drug Authority (NDA) and Uganda National Bureau of Standards (UNBS) recommend drinkable water to not contain more than 50mg per liter of sodium, determine whether the process of water treatment is lawful or not.

48. As a student of Chemistry educated in areas of bonding and properties of substances as a result of type of bonding, you have been approached for help in assessing the suitability of magnesium oxide, copper, and silicon dioxide to be used in designing a new composite material for a high-performance aerospace component. The component must withstand extreme temperatures, conduct electricity, and resist corrosion.

Tasks; Discuss bonding in each material provided and its suitability for the task of designing the aerospace component.

b) Evaluate the substances for the task of designing the aerospace component.

49. A first aid company is testing two chemical reactions to design a reliable heat pack for mountain climbers exposed to freezing temperatures. Each reaction occurs when a chemical dissolves in water inside a sealed pouch. The scientists are confused of which reaction is best for the climbers. You are provided with the following energy contents of the two test chemical reactions.

For reaction A,

$CaCl_2$ (s) + (aq) Ca^{2+} (aq) + Cl^- (aq)

The energy content of reactants and products was determined as -795kJ/mol and -876.3kj/mol

For reaction B,

NH_4NO_3 (s) + (aq) NH_4^{2+} (aq) + NO_3^- (aq)

The energy content of reactants and products was determined as -675kJ/mol and -525kj/mol.

Task

a) Help the scientists determine the enthalpy change for each reaction. (06 scores)
b) Draw a well labelled energy level diagram for each reaction A and B to help scientists understand the reaction kinetics for each. (08 scores)
c) Based on the findings, advise the scientists giving reasons in each case the best reaction to be used in the heat packs for the mountain climbers. (04 scores)
d) Explain the effect of a positive catalyst on the reaction in B. (Use an energy level diagram for proper explanation) (06 scores)

50. Mr. John is an intern chemist at NanoSense Technologies, a company that develops sensors to detect toxic gases. The research team is investigating halogen elements to select the most suitable one for detecting Compound X, a gas known to donate electrons during reactions. The sensor works by using a material that can attract and accept electrons from this gas. A higher electron affinity means the material can interact more strongly with the gas, causing a measurable change in electrical resistance. To help choose the best halogen, the team collected data on the first electron affinities of selected halogens using photoelectron spectroscopy. Mr. John is however stranded with analysis of data.

Table 1 shows first electron affinity data for group 17 Elements

Element	**Atomic number**	**Electron affinity (kJ/mol)**
Fluorine	9	-328
Chlorine	17	-370
Bromine	35	-348
Iodine	53	-320

Task; As a chemistry learner;

a) Using an equation for first electron affinity for chlorine, state what is meant by first electron affinity. (02 scores)
b) Present the provided data on a suitable graph for proper analysis. (05 scores)

c) Explain how the investigated periodic trend varies among the investigated elements.
d) From the graph, compare and explain the electron affinity values for chlorine and fluorine.
e) Based on the results above, explain which element would be the most suitable for the gas sensor's active surface? (03 scores)
f) If period two elements were used for the investigation, explain how the investigated periodic trend varies among these elements. (05 scores)

51. Peter is part of an innovation team at VoltLine Electronics, designing conductive metal traces for printed circuit boards (PCBs). These conductors must allow easy removal of electrons to ensure smooth current flow without unnecessary energy loss. Your team investigates the first ionization energy of Period 3 elements, because this property determines how easily a material loses an electron. To select the best candidate element, peter carried out photoelectron spectroscopy to measure the first ionization energy of selected elements and the following data was obtained though he has failed to analyze it.

Table 2 shows the First Ionization Energy Data for Period 3 Elements

Element	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
Atomic Number	11	12	13	14	15	16	17	18
First I.E(kJ/mol)	496	737	577	786	1012	999	1255	1521

Task; As a chemistry learner;

a) Present the information on a suitable table for proper analysis. (05 scores)
b) Explain the variation of first ionization energy across the investigated elements. (05 scores)
c) Identify and explain any two abnormalities form the graph. (05 scores)
d) Which element(s) would be best suited for making electrical conductors? Justify based on ionization energy. (04 scores)
e) How does low ionization energy support efficient current flow in a circuit? (04 scores)

52. A group of forensic chemists are investigating organic substances they found at certain suspected illegal chemical dump. Analysis gave them the molecular formula of the two compounds as M(CC_3HH_6) and N ($CCHH_4$).

To gather more information about the compounds they also need to know the nature of the two compounds and their chemical reactivity. They are aware that you have some knowledge on organic chemistry and have come to you for advice.

Task: As a chemistry student help them to

a) Write the structural formulae and state the functional groups present in the organic compounds N and M. (04 scores)

b) Predict the reaction and write the mechanisms for the reaction of;

i) M with hydrogen gas

ii) N with chlorine in presence of UV light

(iii) N with concentrated nitric acid at (150-400)°C

c) Analyze the impacts of compound N to the environment. (05 scores)

(i) State a gaseous product formed when N is completely burnt in Air (01sco)

d) Write equation of reaction (01 scores)

e) Explain the impacts of the gaseous product formed and its mitigations (02 scors) (iv) Name one property of the gaseous product that makes it usefull in daily life (02sco)

53. A company that manufactures high-strength electrical cables is researching how different metals and nonmetals interact during production. They are evaluating iron (Fe), copper (Cu), and lead (Pb) as possible metal components, while oxygen (O) is considered because it can react with these metals during processing, forming oxides that affect conductivity and durability. To choose the best material, the team must analyze:

Atomic radius

Ionization energy

Electronic configuration

How these factors influence reactivity and bonding

Task; As a chemistry learner who has studied periodicity, help the company to;

a) Write the electronic configuration of the following elements and some ions.

Oxygen (O = 8)

Copper (Cu = 29)

Copper (I) ions (Cu = 29)

Lead (Pb = 46)

Iron (III) ion (Fe = 26)

b) Explain to the company the term atomic radius
c) State two factors that affect the atomic radius of an element (02 scores)
d) State and explain the trend for atomic radius
   i) Down the group
   ii) Across the period
e) Explain what the following terms mean;
   i) Ionization energy
   ii) First Ionization energy
f) State two factors that affect Ionization energy?
g) Explain how the factors in (b) above affect Ionization energy (03 scores)
h) The table below shows the periodic variation for I.E1 of elements in group I of the Periodic Table

54. The annual Intergalactic Chemistry Competition is underway! This year, delegates from across the Milky Way and beyond have gathered to showcase their understanding of atomic structure and electron configurations. You are a representative from Earth, competing against brilliant minds from nebulae far and wide.

The competition consists of a series of challenges, each testing your ability to determine the electron configurations of various atoms and ions. The judges, a panel of highly intelligent plasma beings, are looking for accuracy, clarity, and the ability to explain your reasoning.

Your Tasks:

The Mystery Element:

A sample of an unknown element, "X," is presented. It is determined experimentally that the X^{2+} ion has the following electron configuration: [Ar] 3d6.

i) Determine the identity of element "X."
ii) Write the full electron configuration of the neutral atom "X."
iii) Explain the process you used to arrive at your answer.

The Charged Particle Challenge:

iv) Write the electron configurations for the following ions:

S^{2-}

Fe^{3+}

N^{3-}

Cu^{+}

v) Explain any variations in electron configuration from the neutral atoms.

The Excited State Puzzle:

An atom of phosphorus (P) is excited, and one of its electrons jumps to a higher energy level.

vi) Write a possible excited-state electron configuration for phosphorus.
vii) Explain why this is considered an excited state.

The Transition Metal Anomaly:

viii) Write the electron configuration for the Chromium (Cr) atom.
ix) Explain why the electron configuration deviates from the expected Aufbau principle filling order.

55. The Mysterious Elements of Planet Xylo

Dr. Hamid, an astrophysicist, has discovered a new planet, Xylo, with an atmosphere composed of previously unknown elements. After analyzing the emitted light spectra, he has determined the following properties of three elements found on Xylo:

Element X: This element has 16 protons in its nucleus.

Element Y: This element forms a stable ion with a -2 charge and has the electronic configuration of [Ar].

Element Z: This element has 19 electrons when it forms a +1 ion.

Tasks:

a) Identify the elements:
b) Determine the names and symbols of elements X, Y, and Z based on the provided information. Explain your reasoning for each identification.
c) Electronic Configurations:
i) Write the ground-state electronic configurations for the neutral atoms of elements X, Y, and Z.
ii) Write the electronic configurations for the ions formed Y^{2-} and Z^{+}.

Quantum Numbers:

d) For element X, identify the set of four quantum numbers (n, l, ml, ms) for the last electron in its ground-state electronic configuration.
e) For the last electron added to create the Y2- ion, identify the set of four quantum numbers.

56. A team of archaeologists has unearthed a strange artifact from an ancient civilization. This artifact emits a faint, but measurable, level of radiation. The team is unsure of its origin, purpose, or potential danger. They have collected samples and data, and they need your help to understand the artifact and its implications. The Isotope in the artifact is found to treat cancer, and the drug dose is only effective when its concentration is above 6g in the body.

Your Task: As a team of scientific consultants, you are tasked with analyzing the data and providing a comprehensive report to the archaeologists.

Your report should include:

a) Using the provided data identify the radioactive isotope present in the artifact.

b) Explain the process of radioactive decay and how it relates to the data you have been given. Include relevant equations like the decay equation

c) Calculate the number of doses a cancer patient will take in a span of 36 years.

57. Dr. Sharma Nakigozi is a medical physicist working in a large hospital. A patient, Mr. Patel, has been diagnosed with a suspected cancerous tumor. To accurately locate and assess the tumor's size and spread, the medical team plans to use a diagnostic imaging technique involving a radioactive tracer. Later, Mr. Patel will undergo targeted radiation therapy to destroy the cancerous cells. Mr. Patel is scared of the prescribed proceedings.

Task: As a student of chemistry, you are requested to allay Mr. Patel's fear by:

a) Describe how a radioactive tracer (such as technetium-99m), is used in medical imaging to diagnose Mr. Patel's condition. What properties make it suitable for this application?
b) Discuss the principles behind radiation therapy and how it utilizes radioactivity to treat Mr. Patel's cancer. What are the potential risks and benefits of this treatment?
c) If the radioactive tracer used in the imaging has a half-life of 6 hours, and the initial dose administered to Mr. Patel is 10 counts, how much of the tracer will remain in his body after 24 hours? Show your calculations.

58. A research laboratory focused on nuclear chemistry, where scientists are investigating the decay of various isotopes to understand their stability and potential applications in medicine and energy. During an experiment, they observed that samples of different isotopes undergo decay by emission of radiations to form new chemical species.

Task:

As a student of Chemistry, you are required to help the researchers write balanced nuclear equations for the reactions and identify the Particles formed or emitted(X).

59. You are part of a national science competition where your school has been tasked with solving a mystery involving a malfunctioning industrial machine used in metal processing. The machine separates metals based on their reactivity and electronic configuration, but it has stopped working correctly due to a suspected programming error in how it identifies elements.

Your team is given a list of six elements used in the machine's sorting system:

Iron (Fe, 26)

Magnesium (Mg, 12)

Calcium (Ca, 20)

Manganese (Mn, 25)

Potassium (K, 19)

Zinc (Zn, 30)

Task

a) You must reprogram the machine to correctly sort these elements by confirming their electronic configurations.
b) The machine accidentally classified manganese and zinc in the same category. Based on their configurations, explain why this is incorrect.
c) Suggest how the machine should differentiate elements with partially filled d-orbitals from those with filled ones

60. An environmental agency is investigating air pollution near an industrial zone. They suspect illegal flaring of hydrocarbons at night. A portable eudiometer is used to sample gases released during a suspected flare event. A 100.0 mL gas sample is collected and analyzed. The gases are assumed to be primarily from the combustion of a gaseous hydrocarbon fuel.

The sample is reacted with excess oxygen in the eudiometer and sparked. After the reaction:

Total gas volume drops from 100.0 mL to 70.0 mL.

The remaining gases are passed through aqueous KOH. After absorption, the volume drops further to 50.0 mL.

The agency believes that incomplete combustion may be occurring, releasing carbon monoxide (CO), a toxic gas, into the environment.

Task:

(a) . Using the data, determine the molecular formula of the hydrocarbon (assume it completely combusted in this reaction).

(b) . Identify how much carbon dioxide was produced.

(c) Critically evaluate whether the combustion was complete or incomplete. Use the volumes to support your answer.

(d) Propose a practical societal solution to prevent the release of toxic gases from industrial flares, based on the chemical behavior observed

61. A local government is launching a campaign to reduce the overuse of fertilizers in farming. As part of a pilot study, a team of chemists analyzes the amount of ammonium nitrate (NH_4NO_3) being used by farmers in a rural area.

One farmer reports using 500 kg of ammonium nitrate per season. The chemists want to understand the potential impact on the local water supply, since excess nitrates can lead to eutrophication in nearby lakes.

Tasks:

a) Calculate the number of moles of ammonium nitrate in 500 kg.
b) Determine the number of nitrogen atoms delivered to the soil.
c) Assuming 10% of the nitrate leaches into water systems, calculate how many moles of nitrate ions enter the environment.

(d) . Based on your results, discuss how chemistry can help address environmental concerns related to fertilizer overuse

62. In a small rural town, local artisans and entrepreneurs are exploring ways to produce alternative fuels and useful chemical products using available resources. A team of young chemists is consulted to advise on the chemical processes and safety implications of the following:

A community wants to produce ethene (a compound used to make lightweight plastics) from ethanol using concentrated sulfuric acid.

A refrigeration technician reports the accidental release of chlorinated propane derivatives after exposure of propane gas to sunlight in an area where cleaning chemicals containing chlorine were being used.

A small-scale soap manufacturer considers using propene and halogens to synthesize disinfectant additives.

The same manufacturer later realizes a dihalide compound is forming when bromine water is added to propene and wants to know how it forms and whether it is safe.

Task; As a consulting chemist, you are tasked with the following:

a) Analyze and write a chemical equation for each reaction implied in the situations above.
b) Identify the type of reaction occurring in each case (e.g., elimination, substitution, addition) and outline the complete reaction mechanism, stating all required conditions.
c) Evaluate the potential risks and suggest safety or environmental considerations for each process, especially in a rural or low-resource context.

d) Propose one sustainable alternative or improvement for any one of the processes above that would reduce harm to people or the environment while still meeting the community's goal.

63. In a lesson, Mr.Kyambadde, a chemistry teacher used Mutebi Edward whose level of perception of concepts was 12 and Nalweyiso Edith whose level of perception of concepts was 7 to represent a couple. He made one of the students who would like to know the nature of the daughter the couple would produce and how the daughter would behave to stand up.

Task 1; As a chemistry learner, how can you help the student perceive this concept?

Edward conducted an experiment in which he dissolved Aluminum Chloride and common salt in methyl benzene and his observation was that Aluminum Chloride could dissolve in methyl benzene unlike common salt.This left him disturbed and he approached you for assistance.

Task 2; As a chemistry learner, help him understand the observation.

64. A team of researchers at Luuka plastics limited has been tasked with developing a new process for producing a specialized polymer.The polymer code named polyX requires a precise mixture of monomers A and B in a specific ratio.The researchers have determined that the ideal ratio of monomer A to monomer B is 3:2.However, the current production process is yielding a mixture of ratio 11:7.To adjust the ratio, the researchers need to calculate the amount of each monomer required to produce a batch of polyX .The molecular weights of monomer A and B are 120gmol^{-1} and 90gmol-^{1} respectively.The researchers have 500kg of monomer A and 300kg of monomer B available.

Task; Using you knowledge of chemistry,help the researchers to know the number of moles of monomer A and B required to produce a batch of polyX with the ideal ratio.

65. Sharon Nakabugo is a chemistry student at Mt. St. Henry's High School-mukono. In an assignment,their teacher told them to write the electronic configuration of an element called chromium whose atomic number was 24.In her response,she clearly noted that the electronic configuration of the said element was:

$1S^2\ 2P^6\ 3P^6\ 2S^2\ 3S^2\ 4S^2\ 3d^4$

Her response was crossed by the teacher claiming that it was not right.The teacher directed him to you for assistance.

Task; As a chemistry learner,how best can you advise John Luwedde?

66. The team of researchers working at a nuclear power station conducted research about the radioactive decomposition of element Z and obtained the data shown in the table below.

Time	0.0	5.0	10.0	15.0	20.0	25.0	30.0
Activity (counts per minute)	25.00	23.00	21.25	19.50	18.00	16.50	15.25

The researchers would wish to determine the time it takes for element Z to decay to a half its original mass and its decay constant.

They have approached you for assistance.

As a chemistry learner, how best would you help the researchers?

James,an industrial chemist carried out an experiment in which he was interested in knowing the actual appearance of a hydrocarbon which he had labeled Z.In this experiment, he exploded 20cm³ of the hydrocarbon with 120cm ³ of oxygen. After the explosion,he found out that the volume of the remaining gases was 90cm³ and this decreased to 50cm³ on treatment with aqueous potassium hydroxide.He has approached you for assistance.

Task; As a chemistry learner, help him find out the solution to his challenge.

67. In the rugged highlands of Kasese District,a mineral prospector named Mr. Mbabazi made an exciting discovery: a rich vein of a mineral containing the element boron. To properly assess its commercial value and potential applications in the local glass manufacturing industry, he needed to determine its precise chemical composition. He collected a substantial sample and sent it to the Uganda Geological Laboratories in Entebbe for detailed isotopic analysis. The laboratory technicians, using a state-of-the-art mass spectrometer, determined that the boron in the sample consisted of two stable isotopes. They found that Boron-10, with an atomic mass of 10.013 amu, had a relative abundance of 19.9%, while Boron-11, with an atomic mass of 11.009 amu, made up the remaining 80.1% of the boron atoms present. Mr.Mbabazi now needs to understand this data to accurately report the findings to potential investors at the Ministry of Energy and Mineral Development, explaining why the atomic mass of his boron sample isn't a simple whole number and how this affects its potential industrial uses in making borosilicate glass and other chemical applications relevant to Uganda's growing industrial sector.

Task:

a) Define the term isotope.

b) Calculate the accurate relative atomic mass of the Boron sample from the mine.

c)State why the relative atomic mass of Boron is not a whole number.

d)The mass spectrometer is an instrument used to determine such isotopic abundances. State one property it uses to separate the isotopes.

68. At the Uganda Cancer Institute in Kampala,Dr. Ngambo, a senior medical physicist, was preparing a dosage of radioactive iodine-131 for a patient diagnosed with thyroid cancer. He gathered a group of medical interns to explain the procedure, emphasizing the importance of understanding nuclear chemistry in medical applications. He detailed how Iodine-131, with a mass number of 131, decays owever, one observant intern noticed a seeming contradiction: the periodic table on the wall listed the relative atomic mass of iodine as approximately 126.90, not 131. This led to a detailed discussion about the distinctions between mass number, which characterizes a specific isotope, and relative atomic mass, which represents a weighted average of all naturally occurring isotopes. Dr. Ngambo used this teaching moment to elaborate on iodine's isotopic composition in nature, explaining that Iodine-127 is by far the most abundant isotope, which pulls the average atomic mass down significantly, despite the existence of other isotopes like Iodine-131 used in their medical work.

Task:

a) Distinguish between the terms mass number and relative atomic mass.
b) Iodine-131 has a mass number of 131. Calculate the number of neutrons in one atom of this isotope, given that its atomic number is 53.

c) Explain why the relative atomic mass of iodine listed on the periodic table is closer to 127 than to 131.

69. At the Kilembe Mines copper smelting plant near Kasese,Engineer Amanya faced a pressing quality control issue. A major shipment of copper anodes, destined for use in the Mukono electrical wiring factory, was suspected of contamination. Pure copper is vital for optimal electrical conductivity, and even small impurities could degrade the performance of the wires. He knew that natural copper consists primarily of two stable isotopes: Copper-63 with an isotopic mass of 62.930 amu and a natural abundance of 69.17%, and Copper-65 with an isotopic mass of 64.928 amu and an abundance of 30.83%. He ordered a mass spectrometric analysis of the suspect batch. The results showed a slight but significant deviation from the standard isotopic ratio, indicating contamination with a foreign material that was altering the overall atomic mass. Engineer Tibuhaburwa now had to calculate the exact extent of this deviation, identify which copper isotope was being disproportionately affected by the contaminant, and recommend a process to rectify the issue to ensure Uganda's electrical products meet international quality standards and support the country's growing infrastructure development.

Task:

a) Calculate the accurate relative atomic mass of pure copper.
b) If the contaminated sample was found to have a lower relative atomic mass than pure copper, which isotope (Cu-63 or Cu-65) would you expect to be less abundant in that sample? Explain your answer.
c) Suggest a potential industrial method that could be used to separate isotopes, albeit on a small scale, to understand the nature of the contamination.

70. At the AgroPlus fertilizer plant in Jinja,the chief chemist, Mr. Ochieng, faced a critical production challenge. A large international order for ammonium sulfate fertilizer, crucial for boosting maize yields in the country, was due for shipment. The production team had prepared a massive batch, resulting in a 10 kg bag of pure ammonium sulfate, $(NH_4)_2SO_4$. However, to ensure precise quality control, accurate labeling, and correct pricing, Mr. Ochieng needed to determine the exact number of moles contained in each bag. This information was vital not only for inventory and sales but also for the farmers who relied on precise application rates to optimize their crop nutrition without causing environmental damage through overuse. He gathered his team and emphasized the importance of the mole concept as a bridge between the microscopic world of atoms and the macroscopic world of grams and kilograms, which they could measure in the factory. Understanding this would allow them to calculate the number of fundamental formula units and, specifically, the number of ammonium ions (NH_4^+), which are the key source of nitrogen for plants. This calculation was essential to guarantee that the fertilizer met the stated nutritional grade and complied with the standards set by the Uganda National Bureau of Standards.

Task:

a)Calculate the molar mass of ammonium sulfate, $(NH_4)_2SO_4$. (N=14, H=1, S=32, O=16)

b)How many moles of ammonium sulfate are present in the 10 kg bag?

c)Calculate the number of ammonium ions (NH_4^+) present in the bag.

71. During a practical chemistry lesson at Mengo Secondary School,the advanced-level students were conducting a titration to master the concepts of concentration and moles. The experiment involved neutralizing 25 cm^3 of a 2.0 M hydrochloric acid (HCl) solution with a standard sodium hydroxide (NaOH) solution. The teacher, Mr. Kato, explained that this simple reaction,

$HCl + NaOH \rightarrow NaCl + H_2O$, was fundamental to many industrial processes in Uganda, from treating acidic waste at the Nile Breweries to controlling pH in food processing. He tasked the students with calculating the exact amount of sodium hydroxide required for complete neutralization. One student, Sarah, carefully performed the titration, reaching the pale pink endpoint of the phenolphthalein indicator. However, to verify her practical skills, Mr. Kato also required the theoretical calculations. He then presented a follow-up challenge: if the sodium hydroxide solution available was more dilute, with a concentration of only 0.5 M, how would that affect the volume needed? This exercise was designed to reinforce the direct relationship between moles, concentration, and volume, and to highlight the importance of accurate calculations in preparing reagents for medical laboratories and water quality testing across the country.

Task:

a)Calculate the number of moles of hydrochloric acid in the 25 cm^3 of 2M solution used.
b)Determine the number of moles of sodium hydroxide required for complete neutralization.

c)If the sodium hydroxide solution had a concentration of 0.5 M, calculate the volume of it that would be required for the reaction.

72. A chemistry teacher at St.Josephs Seminary, Bushenyi, Mrs. Acheng, was demonstrating the principle of stoichiometry through the combustion of methane gas, the primary component of the natural gas used in their laboratory Bunsen burners. She ignited the burner and adjusted it to a clean, blue flame, explaining that this represented the complete combustion of methane (CH_4) according to the equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. To make the concept tangible, she posed a problem to her Senior Five class: if she were to burn exactly 8 grams of methane gas, how could they predict the amount of oxygen consumed and the resulting carbon dioxide produced? She emphasized that such calculations were not just academic; they were crucial for environmental science, helping to understand greenhouse gas contributions from different fuel sources, and for engineers designing biogas systems that are becoming increasingly common in rural Uganda. The students had to use the mole concept to navigate from the mass of a reactant to the moles of another reactant and finally to the mass of a product, thereby solving a real-world problem relevant to Uganda's energy and environmental landscape.

Task:

a) Calculate the number of moles in 8 grams of methane (CH_4). (C=12, H=1)
b) Using the reaction equation, determine the number of moles of oxygen gas (O_2) required to burn this methane completely.
c) What mass of carbon dioxide (CO_2) would be produced from this reaction?

73. The low-lying,frequently flooded community of Katwe in Kampala has long battled a pervasive problem: the rapid rusting of corrugated iron roofing sheets. A community development officer, Mr. Ochieng, decided to use this issue to educate local youth volunteers about the chemistry of corrosion. He explained that rust is a form of hydrated iron(III) oxide, and its formation is a complex reaction involving iron, oxygen from the air, and water. He simplified the process for the demonstration,

representing rust as Fe_2O_3. Mr. Ochieng tasked the group with writing a balanced chemical equation to understand the reactants and products. He then linked this knowledge to practical prevention methods, asking them to suggest ways to stop the reaction by excluding one of the essential reactants. Finally, to quantify the problem, he presented a calculation: if a typical roofing sheet contained 112g of iron that rusted completely, how much mass would be added in the form of rust? This exercise aimed to empower the community with scientific knowledge, helping them make informed decisions about material protection and saving significant costs in household maintenance.

Task:

a) Write a balanced chemical equation for the formation of rust (iron(III) oxide) from iron and oxygen.
b) State two ways, based on the reaction, to prevent iron from rusting.
c) If 112g of iron rusts completely, calculate the mass of iron(III) oxide produced. (Fe=56, O=16)

74. The science club at Kampala Parents' School was in a frenzy of preparation for the annual national science fair. Their flagship project was a spectacular model volcano that would "erupt" using a classic chemical reaction: the reaction between baking soda (sodium hydrogencarbonate, $NaHCO_3$) and vinegar (a dilute solution of ethanoic acid, CH_3COOH). The students, led by their president David, knew the reaction produced sodium ethanoate, water, and the carbon dioxide gas that caused the foaming eruption. To ensure a dramatic and controlled eruption, they needed to master the stoichiometry. They decided to use 8.4g of baking soda for the final demonstration. David gathered his team to plan the experiment, emphasizing the need to write a balanced equation first to understand the mole ratios. They then needed to calculate the exact amount of carbon dioxide gas this would produce to predict the volume of the "lava" flow. Understanding this relationship between the mass of a solid reactant and the volume of a gaseous product was key to making their project both visually impressive and scientifically accurate, demonstrating important principles of chemical reactions to the judges and audience.

Task:

a) Write a balanced chemical equation for the reaction between sodium hydrogencarbonate and ethanoic acid.
b) The students use 8.4g of baking soda. Calculate the number of moles used.
c) Determine the volume of carbon dioxide gas produced at room temperature from this amount. (Molar gas volume at RTP = 24 dm^3)

75. The massive rotary kilns at the Tororo Cement Factory work tirelessly,heating limestone (calcium carbonate, $CaCO_3$) to high temperatures in a process known as calcination. Mr. Ogwang, a process engineer, was tasked with optimizing fuel efficiency and output for the plant. The key reaction, the thermal decomposition of limestone into quicklime (calcium oxide, CaO) and carbon dioxide gas, is the heart of cement production. He was reviewing the process data when he was interrupted by a group of visiting engineering students from Busitema University. He used the opportunity for an impromptu lecture, starting with the importance of writing a balanced chemical equation for the decomposition. He then presented a real-world problem: for a typical production run processing 50 tonnes of pure limestone, how much quicklime could the plant expect to produce? He explained that this calculation was fundamental to predicting yield, managing inventory, and calculating the carbon footprint of their operations. Finally, he connected the chemistry to its

application, questioning the students on the vital role quicklime plays in the construction industry, thus linking the abstract chemical reaction to the tangible development of Uganda's infrastructure.

Task:

a)Write a balanced chemical equation for the thermal decomposition of calcium carbonate.
b)Calculate the mass of quicklime (CaO) produced when 50 tonnes of pure limestone is completely decomposed. (Ca=40, C=12, O=16)

c)State one major use of quicklime (CaO) in the construction industry.

76. A technician at Makerere University repairs a photocopier,explaining that its drum is coated with selenium. Its specific electron configuration allows it to conduct electricity when exposed to light, forming an electrostatic image. Selenium (atomic number 34) is in the same group as oxygen. The technician needs to document how selenium's electron configuration makes it suitable for this application compared to its lighter counterpart, sulfur. Understanding this atomic property is key to maintaining office equipment across Uganda's institutions.

Task:

a) Write the electron configuration of a selenium atom.
b) Explain what happens to the electron configuration when selenium forms the Se^{2-} ion.
c) State the number of unpaired electrons in a selenium atom.

77. At the Gaba Water Treatment Plant,a chemist uses aluminium sulfate (alum) as a coagulant. The Al^{3+} ion's electron configuration allows it to attract impurities, clarifying water for Kampala. The chemist trains new staff on why aluminium, a Period 3 metal, forms a 3+ ion and how this relates to its position in the periodic table and its reactivity, ensuring effective and safe water purification practices.

Task:

a) Write the electron configuration of an aluminium atom (atomic number 13).
b) Write the electron configuration of an Al^{3+} ion.
c) State which noble gas has the same electron configuration as the Al^{3+} ion.

78. An engineer at a Namanve lighting company designs LEDs.She uses gallium (atomic number 31) in semiconductors. The color of light emitted depends on energy gaps influenced by gallium's electron configuration. She must select elements with specific electronic structures to produce different colors for traffic lights and displays, supporting Uganda's growing electronics sector.

Task:

a) Write the electron configuration of a gallium atom using subshell notation.
b) Identify the block (s, p, d, f) in the periodic table where gallium is located.
c) State whether a gallium atom is paramagnetic or diamagnetic. Explain your answer.

79. At the Uganda Cancer Institute,a radiographer uses Cobalt-60 for radiotherapy. Its beta and gamma radiation target cancer cells. The source has a half-life of 5.27 years and must be replaced when its activity diminishes to ensure consistent treatment doses. Understanding its decay process and half-life is critical for patient safety and effective cancer care in the country.

Task:

a) Write a balanced nuclear equation for the beta decay of Cobalt-60.
b) Calculate the percentage of a Cobalt-60 sample that would remain after 21 years. c)State why gamma radiation is particularly suitable for radiotherapy.

80. Archaeologists at the Bigo bya Mugenyi site use Carbon-14 dating on a wooden artifact. They find it has 25% of the original Carbon-14 activity. This isotope decays predictably, with a half-life of 5730 years, allowing them to accurately date the ancient settlement and understand Uganda's early history. The team must calculate the artifact's age to confirm the site's timeline.

Task:

a) Write the nuclear equation for the beta decay of Carbon-14.
b) Given the half-life is 5730 years, calculate the age of the wooden artifact.
c) State one assumption made in Carbon-14 dating.

81. In a Jinja steel mill,a quality controller uses a Strontium-90 source in a thickness gauge. The beta particles penetrate the steel sheets; weaker signals indicate thicker sheets. Strontium-90 has a half-life of 28.8 years. The source must be replaced once its activity falls below 10% to maintain quality control in manufacturing.

Task:

a) Strontium-90 decays to Yttrium-90. Write the nuclear equation for this decay.
b) Calculate how long the source can be used before replacement.
c) State why a beta emitter is preferred over an alpha emitter for this application.

82. At Lake Katwe,a salt farmer harvests sodium chloride crystals. A visiting chemist explains that the strong ionic bonds in NaCl give it a high melting point and solubility. These bonds form when sodium atoms lose electrons to chlorine atoms, creating a lattice of Na^+ and Cl^- ions. This structure is why the salt dissolves in lake water but forms solid crystals when the water evaporates.

Task:

a) Describe how an ionic bond forms between sodium and chlorine atoms.
b) Explain why solid sodium chloride does not conduct electricity but does so when molten.
c) State the coordination number of each ion in the sodium chloride crystal lattice.

83. An electrician in Kampala uses copper for wiring due to its excellent conductivity from metallic bonding.In this bond, copper atoms release electrons into a 'sea' that moves freely, carrying current. This same delocalized electron pool allows copper to be malleable, drawn into wires for Uganda's expanding electrical grid without breaking the material.

Task:

a) Describe the nature of metallic bonding in copper.
b) Explain how metallic bonding accounts for the high electrical conductivity of copper.

c) State why copper is malleable and can be drawn into wires.

84. At Tororo Cement,magnesium oxide lines furnaces as a refractory. The engineer explains that the high melting point is due to strong ionic bonding between Mg^{2+} and O^{2-} ions. The high charges and small sizes of the ions create a very strong electrostatic attraction, making MgO capable of withstanding extreme temperatures during clinker production.

Task:

a) Compare the strength of ionic bonding in magnesium oxide with that in sodium chloride, giving a reason.
b) Write the electron configuration of Mg^{2+} and O^{2-} ions.
c) Calculate the percentage ionic character in the Mg-O bond (electronegativity: Mg=1.2, O=3.5).

85. An anesthetist at Mulago Hospital uses nitrous oxide(N_2O). A student asks about its structure. The doctor explains that its linear shape and specific bonding make it suitable as an anesthetic. Understanding its Lewis structure and properties ensures safe and effective use in surgical procedures, a key skill for medical professionals in Uganda.

Task:

a) Draw the Lewis structure for N_2O.
b) Use VSEPR theory to predict the molecular shape of N_2O.
c) State the approximate bond angle in the molecule.

86. At the National Water plant,ozone (O_3) purifies water. Its effectiveness stems from its molecular structure and unstable bonding. A chemist explains that ozone's resonance structures and bent shape make it a powerful oxidizing agent that destroys bacteria and organic impurities, ensuring safe drinking water for urban populations.

Task:

a) Draw the resonance structures of ozone (O_3).
b) Predict the O-O-O bond angle in ozone.
c) Calculate the average bond order for each O-O bond in ozone.

87. At a dairy farm,ammonia (NH_3) is used in refrigeration. The technician explains that its polarity, due to its trigonal pyramidal shape and lone pair, allows it to dissolve readily in water. This high solubility is essential for its use in liquid fertilizers, a major input for Uganda's agricultural sector, unlike non-polar methane.

Task:

a) Use VSEPR theory to predict the molecular shape of ammonia (NH_3).
b) State and explain the bond angle in ammonia.
c) Explain why ammonia is highly soluble in water while methane is not.

88. At Mbarara University of Science and Technology,chemistry researchers discovered an unknown metallic element in mineral samples from the Kigezi highlands. Initial analysis showed properties similar to calcium but with higher density. The element appeared to occupy a position between calcium and titanium in the periodic table, suggesting it belonged to Group 3. Professor Mugisha and his research team needed to classify this element accurately to understand its potential applications in Uganda's growing technology sector. They conducted detailed tests to determine its electron configuration and chemical behavior, comparing it with known elements in the same period. The discovery prompted important discussions about how Moseley's work established the modern periodic law based on atomic number rather than atomic mass, which would be crucial for correctly placing this new element. The research team worked to predict its likely physical and chemical properties based on its position, considering how it might be used in alloy production or electronic components to support local industries.

Task:

a) State the block (s, p, d, or f) in which this Group 3 element would be located.
b) Predict two physical properties of this element based on its position in the periodic table.
c) Explain how Moseley's work led to the modern arrangement of the periodic table.

89. Engineers at the Uganda Industrial Research Institute were developing semiconductor materials for solar panel production.They focused on element X from Period 3, Group 14, which showed ideal semiconductor properties with its intermediate electrical conductivity. Dr. Nakiwala and her team investigated why this element's atomic radius decreased compared to the element above it in the same group, despite having more electrons. They explored how doping this element with small amounts of phosphorus from Group 15 would alter its electrical properties, creating n-type semiconductors suitable for renewable energy applications. This research aimed to reduce Uganda's dependence on imported electronic components while promoting clean energy solutions. The team documented how the periodic trends in atomic structure directly influenced the element's technological applications, providing valuable insights for training technicians in the emerging electronics manufacturing sector.

Task:

a) Identify element X from Period 3, Group 14.
b) Explain why the atomic radius of element X is smaller than that of the element above it in the same group.
c) Predict how the electrical conductivity of element X changes when it is doped with an element from Group 15.

90. At the Kabaale Petroleum Refinery,chemical engineers optimized a catalytic cracking process using a transition metal catalyst. Mr. Okello explained to junior engineers how the catalyst's position in the d- block provided unique electronic properties that enhanced the breakdown of heavy petroleum fractions into gasoline. The team analyzed how the incomplete d-subshell in these elements allowed for variable oxidation states and complex formation, crucial for catalytic activity. They compared different transition metals across the same period to identify the most cost-effective catalyst for Uganda's specific crude oil composition. This understanding helped improve fuel production efficiency while reducing operational costs, contributing to the country's goal of petroleum self-sufficiency. The training emphasized how periodic table knowledge directly impacted industrial process optimization in Uganda's emerging oil and gas sector.

Task:

a) State two characteristic properties of transition metals that make them good catalysts.
b) Explain how the electronic configuration of transition metals contributes to these properties.
c) Identify which period contains the largest number of transition metals.

91. Researchers at Kyambogo University's Materials Science Department were developing advanced battery systems for Uganda's renewable energy storage needs.Dr. Kigozi and his team systematically studied Period 3 elements to identify optimal anode materials. They documented how atomic radius decreased from sodium to argon due to increasing nuclear charge, while ionization energy generally increased across the period. The team encountered the unexpected drop in ionization energy between Groups 2 and 13, which they explained through electron sub-shell theory. They also analyzed the dramatic variation in melting points, from sodium's low melting metal to silicon's giant covalent structure and phosphorus' molecular solid form. This comprehensive understanding of periodic trends enabled them to select the most promising materials for developing affordable, efficient batteries suited to Uganda's climate and energy requirements.

Task:

a) Explain the general trend in atomic radius across Period 3 from sodium to argon.
b) State which element in Period 3 has the highest ionization energy and explain why.
c) Predict how the melting points of the elements change across Period 3, explaining the trend.

92. At the Gaba Water Treatment Plant,chemists were comparing aluminium and beryllium compounds for removing impurities from Lake Victoria water. Ms. Namutebi noticed unexpected similarities in their chemical behavior despite their different group positions. She organized a training session to explain the diagonal relationship between beryllium (Group 2) and aluminium (Group 13), highlighting how their similar charge densities led to comparable properties. The team examined how both elements formed covalent compounds, exhibited amphoteric characteristics in their oxides and hydroxides, and resisted reaction with water unlike their group members. This understanding helped optimize chemical usage in water treatment, ensuring effective purification while minimizing costs and environmental impact for Uganda's largest water treatment facility.

Task:

a) Identify the diagonal relationship between beryllium and aluminium.
b) State two chemical properties that show this diagonal relationship.
c) Explain why beryllium chloride is covalent while magnesium chloride is ionic.

93. At a technology innovation hub in Kampala,engineers were characterizing silicon for local semiconductor device manufacturing. Mr. Ssebagala explained silicon's intermediate properties between its periodic neighbors aluminium and phosphorus. The team analyzed trends across Period3, noting how electrical conductivity decreased from metallic sodium to semi-conducting silicon and further to insulating phosphorus and sulfur. They investigated why silicon's giant covalent structure gave it a much higher melting point than molecular phosphorus. The engineers also documented how the acid-base character of oxides transitioned from basic through amphoteric to acidic across the period, information crucial for understanding silicon dioxide's role in semiconductor fabrication. This knowledge supported Uganda's nascent electronics industry in selecting appropriate materials for device manufacturing.

Task:

a) Describe the trend in electrical conductivity across Period 3 elements.
b) Explain why silicon has a much higher melting point than phosphorus.
c) State how the acid-base character of oxides changes across Period 3

94. A Kampala pharmaceutical company was developing a new antacid formulation using Group 2 elements.Dr. Nalubwama and her research team tested various compounds to identify the most effective and safest option for neutralizing stomach acid. They evaluated magnesium, calcium, and barium compounds, analyzing reaction rates and neutralization capacities. The team noted that while barium hydroxide was most effective chemically, its toxicity made it unsuitable for medicinal use. They documented the increasing solubility of hydroxides down the group and related this to reaction efficiency. Safety considerations led them to select magnesium hydroxide as the optimal active ingredient, providing effective relief while ensuring patient safety. The research contributed to developing affordable gastrointestinal medications for the Ugandan market.

Task:

a) Write a balanced chemical equation for the reaction between magnesium hydroxide and stomach acid (HCl).
b) Explain why barium compounds are not suitable for use in antacids despite being better at neutralizing acid.
c) Predict how the solubility of hydroxides changes down Group 2.

95. A Jinja-based pyrotechnics company was developing new colored fireworks for Uganda's independence celebrations.Mr. Mukasa experimented with Group 2 elements to create vibrant flame colors: calcium for orange-red, strontium for crimson, and barium for green. He explained to his production team how the flame test results from electrons in these metals being excited by the flame's heat and emitting characteristic colors as they return to ground state. The team also studied the thermal stability trends of Group 2 carbonates, noting how decomposition temperatures increased down the group due to decreasing cation polarizing power. This understanding helped them create stable, colorful pyrotechnic compositions that met safety standards while providing spectacular visual displays.

Task:

a) State the color of the flame produced by barium compounds.
b) Explain why Group 2 elements produce characteristic flame colors.
c) Describe the trend in thermal decomposition of Group 2 carbonates down the group.

96. The National Water and Sewerage Corporation conducted a comprehensive survey of water hardness across Uganda.Ms. Arach and her team analyzed samples from different regions, finding high concentrations of Group 2 ions in areas with limestone geology. They identified calcium and magnesium ions as the primary causes of both temporary and permanent hardness. The team educated community water committees about removing temporary hardness through boiling, which precipitates calcium carbonate. They explained the puzzling trend of decreasing sulfate solubility down Group 2 while hydroxide solubility increased, relating this to lattice and hydration energy changes. This knowledge helped design appropriate water treatment methods for different regions of Uganda.

Task:

a) Identify which Group 2 elements commonly cause water hardness.
b) Write a balanced chemical equation to show how temporary hardness can be removed by boiling.
c) Explain why the solubility of sulfates decreases down Group 2 while that of hydroxides increases.

97. A small enterprise in Kampala,"WarmUg," is developing a reusable hand warmer for farmers and motorcycle riders during cold mornings. The design uses a supersaturated solution of sodium acetate that releases heat when crystallized. The lead chemist, Sarah, must create an energy profile diagram to explain this exothermic process to her team. She illustrates how the products have lower energy than the reactants, with the difference being the enthalpy change (ΔH), released as heat. Sarah emphasizes the importance of activation energy, which is provided by flexing the metal disc in the pouch, initiating crystallization. She also explains how the hand warmer can be "recharged" by boiling, which makes the process endothermic, absorbing heat to re-dissolve the crystals. Understanding these energy profiles helps the team optimize the formulation for maximum heat output and durability, supporting local innovation in personal thermal comfort products.

Task:

a) Draw a fully labeled energy profile diagram for the exothermic crystallization process.
b) Define the term 'activation energy' and show it on your diagram.
c) State how the energy profile would differ for the endothermic recharging process.

98. A sports clinic in Jinja is designing an instant cold pack for treating athletes'injuries using ammonium nitrate and water. The head physiotherapist, Coach James, needs to explain the science to his staff. He describes how the dissolution of ammonium nitrate in water is endothermic, absorbing heat from the surroundings and causing the temperature to drop. He sketches an energy profile showing the reactants at a lower energy level than the products, with a positive ΔH. Coach James highlights the role of activation energy in starting the dissolution process, which occurs when the inner pouch is broken and the chemicals mix. Understanding this helps the staff use the cold packs effectively for immediate injury management, reducing swelling and pain for players in local football tournaments and athletics competitions.

Task:

a) Draw a fully labeled energy profile diagram for the endothermic dissolution of ammonium nitrate.
b) State the sign (positive or negative) of ΔH for this process and justify your answer.
c) Explain how the energy profile relates to the cooling effect experienced.

99. At the Hima Cement plant,engineers are analyzing the energy changes in limestone decomposition to improve fuel efficiency. The process engineer, Mr. Omondi, explains that heating calcium carbonate to form quicklime and carbon dioxide is highly endothermic. He presents an energy profile diagram showing the reactants at a lower energy level than the products, with a large activation energy barrier overcome by the kiln's heat. Mr. Omondi discusses how understanding this profile helps in selecting better insulation and alternative fuels to reduce energy costs. He also links this to Uganda's industrial growth, where cement is vital for infrastructure, and efficiency gains can lower production costs and environmental impact.

Task:

a) Write a balanced chemical equation for the decomposition of limestone (calcium carbonate).
b) Sketch an energy profile diagram for this reaction, clearly showing the enthalpy change.
c) State whether this reaction is endothermic or exothermic, based on your diagram.

100. Scientists at the Ministry of Defence are researching hydrazine(N_2H_4) as a potential rocket fuel. Due to safety concerns, they cannot directly measure its enthalpy of formation in the lab. Dr. Amina and her team use Hess's Law, constructing a cycle from the enthalpies of combustion of hydrazine, nitrogen, and hydrogen. They explain how the law allows them to calculate the unknown enthalpy change indirectly, using known values from data tables. This method ensures accuracy while minimizing risks. The research aims to develop propulsion technology for satellite launch vehicles, positioning Uganda in the African space industry.

Task:

a) Define the term 'standard enthalpy of formation'.
b) Construct a Hess's Law cycle to show how the enthalpy of formation of hydrazine can be determined from combustion data.
c) State why Hess's Law is particularly useful in determining enthalpy changes that are difficult to measure directly.

101. A nutritionist at Mulago Hospital is analyzing the energy content of a new high-energy food bar for athletes and patients.Using a calorimeter, she measures the enthalpy of combustion of the bar's ingredients. She then applies Hess's Law to calculate the energy available per gram, constructing a cycle that links the combustion data to the formation enthalpies of the products (CO_2 and H_2O). This helps in accurately labeling the food bar with its caloric content, ensuring it meets dietary standards and supports health initiatives in Uganda.

Task:

a) Define the term 'enthalpy of combustion'.
b) Construct a Hess's Law cycle showing how the enthalpy of formation of a food component can be determined from its enthalpy of combustion.
c) Calculate the energy content per gram of a substance given relevant enthalpy data.

102. At a Lugazi-based chemical plant,engineers are optimizing ethanol production from ethene and steam. The reaction is exothermic, but direct measurement of ΔH is complex. Using Hess's Law, the team constructs a cycle involving the combustion enthalpies of ethene, ethanol, and water. This allows them to calculate the reaction enthalpy accurately, ensuring efficient heat management in the reactor. The project supports local biofuel production, reducing Uganda's reliance on imported fuels and promoting sustainable energy.

Task:

a) Write a balanced chemical equation for the hydration of ethene to form ethanol.
b) Construct a Hess's Law cycle using enthalpies of combustion to calculate the enthalpy change for this reaction.
c) State two reasons why industrial processes might use reactions that are endothermic.

103. A chemist at Mbarara University is studying the solubility patterns of Group 1 halides.She uses Born- Haber cycles to calculate lattice energies, explaining why salts like sodium chloride have high solubility while others do not. The cycle includes steps like atomization, ionization, and electron affinity, culminating in lattice formation. She shows how lower lattice energy increases solubility, as seen in potassium iodide compared to sodium fluoride. This research aids in selecting salts for pharmaceutical and agricultural use in Uganda.

Task:

a) Define the term 'lattice energy'.
b) Draw a Born-Haber cycle for the formation of sodium chloride.
c) Explain how lattice energy influences the solubility of ionic compounds.

104. At a Tororo-based fertilizer plant,engineers are selecting metal halides as catalysts for ammonia production. They use Born-Haber cycles to compare lattice energies of different halides, as lower lattice energy often correlates with better catalytic activity due to easier dissociation. The cycles help them understand energy changes in formation and dissociation, ensuring optimal catalyst choice for efficient fertilizer synthesis to support Uganda's agriculture.

Task:

a) Draw a Born-Haber cycle for the formation of magnesium chloride.
b) Explain how the cycle can be used to calculate the electron affinity of chlorine.
c) State how lattice energy affects the thermal stability of ionic compounds.

105. Researchers at Makerere University are developing magnesium-ion batteries as a cheaper alternative to lithium-ion.They use Born-Haber cycles to analyze the lattice energies of magnesium compounds, which influence ion mobility and battery efficiency. The cycles help identify compounds with optimal energy profiles for repeated charging and discharging. This innovation could lead to affordable energy storage solutions for rural Uganda, promoting renewable energy use.

Task:

a) Draw a Born-Haber cycle for the formation of magnesium oxide.
b) Explain why magnesium oxide has a higher lattice energy than sodium chloride.
c) State how lattice energy impacts the performance of battery materials.

106. The Uganda National Bureau of Standards launched an investigation into suspected fuel adulteration at several Kampala petrol stations.Chemists analyzed samples and found unusual mixtures of hydrocarbons. Dr. Mbabazi, the lead investigator, needed to classify the organic compounds present to identify the contaminants. His team identified alkanes, alkenes, and alkynes using chemical tests and spectroscopic methods. They explained how the unique nature of carbon, with its ability to form single, double, and triple bonds, creates diverse homologous series with different properties. The investigation revealed that adulterers were mixing cheaper alkynes with petrol, compromising fuel quality and damaging vehicle engines. This case highlighted the importance of understanding organic compound classification and functional groups in protecting Ugandan consumers and maintaining fuel standards.

Task:

a) Explain the unique nature of carbon that allows it to form diverse organic compounds.

b) Describe how you would distinguish between an alkane, alkene, and alkyne using chemical tests.
c) State the general molecular formula for a straight-chain alkyne and name the first member of this homologous series.

107. At a pharmaceutical manufacturing plant in Entebbe,quality control chemists were struggling with inconsistent naming of organic compounds in their documentation. This led to confusion in importing raw materials and exporting finished drugs. The chief pharmacist organized intensive training on IUPAC nomenclature, emphasizing its importance in global trade and patient safety. The trainees practiced naming complex molecules with multiple functional groups, including alcohols, aldehydes, and carboxylic acids. They learned to identify parent chains, number carbon atoms correctly, and prioritize functional groups according to IUPAC rules. This standardization improved communication with international suppliers and regulators, ensuring Uganda's pharmaceuticals met global standards.

Task:

a) Name the following compound using IUPAC rules: CH_3-CH_2-CH(OH)-CH_3
b) Draw the structural formula for 2-methylpropan-1-ol
c) Explain why systematic IUPAC naming is preferable to common names in pharmaceutical manufacturing

108. A chemical engineer at a Jinja-based paint factory was troubleshooting quality issues with their industrial solvents.She suspected that different structural isomers in their hydrocarbon solvents were causing inconsistent evaporation rates and finish quality. The engineer conducted a detailed isomer analysis, identifying chain, position, and functional group isomers in their solvent mixtures. She demonstrated how isomers with branched structures evaporated faster than straight-chain counterparts, while positional isomers of alcohols showed different solubility properties. This understanding allowed the factory to optimize their solvent blends for specific applications, improving product quality and reducing waste in Uganda's growing manufacturing sector.

Task:

a) Define the term 'structural isomerism'
b) Draw and name all possible structural isomers of pentanol ($C_5H_{11}OH$)
c) Explain how structural isomerism affects the physical properties of organic compounds

109. The discovery of natural gas reserves in the Bunyoro region prompted the government to develop utilization strategies.Chemical engineers from Makerere University analyzed the gas composition, finding mainly methane with smaller alkanes. They educated local communities about alkane properties and combustion characteristics, emphasizing complete combustion for clean energy. The team also demonstrated substitution reactions of alkanes with chlorine under UV light, explaining how these reactions could be used to produce chlorinated solvents for local industries. This knowledge transfer empowered communities to participate in value addition to their natural resources.

Task:

a) Write balanced equations for the complete and incomplete combustion of methane
b) Describe the mechanism of free radical substitution in the reaction of methane with chlorine
c) State two environmental concerns associated with alkane combustion

110. An agricultural engineer in Masaka was designing ethylene-based fruit ripening chambers for banana farmers.She needed to explain the chemistry of alkenes to farmers, focusing on ethylene's role as a plant hormone. The engineer demonstrated addition reactions of alkenes with bromine water and acidified potassium permanganate, showing how these tests confirm double bond presence. She also explained polymerization of ethene to make polyethylene plastics for fruit packaging. This integrated approach helped farmers understand both the ripening process and value addition opportunities for their produce.

Task:

a) Describe how you would test for the presence of a double bond in an organic compound
b) Write the mechanism for the addition of hydrogen bromide to ethene
c) Explain how Ziegler-Natta catalysts improve the polymerization of ethene

111. A vocational training institute in Kasese was developing safety protocols for oxy-acetylene welding.The chemistry instructor needed to explain alkyne properties and reactions to welding students. He demonstrated the combustion of acetylene with pure oxygen, producing the high-temperature flame needed for welding. The training covered the linear structure of alkynes, their acidity compared to alkanes and alkenes, and safe handling procedures to prevent explosive decomposition. Students learned to identify alkyne functional groups and understand their unique reactivity patterns.

Task:

a) Write the equation for the complete combustion of acetylene (ethyne)
b) Explain why terminal alkynes are more acidic than other hydrocarbons
c) Describe the test used to distinguish between terminal and internal alkyne

112. At an agricultural research station in Mbale,chemists were developing environmentally friendly pesticides based on alkyl halides. They needed to understand the reactivity of different halogen compounds to design effective but biodegradable formulations. The team studied nucleophilic substitution reactions of primary, secondary, and tertiary alkyl halides with hydroxide ions, noting how structure affects reaction mechanism (SN1 vs SN2). They also investigated elimination reactions that could produce unwanted alkene byproducts. This research aimed to create targeted pesticides that would break down safely in Uganda's tropical environment.

Task:

a) Compare the mechanisms of SN1 and SN2 reactions in alkyl halides
b) Explain how the nature of the halogen affects the reactivity of alkyl halides
c) State two factors that favor elimination over substitution in alkyl halides

113. A Kampala-based pharmaceutical company was optimizing the synthesis of an antimalarial drug containing chlorine atoms.The process development chemists needed to select the best method for introducing halogen atoms into the organic molecule. They compared free radical halogenation, electrophilic addition to alkenes, and halogen exchange reactions. The team also studied the environmental impact of different halogenated intermediates, choosing the most sustainable pathway that minimized toxic waste generation while maintaining high yield for affordable drug production.

Task:

a) Describe the free radical mechanism for the chlorination of methane
b) Write the reaction for the addition of bromine to ethene
c) Explain why aryl halides are less reactive than alkyl halides in nucleophilic substitution

114. An environmental NGO in Wakiso District launched a program to recycle chlorinated solvents from automotive and dry-cleaning businesses.The project chemist needed to educate participants about the properties and safe handling of alkyl halides. She explained their density, boiling points, and immiscibility with water, which made them useful as solvents but also environmental hazards. The training covered proper disposal methods and chemical reactions that could detoxify these compounds before release into the environment.

Task:

a) Explain why many alkyl halides are immiscible with water despite their polar C-X bond
b) Describe the reaction of alkyl halides with alcoholic potassium hydroxide
c) State two environmental concerns associated with chlorinated solvents

115. A major industrial plant in Namanve that uses benzene as a solvent was undergoing a safety audit after several workers reported health issues.The safety officer, Mr. Tumwebaze, had to educate the staff about the unique structure and stability of benzene. He explained the concept of resonance and delocalized pi- electrons, which give benzene its unusual stability compared to alkenes. Mr. Tumwebaze demonstrated how this stability affects benzene's reactions, making it undergo electrophilic substitution rather than addition. He contrasted this with methyl benzene (toluene), which the plant was considering as a safer alternative due to its lower toxicity and higher reactivity in side-chain reactions. The audit concluded with recommendations to switch to methyl benzene where possible and implement stricter handling procedures for benzene.

Task:

a) Explain the resonance structure of benzene and how it contributes to its unusual stability.
b) Compare the reactivity of benzene and methyl benzene towards electrophilic substitution.
c) State two reasons why methyl benzene is considered a safer industrial solvent than benzene.

116. A small-scale dye manufacturing cooperative in Jinja was exploring ways to produce azo dyes for the local textile industry.Their chemist, Ms. Nalubega, chose methyl benzene as the starting material due to its enhanced reactivity in electrophilic substitution compared to benzene. She explained to the cooperative members how the methyl group activates the benzene ring and directs incoming electrophiles to the ortho and para positions. The team practiced nitration and sulfonation reactions, carefully controlling conditions to achieve the desired substitution patterns. This project aimed to reduce Uganda's reliance on imported textile dyes and create employment opportunities in the chemical industry.

Task:

a) Describe the mechanism of nitration in methyl benzene.
b) Explain why the methyl group in methyl benzene is ortho-para directing.
c) Write the reaction for the oxidation of the side chain in methyl benzene.

117. Environmental scientists from Makerere University were investigating benzene contamination in an industrial area of Kampala.They needed to understand benzene's chemical behavior to develop effective remediation strategies. The team studied benzene's resistance to oxidation and addition reactions, which makes it persistent in the environment. They explored using strong electrophiles to substitute hydrogen atoms with more biodegradable groups. The research also covered the health effects of benzene derivatives, particularly their carcinogenic properties, to raise awareness in affected communities and push for stricter industrial regulations.

Task:

a) Explain why benzene resists addition reactions that are typical of alkenes.
b) Describe the health and environmental impacts of benzene and its derivatives.
c) Suggest a chemical method that could make benzene less hazardous in contaminated soil.

118. The Tororo Industrial Park fertilizer plant was struggling with low ammonia production efficiency in their Haber process operation.Engineer Okot gathered his team to analyze the equilibrium principles governing the reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. They calculated the equilibrium constant Kc and found it was temperature-dependent. The team investigated how reaction conditions affected the equilibrium position, recognizing that while high pressure favored ammonia formation, operational costs increased significantly. They used Le Chatelier's principle to predict how changes in temperature, pressure, and concentration would shift the equilibrium, ultimately optimizing conditions for maximum yield while considering economic constraints in the Ugandan context.

Task:

a) Write the equilibrium constant expression (Kc) for the Haber process.
b) Use Le Chatelier's principle to explain how increasing pressure affects ammonia yield.
c) Calculate Kc given equilibrium concentrations of reactants and products.

119. Chemistry students at Uganda Martyrs University were determining the equilibrium constant for ester formation in the reaction between ethanol and ethanoic acid.Dr. Kigozi emphasized the dynamic nature of equilibrium, where forward and reverse reactions proceed at equal rates in a closed system. Students carefully measured initial concentrations and used titration to find equilibrium concentrations. They encountered the concept of equilibrium constant and learned that its value indicates the extent of reaction completion. This practical reinforced theoretical knowledge while developing analytical skills relevant to Uganda's food and fragrance industries.

Task:

a) Define a 'dynamic equilibrium' in the context of chemical reactions.
b) Describe an experimental method to determine when equilibrium is established in esterification.
c) Explain what the magnitude of Kc reveals about the position of equilibrium.

120. Environmental scientists monitoring Lake Victoria's water quality needed to understand equilibrium concepts in oxygen dissolution.They explained how the equilibrium between atmospheric oxygen and dissolved oxygen in water is affected by temperature and pressure changes. The team applied Le Chatelier's principle to predict how thermal pollution from industries could decrease oxygen levels, threatening aquatic life. They also studied how the equilibrium shifts with

algal blooms that consume oxygen, providing crucial data for conservation efforts to protect East Africa's largest lake.

Task:

a) Write the equilibrium expression for oxygen dissolution in water.
b) Use Le Chatelier's principle to explain why oxygen solubility decreases with increasing temperature.
c) Suggest two ways to increase dissolved oxygen levels in aquatic ecosystems.

121. A chemical plant in Kasese was establishing sulfuric acid production using the contact process.The engineers faced challenges in optimizing the oxidation of sulfur dioxide:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g).$$

They analyzed how vanadium pentoxide catalyst affects the reaction rate without altering the equilibrium constant. The team balanced the need for high conversion (favored by low temperature) with practical reaction rates (favored by high temperature), ultimately choosing an optimum temperature. They also implemented pressure considerations and removal of product to shift equilibrium rightward, ensuring economic viability for this crucial industrial chemical in Uganda's mining sector.

Task:

a) Write the equilibrium expression for the oxidation of sulfur dioxide.
b) Explain the role of the catalyst in the contact process.
c) Justify the industrial choice of moderate temperature despite thermodynamic predictions.

122. The government was exploring the feasibility of soda ash production from Lake Katwe minerals.Chemical engineers studied the Solvay process equilibrium systems, particularly the reaction between sodium chloride, ammonia, and carbon dioxide. They analyzed multiple equilibria involved and how careful control of temperature and concentration allowed efficient bicarbonate precipitation. The project aimed to reduce Uganda's dependence on imported soda ash, crucial for glass, detergent, and water treatment industries, while creating jobs in the salt mining region.

Task:

a) Identify two equilibrium systems involved in the Solvay process.
b) Explain how the common ion effect is utilized in this process.
c) State one economic benefit of establishing local soda ash production in Uganda.

123. An energy company was designing a methanol plant using syngas from biomass:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g).$$

The process engineers applied equilibrium principles to maximize methanol yield while minimizing production costs. They chose appropriate pressure and temperature conditions and decided on a copper-based catalyst. The team also implemented product removal strategies to shift equilibrium toward methanol formation. This renewable methanol project aligned with Uganda's green energy initiatives and provided an alternative to petroleum-based fuels.

Task:

a) Use Le Chatelier's principle to explain why high pressure favors methanol formation.
b) Describe how continuous removal of methanol affects the equilibrium position. c)Calculate the equilibrium constant given partial pressures of gases.

124. Environmental scientists were alarmed by rising pH levels in Lake Bunyonyi,threatening its unique ecosystem. Investigation revealed that agricultural runoff containing basic salts was causing the problem. The team explained how salts like sodium carbonate undergo hydrolysis, producing hydroxide ions and increasing pH. They conducted tests to measure the hydrolysis constant (Kh) of various salts present in the runoff. Using this data, they predicted the extent of pH change and recommended remediation strategies to local farmers, including using alternative fertilizers that form neutral solutions. This case highlighted the importance of understanding ionic equilibrium in environmental conservation.

Task:

a) Write the hydrolysis reaction for sodium carbonate and explain why it produces a basic solution.
b) Define the hydrolysis constant (Kh) and relate it to Kw and Kb.
c) Calculate the pH of a 0.1M sodium carbonate solution given Kh = 2.1 × 10-4.

125. A research team at Mulago Hospital was developing buffer solutions for storing sensitive medications.They needed to create phosphate buffers that could maintain stable pH despite dilution or addition of small amounts of acids/bases. The team demonstrated how buffer solutions resist pH changes using the equilibrium between $H_2PO_4^-$ and HPO_4^{2-} ions. They calculated exact ratios of acid to conjugate base needed for different pH values and tested buffer capacity. This research was crucial for ensuring drug stability in Uganda's healthcare system, particularly for temperature-sensitive vaccines.

Task:

a)Explain how a phosphate buffer resists pH changes when small amounts of acid are added.
b)Calculate the ratio of $[HPO_4^{2-}]$ to $[H_2PO_4^-]$ needed to prepare a buffer of pH 7.4 (Ka = 6.2 × 10-8).
c)Define 'buffer capacity' and state two factors that affect it.

126. A textile factory in Jinja was struggling with acidic wastewater damaging local water systems.Chemical engineers designed a treatment system using salt hydrolysis principles. They selected appropriate salts that would hydrolyze to produce basic solutions and neutralize the acidic waste. The team calculated exact quantities needed based on hydrolysis constants and monitored the process using pH meters. This solution provided a cost-effective way for Ugandan industries to meet environmental regulations while protecting aquatic life.

Task:

a) Identify which salt would be most effective for neutralizing acidic wastewater: NH_4Cl, Na_2CO_3, or KCl. Explain your choice.
b) Write the hydrolysis equation for your chosen salt.
c) Calculate the amount of salt needed to neutralize 1000L of wastewater at pH 3.0.

127. Urologists at Mengo Hospital noticed an increase in calcium oxalate kidney stones among patients.They launched an educational program explaining the solubility equilibrium of ionic compounds in urine. The doctors demonstrated how the ion product compared to Ksp determines precipitation, and how factors like pH and common ions affect solubility. Patients learned to modify their diet and fluid intake to maintain ion concentrations below Ksp values, significantly reducing stone formation in the Kampala community.

Task:

a) Write the solubility equilibrium expression for calcium oxalate (CaC_2O_4).
b) Explain how the common ion effect reduces calcium oxalate solubility.
c) Calculate whether precipitation will occur when $[Ca^{2+}] = 0.01M$ and $[C_2O_4^{2-}] = 0.001M$ (Ksp = 2.3 × 10-9).

128. Health officials investigated lead poisoning cases in a Kampala neighborhood and traced it to lead pipes.Chemists explained the solubility equilibrium of lead compounds in water, particularly how pH affects lead carbonate and hydroxide solubility. The team used Ksp calculations to predict lead concentrations in different water conditions and recommended optimal pH treatment at the water plant to minimize lead dissolution while ensuring safe drinking water for the affected community.

Task:

a) Write the solubility equilibrium for lead carbonate ($PbCO_3$).
b) Explain how decreasing pH increases lead solubility from pipes. c)Calculate the molar solubility of $PbCO_3$ in pure water (Ksp = 7.4 × 10-14).

129. A chemical company in Tororo was optimizing barium sulfate precipitation for paint pigment production.Engineers needed to maximize yield while controlling particle size by manipulating solubility equilibrium. They studied how temperature, pH, and common ions affected precipitation and used Q (ion product) versus Ksp comparisons to predict exactly when precipitation would begin. This precision allowed them to produce high-quality pigments for Uganda's growing paint industry while minimizing waste.

Task:

a) Write the solubility equilibrium expression for barium sulfate.
b) Explain how adding sodium sulfate affects barium sulfate solubility.
c) Calculate whether a solution containing $[Ba^{2+}] = 0.001M$ and $[SO_4^{2-}] = 0.0001M$ will form a precipitate (Ksp = 1.1 × 10-10).

130. A women's cooperative in Fort Portal was extracting essential oils from local plants using steam distillation.Chemists explained the physical equilibrium between immiscible liquids, where the vapor pressure (and thus boiling point) depends on the mole fractions of both components. The team demonstrated how this principle allows distillation at temperatures below water's boiling point, preserving delicate fragrances. This knowledge helped the cooperative produce high-quality oils for Uganda's growing aromatherapy and cosmetic industries.

Task:

a)Explain why immiscible liquids boil at temperatures lower than their individual boiling points.
b)Calculate the composition of vapor over a mixture of two immiscible liquids.

c)State two advantages of steam distillation over simple distillation for essential oil extraction.

131. A biofuel plant in Masaka was producing ethanol from molasses and needed to separate ethanol-water azeotropes.Engineers explained how positive deviations from Raoult's Law create minimum-boiling azeotropes that limit distillation efficiency. The team explored alternative separation methods including adding a third component to break the azeotrope. This optimization was crucial for producing the 99% ethanol needed for blending with gasoline in Uganda's renewable energy program.

Task:

a) Define 'azeotrope' and explain why ethanol-water mixtures form azeotropes.
b) Sketch a vapor pressure-composition diagram for a solution showing positive deviation from Raoult's Law.
c) Suggest one industrial method for breaking the ethanol-water azeotrope.

132. Engineers were designing a system to recover different salts from Lake Katwe brines using phase diagrams.They explained how the eutectic point in salt-water systems determines the crystallization sequence during evaporation. The team used cooling curves to construct phase diagrams and identified optimal temperatures for harvesting specific salts. This scientific approach maximized salt recovery while minimizing energy costs for this important Ugandan mineral resource.

Task:

a) Define 'eutectic point' in a two-component system.
b) Explain how phase diagrams help in separating salt mixtures.
c) Sketch a simple phase diagram for a salt-water system and label the eutectic point.

133. A malfunctioning freezer at a Kampala blood bank caused plasma to freeze,damaging valuable donations. Pathologists explained how adding glycerol as a cryoprotectant lowers the freezing point via colligative properties. They calculated the exact glycerol concentration needed to prevent freezing at the storage temperature of -30°C. This understanding helped redesign the blood storage system, ensuring safe preservation of life-saving plasma for Ugandan hospitals.

Task:

a) Explain the molecular basis of freezing point depression.
b) Calculate the mass of glycerol needed to prevent 1L of plasma from freezing at -30°C.
c) State why colligative properties depend on the number of solute particles rather than their identity.

134. A pharmaceutical company in Entebbe was investigating why some intravenous fluids caused patient complications.Chemists discovered improper salinity affected osmotic pressure, causing hemolysis or crenation of red blood cells. The team implemented rigorous quality control using freezing point depression measurements to ensure all IV fluids were isotonic with blood. This prevented medical complications and improved patient safety across Ugandan healthcare facilities.

Task:

a)Define 'osmotic pressure' and explain its importance in IV fluids.

b)Calculate the osmotic pressure of a 0.9% NaCl solution at body temperature.

c)Explain what happens to red blood cells in hypotonic and hypertonic solutions.

135. A sugar factory in Lugazi was losing product through inefficient crystallization.Chemical engineers used boiling point elevation calculations to optimize the evaporation process. They determined the exact temperature profiles needed for maximum sugar recovery from molasses while minimizing energy consumption. This optimization increased yield by 15%, significantly boosting profitability for Uganda's important sugar industry.

Task:

a)Explain why adding solute increases the boiling point of a solvent.

b)Calculate the boiling point elevation of a 2m sucrose solution.

c)State two industrial applications of colligative properties other than food processing.

136. A popular brewery in Kampala faced a sudden quality issue:their beer batches were developing a bitter, medicinal off-flavor. The head brewer, Ms. Nakato, suspected contamination during fermentation.

Investigation revealed that cleaning agents containing phenols had contaminated the fermentation tanks. Ms. Nakato had to explain to her team the critical chemical differences between the ethanol they intended to produce and the introduced phenols. She demonstrated how phenols, unlike alcohols, are weakly acidic and form colored complexes with iron(III) chloride, a test they could use for rapid contamination checks. This incident highlighted the importance of understanding functional group chemistry in maintaining product quality in Uganda's growing beverage industry.

Task:

a) Describe a chemical test to distinguish between ethanol and phenol.
b) Explain why phenol is more acidic than ethanol.
c) Write the reaction for phenol with bromine water.

137. A research team at Makerere University was investigating the production of biofuels from sugarcane bagasse.They focused on converting plant biomass into various alcohols, including methanol, ethanol, and butanol. The team needed to understand the different reactivity of primary, secondary, and tertiary alcohols to optimize their conversion processes. They studied oxidation reactions using acidified potassium dichromate, noting how primary alcohols oxidize to aldehydes and then carboxylic acids, while secondary alcohols stop at ketones. This knowledge was crucial for developing efficient biofuel production methods to reduce Uganda's dependence on imported fossil fuels.

Task:

a) Write the oxidation reaction for a primary alcohol to a carboxylic acid.
b) Explain why tertiary alcohols are resistant to oxidation.
c) Describe how the Lucas test can distinguish between primary, secondary, and tertiary alcohols.

138. A community-based enterprise in Gulu was producing disinfectants and antiseptics for local clinics and households.They used different alcohols and phenols in their formulations but needed to understand the relationship between molecular structure and antimicrobial effectiveness. The team studied how longer carbon chains in alcohols increase antibacterial activity but decrease water solubility. They also explored how phenols denature proteins more effectively than alcohols but are more toxic. This understanding allowed them to formulate safe, effective, and affordable disinfectants tailored to local needs in Northern Uganda.

Task:

a) Explain how the antimicrobial activity of alcohols changes with increasing molecular weight.
b) Compare the mechanism of antimicrobial action between alcohols and phenols.
c) State why dilute phenol solutions are preferred over concentrated ones for antiseptic use.

139. A medical technology startup in Kampala was developing affordable diabetes diagnostic strips for local clinics.The strips detect glucose in urine through a color change reaction with Benedict's solution. The chemists had to explain how glucose, an aldehyde sugar, reduces copper(II) ions to copper(I) oxide, producing the characteristic color change. They contrasted this with ketone bodies, which don't give this reaction, helping healthcare workers distinguish between different metabolic conditions common in Ugandan diabetic patients.

Task:

a) Describe the reaction between an aldehyde and Benedict's solution.
b) Explain why ketones do not react with Benedict's solution.
c) Write the mechanism for the nucleophilic addition of hydrogen cyanide to a carbonyl group.

140. An agricultural processing company in Jinja was exploring ways to add value to local crops by extracting and synthesizing flavor compounds.Their chemists focused on carbonyl compounds, particularly aldehydes and ketones responsible for many natural aromas. The team studied preparation methods including alcohol oxidation and hydration of alkynes. They also investigated reactions like aldol condensation that could create new fragrance molecules. This project aimed to develop Uganda's capacity in specialty chemicals for the food and cosmetics industries.

Task:

a) Describe two different methods for preparing aldehydes.
b) Explain the difference in reactivity between aldehydes and ketones in nucleophilic addition reactions.
c) Write the reaction for the preparation of a ketone from a secondary alcohol.

141. A furniture factory in Wakiso using acetone and formaldehyde-based solvents reported several worker health issues.The safety officer organized training on carbonyl compound properties and hazards. He explained how formaldehyde's high reactivity makes it more irritating than acetone, and how both compounds can be detected using 2,4-DNP test. The training covered proper handling procedures and first aid measures for exposure, significantly improving workplace safety in Uganda's growing manufacturing sector.

Task:

a) Describe how to distinguish between an aldehyde and a ketone using chemical tests.
b) Explain why formaldehyde is more reactive than acetone in nucleophilic addition reactions.
c) State two health hazards associated with formaldehyde exposure.

142. A fruit processing plant in Masaka experienced massive spoilage of their mango juice products.Microbiological analysis revealed microbial production of short-chain carboxylic acids, causing souring and off-flavors. The quality control team needed to identify the specific acids present and understand their formation pathways. They used esterification tests and pH measurements to characterize the acids and implemented better sterilization processes. This case highlighted the importance of carboxylic acid chemistry in Uganda's fruit processing industry, which suffers significant post-harvest losses.

Task:

a) Describe the esterification reaction of a carboxylic acid with an alcohol.
b) Explain why carboxylic acids have higher boiling points than alcohols of similar molecular weight.
c) Write the reaction for the preparation of a carboxylic acid from a primary alcohol.

143. A women's cooperative in Lira was producing traditional soap using local plant oils and ash.They wanted to improve their product quality and understand the saponification process scientifically. A chemist explained how triglycerides (esters) in oils react with sodium hydroxide to produce carboxylic acid salts (soap) and glycerol. The team learned to calculate the exact amount of alkali needed for complete saponification and tested their soap's properties based on the fatty acid composition. This knowledge helped them produce consistent, high-quality soap for local markets.

Task:

a) Write the saponification reaction for a triglyceride.
b) Explain how soap molecules clean greasy dirt.
c) Calculate the amount of NaOH needed to saponify 1kg of fat with average molecular weight 850g/mol.

144. Researchers at the Pharmaceutical Research Institute in Entebbe were developing local production methods for essential medicines like aspirin.They needed to master carboxylic acid derivative chemistry, particularly ester and amide formation. The team studied reaction mechanisms, optimizing conditions for maximum yield while minimizing side products. They also investigated the hydrolysis rates of different derivatives to ensure drug stability. This research supported Uganda's goal of increasing local drug manufacturing capacity and reducing import dependence.

Task:

a) Compare the relative reactivity of acid chlorides, esters, and amides.
b) Write the mechanism for the hydrolysis of an ester in basic medium.
c) Explain why amides are less reactive than esters in nucleophilic substitution reactions.

145. The National Water and Sewerage Corporation was troubleshooting their chlorination system in Kampala.Engineers needed to understand the redox chemistry involved in water disinfection where chlorine (0) is reduced to chloride (-1) while oxidizing organic contaminants. The team analyzed oxidation number changes in various disinfection byproducts and optimized chlorine dosing to ensure effective pathogen kill while minimizing harmful byproducts. This understanding helped maintain safe drinking water for Uganda's growing urban population.

Task:

a) Calculate the oxidation number of chlorine in ClO_2.
b) Balance the redox equation for chlorine reaction with water: $Cl_2 + H_2O \rightarrow HClO + HCl$
c) Explain why chlorine is both oxidized and reduced in this disproportionation reaction.

146. The Uganda Railways Corporation was experiencing significant corrosion of steel bridges and tracks,especially in humid areas. Materials engineers conducted a study of redox reactions involved in rust formation, where iron(0) oxidizes to iron(III) oxide. The team identified areas with different oxygen concentrations creating electrochemical cells that accelerated corrosion. They implemented cathodic protection systems and developed maintenance schedules based on their redox chemistry understanding, significantly extending infrastructure lifespan.

Task:

a) Write the half-reactions for the rusting of iron.
b) Explain how the presence of salt water accelerates corrosion.
c) Describe one method of cathodic protection for iron structures.

147. A gold mining company in Busia was treating wastewater containing toxic cyanide complexes.Environmental engineers used redox chemistry to break down cyanide by oxidation with chlorine or hydrogen peroxide. The team monitored the process using oxidation number changes and ensured complete conversion to less harmful products. This application of redox principles helped the mining industry meet Uganda's environmental standards while continuing operations.

Task:

a)Balance the redox equation for cyanide oxidation: $CN^- + OCl^- \rightarrow CNO^- + Cl^-$

b)Calculate the oxidation number of carbon in CN^- and CNO^-.

c)Explain why redox reactions are important in environmental chemistry.

148. A health center in the rural Kigezi region faced frequent power outages,jeopardizing the refrigeration of vaccines. An engineering team was tasked with designing a reliable backup power system using galvanic cells. They constructed simple zinc-copper voltaic cells, explaining how the spontaneous redox reaction generates electrical energy. The team calculated cell potentials using standard electrode potential tables and connected multiple cells in series to achieve the required

voltage. They also educated clinic staff on maintenance and safe disposal, ensuring the vaccines remained viable and supporting healthcare delivery in remote areas of Uganda.

Task:

a)Calculate the standard cell potential for a Zn^{2+}/Zn and Cu^{2+}/Cu cell.

b)Write the half-cell reactions and the overall cell reaction.

c)Explain why the zinc electrode loses mass over time in this cell.

149. A jewelry makers'cooperative in Kampala wanted to improve their products by electroplating with silver and gold. A chemist taught them the principles of electrolytic cells, where electrical energy drives non- spontaneous reactions. The team practiced calculating the time and current needed to deposit specific metal thicknesses using Faraday's laws. They learned to prepare clean surfaces and control conditions to achieve smooth, adherent coatings. This knowledge enabled the artisans to enhance their products' value and appeal, boosting their incomes in Uganda's competitive crafts market.

Task:

a) Distinguish between galvanic and electrolytic cells.
b) Calculate the time required to deposit 2.0g of silver using a 2A current.
c) State two factors that affect the quality of an electroplated coating.

150. Agricultural scientists in Mbale were concerned about corrosion of metal components in irrigation systems,which was contaminating soil and water. They used the concept of standard electrode potentials to predict which metals would corrode when buried in different soil types. The team set up experiments to measure corrosion rates and identified that acidic soils and dissolved salts accelerated the process. Their findings led to recommendations for using more resistant metals and protective coatings, safeguarding both the irrigation infrastructure and the environment.

Task:

a) Predict whether iron will corrode when in contact with copper in moist soil. Justify using E° values.
b) Explain how soil pH affects the corrosion rate of metals.
c) Suggest a metal that could be used as a sacrificial anode to protect iron from corrosion.

151. A youth group in Jinja started a business recycling aluminum scrap into useful products.They used electrolysis to purify the metal and needed to understand Faraday's laws to control the process efficiently. The members learned to calculate the amount of aluminum deposited or dissolved based on current and time. They optimized their setup to maximize yield while minimizing energy costs, turning waste into income and contributing to environmental conservation in Uganda.

Task:

a) State Faraday's first law of electrolysis.
b) Calculate the mass of aluminum deposited when a 5A current passes through molten Al_2O_3 for 3 hours.
c) c)Write the half-reaction for the deposition of aluminum at the cathode.

152. Researchers at Kyambogo University were exploring hydrogen production as a clean fuel alternative.They built an electrolysis apparatus to split water into hydrogen and oxygen, applying Faraday's laws to determine gas volumes produced. The team faced challenges with efficiency due to the high overpotential of oxygen evolution. They experimented with different catalysts and electrolytes to improve the process, aiming to make green hydrogen a viable energy source for Uganda's future.

Task:

a) Write the half-reactions for the electrolysis of acidified water.
b) Calculate the volume of hydrogen produced at STP by a 2A current in 1 hour.
c) Explain why adding an electrolyte is necessary for water electrolysis.

153. An auditor visited a copper refining plant in Kilembe to assess its efficiency.The plant used electrolysis to purify copper, and the auditor applied Faraday's laws to check if the actual copper production matched theoretical predictions. Discrepancies were found due to side reactions and current inefficiencies. The auditor recommended improvements to electrode design and current management, which increased the plant's output and profitability, supporting Uganda's mining sector.

Task:

a) Describe the process of electrolytic refining of copper.
b) Calculate the current efficiency if 5.0g of copper is deposited instead of the expected 5.5g.
c) State two common impurities found in blister copper.

154. A technology institute in Kampala was researching the potential for local microchip production.They focused on silicon from Group 14, studying its semiconductor properties and how they differ from carbon (diamond) and germanium. The team explored the trend from non-metallic to metallic character down the group and how this affects electrical conductivity. They also investigated silicon's oxide layer, which is crucial for chip manufacturing. This foundational research aimed to position Uganda in the global technology value chain.

Task:

a) Explain the trend in electrical conductivity down Group 14.
b) Compare the structure and bonding in diamond and silicon.
c) State why silicon is preferred over germanium for making semiconductors.

155. Environmental scientists in Uganda were studying carbon dioxide emissions from various sources.They compared CO_2 to other Group 14 oxides like SiO_2 and PbO_2, explaining differences in volatility and acidity based on periodic trends. The team highlighted how carbon's unique ability to form stable double bonds with oxygen makes CO_2 a gas, while SiO_2 is a solid. This understanding informed policies on emissions control and climate change mitigation in Uganda.

Task:

a) Compare the acidity of CO_2 and SiO_2.
b) Explain the trend in thermal stability of Group 14 hydrides.
c) Write the reaction between CO_2 and limewater.

156. An environmental NGO in Wakiso addressed the improper disposal of lead-acid batteries,which was causing soil contamination. They educated the community about lead's position in Group 14 and its toxic properties compared to other group elements. The NGO set up a recycling program that safely extracted lead and its compounds, demonstrating redox reactions involving lead. This initiative protected the environment and created jobs in Uganda's waste management sector.

Task:

a) Describe the trend in metallic character down Group 14.
b) Write the reaction at the anode in a lead-acid battery.
c) State two health hazards associated with lead exposure.

157. The National Water and Sewerage Corporation evaluated different halogens for water treatment.They compared chlorine, bromine, and iodine in terms of disinfecting power, solubility, and cost. The team explained how oxidizing ability decreases down the group, making chlorine the most effective disinfectant. They also considered the formation of disinfection byproducts and adjusted pH to optimize chlorine efficiency, ensuring safe drinking water for Ugandan households.

Task:

a) Explain the trend in oxidizing power down Group 17.
b) Write the reaction between chlorine and water.
c) State why iodine is less soluble in water than chlorine.

158. A salt processing plant in Lake Katwe was producing iodized salt to prevent iodine deficiency disorders.Quality controllers monitored the iodine content, understanding its volatility and sublimation properties. They tested for iodine using starch solution and ensured proper packaging to prevent iodine loss. This program helped combat goiter and other iodine-related health issues in Uganda.

Task:

a) Describe the test for iodine using starch.
b) Explain why iodine sublimes more easily than chlorine.
c) Calculate the percentage of iodine in potassium iodate (KIO_3).

159. A chemical plant in Namanve producing sodium hypochlorite bleach trained workers on halogen chemistry.They covered chlorine's high reactivity and toxicity compared to other halogens. The team demonstrated the disproportionation reaction of chlorine with cold, dilute NaOH to produce bleach. Safety protocols were emphasized to prevent accidents, protecting workers and the environment in Uganda's chemical industry.

Task:

a) Write the reaction for the formation of bleach from chlorine and NaOH.
b) Compare the bond energies of Cl_2, Br_2, and I_2.
c) State two safety precautions when handling chlorine gas.

160. Engineers at a Kampala auto workshop were developing cheaper catalytic converters using transition metals like iron and copper instead of platinum.They studied how variable oxidation states and surface adsorption properties make transition metals good catalysts. The team tested their converters' efficiency in reducing vehicle emissions, contributing to cleaner air in Ugandan cities.

Task:

a) Explain why transition elements show variable oxidation states.
b) Describe how a catalytic converter reduces NO emissions.
c) State two other industrial uses of transition metal catalysts.

161. A gemology center in Mbale was identifying and valuing colored stones.They explained how transition elements like chromium in emeralds and iron in amethysts cause colors through d-d electron transitions. The team used spectroscopy to analyze these transitions and detect synthetic gems, supporting Uganda's growing gemstone industry.

Task:

a) Explain how transition elements cause color in compounds.
b) Why are zinc and scandium not considered typical transition elements?
c) Calculate the oxidation state of chromium in $Cr_2O_7^{2-}$.

162. A pharmaceutical company in Entebbe was formulating iron supplements to treat anemia. They faced challenges with iron's oxidation from Fe^{2+} to Fe^{3+} in storage, which reduced bioavailability. Chemists used complex formation with ligands like EDTA to stabilize Fe^{2+} and prevent oxidation. This ensured effective supplements for addressing anemia, a common health issue in Uganda.

Task:

a) Explain the biological importance of iron in hemoglobin.
b) Write the electron configuration of Fe^{2+} and Fe^{3+}.
c) Why are Fe^{2+} compounds usually green while Fe^{3+} compounds are yellow/brown?

163. A dairy cooperative in Mbarara was experiencing significant financial losses due to the rapid spoilage of milk during transportation to processing centers.The spoilage, caused by bacterial fermentation, is a chemical reaction whose rate needed to be slowed. The cooperative's chemist, Mr. Tugume, organized a workshop for the farmers and drivers. He explained how the rate of bacterial growth and the ensuing souring of milk is highly dependent on temperature. He demonstrated this by showing how milk left in the sun spoils much faster than milk kept in a cool shade. The campaign promoted the use of insulated cooler boxes during transit and highlighted the importance of the Arrhenius equation, which quantitatively describes how reaction rates increase exponentially with temperature. This simple understanding helped drastically reduce spoilage, increasing the farmers' profits.

Task:

a) State the Arrhenius equation and define its terms.
b) Explain why storing milk at a lower temperature slows down the spoilage reaction.
c) If the rate of spoilage doubles with a 10°C rise in temperature, calculate the activation energy for the process (use the appropriate approximation).

164. The mechanics at a large boda boda (motorcycle) repair shop in Kampala were concerned about the rapid rusting of motorcycle parts, especially during the rainy season. The head mechanic, Ms. Nansubuga, researched how to slow down the corrosion reaction. She explained to her apprentices that rusting is an electrochemical process that requires both water and oxygen. She demonstrated how spraying a thin layer of oil on metal parts creates a protective barrier. This barrier does not change the reaction's activation energy but drastically reduces the frequency of collisions between the metal surface and the reactants (water & oxygen) by physically separating them. Implementing this simple, cost-effective practice significantly extended the lifespan of the motorcycles.

Task:

a) Explain how a protective oil layer affects the collision theory parameters to reduce the rusting rate.
b) Rusting is faster in salty water. Suggest a reason for this observation.
c) Apart from creating a barrier, name one other method to prevent rusting and briefly explain how it works.

165. Following a near-miss incident,the safety officer at a large maize milling plant in Jinja conducted a mandatory safety training on the hazards of grain dust. He explained that a dust explosion is an extremely rapid combustion reaction. He demonstrated that while a pile of maize flour burns slowly, a fine cloud of the same flour suspended in air can explode violently when ignited. He emphasized that this is because pulverizing the solid maize into a fine dust increases its surface area exponentially, allowing oxygen molecules to collide with a vastly greater number of fuel particles simultaneously. This training led to the strict enforcement of housekeeping rules to minimize dust accumulation.

Task:

a) Using the concepts of surface area and collision theory, explain why a dust explosion is more violent than the burning of a solid lump.
b) State the three components of the "fire triangle" necessary for combustion.
c) Besides controlling dust, suggest one other safety measure to prevent such explosions in a mill.

166. A wave of catalytic converter thefts from vehicles in Entebbe prompted a police awareness campaign.A police chemist was invited to explain the device's importance. She explained that a car's engine produces harmful gases like carbon monoxide (CO) and unburnt hydrocarbons. The catalytic converter uses a platinum-rhodium catalyst to provide an alternative reaction pathway with a lower activation energy for the conversion of these pollutants into less harmful carbon dioxide and water vapor. This allows the reactions to occur rapidly at the exhaust system's temperature, which would otherwise be too low. The campaign helped the public understand the environmental and health value of the device, encouraging better vigilance.

Task:

a) Explain the role of the platinum catalyst in a catalytic converter in terms of activation energy.
b) Write a balanced equation for the oxidation of carbon monoxide (CO) to carbon dioxide (CO_2) inside a catalytic converter.
c) Why are catalysts like platinum not consumed in the reactions they speed up?

167. A women's group in Gulu was producing homemade passion fruit juice for sale at the local market.To ensure its safety and extend its shelf life, they were taught the basics of pasteurization. The facilitator explained that spoilage is caused by microorganisms, whose destruction follows the principles of reaction kinetics. Heating the juice to a specific temperature for a precise time ensures that the rate of the "reaction" (killing the microbes) is fast enough to be effective. She highlighted that this is a delicate balance; higher temperatures or longer times, while more effective, can also degrade the juice's flavor and nutrients, demonstrating how changing conditions affects the rates of multiple, competing reactions.

Task:

a) Pasteurization controls the rate of microbial death.

Name the factor being manipulated and state how it affects the reaction rate.

b) Why is it important to cool the juice rapidly after the heating process is complete?
c) If the rate of microbial destruction is known to double for every 10°C rise in temperature, and it takes 5 minutes at 70°C, estimate the time needed at 60°C.

168. Park rangers at Murchison Falls National Park were using chemical light sticks for night patrols to deter poachers without using bright lights that could scare animals.The head ranger explained that the light is produced by a chemical reaction (chemiluminescence) whose rate is controlled by temperature. On cooler nights, the light lasted longer but was dimmer, while on warmer nights, it was brighter but drained quickly. Rangers learned to slightly warm the sticks in their hands for a brighter light when inspecting an area and to cool them in river water to conserve the reaction for longer patrols, demonstrating practical control over reaction rates in the field.

Task:

a) Explain why the light stick glows brighter when warmed, using concepts of particle energy and collision theory.
b) Sketch a graph showing the relationship between the initial brightness of the glow and the temperature.
c) If a light stick lasts for 8 hours at 20°C, would you expect it to last for more or less than 8 hours at 30°C? Explain your answer.

169. At the Hima cement factory,engineers were monitoring the calcination process where limestone ($CaCO_3$) is heated to produce quicklime (CaO). They found that grinding the limestone into a fine powder before feeding it into the kiln significantly increased the production rate. The plant manager explained that this increase in surface area allowed heat and the reaction to penetrate the material more efficiently, allowing them to lower the kiln temperature slightly, which saved on fuel costs while maintaining their output targets for Uganda's construction industry.

Task:

a) Explain how decreasing the particle size of limestone increases the rate of its thermal decomposition.
b) Write a balanced chemical equation for the thermal decomposition of limestone.
c) State one economic benefit of increasing the reaction rate in this industrial process.

170. A silversmith in Mpigi was frustrated that her intricately designed jewelry was tarnishing(reacting with atmospheric sulfur to form black Ag_2S) in her workshop, which was located near a road with high traffic emissions. She consulted a chemist who explained that the tarnishing was faster in her workshop than in a cleaner environment because sulfur dioxide (SO_2) from vehicle exhaust acted as a catalyst for the reaction. The chemist recommended installing an air filtration system, which removed the SO_2 and significantly slowed down the tarnishing rate, preserving the jewelry's shine.

Task:

a) Define a catalyst and explain how the presence of SO_2 gas increased the tarnishing rate of silver.
b) Write a balanced chemical equation for the formation of silver sulfide (Ag_2S) from silver and atmospheric hydrogen sulfide (H_2S).
c) Why would polishing the silver jewelry also help to slow down the tarnishing process?

171. A traditional brewer in Bushenyi was producingtonto (a local banana beer) and noticed that the fermentation rate was inconsistent. An agricultural extension officer explained that the concentration of yeast, which acts as a biological catalyst, was crucial. By measuring the sugar concentration at the start and carefully adding a standardized amount of yeast, the brewer could control the rate of ethanol production. The officer also highlighted that temperature was a key factor; fermentation was too slow in the cool mornings and too violent in the hot afternoons, so maintaining a steady, optimal temperature was essential for a consistent and high-quality product.

Task:

a) Yeast is a biological catalyst. How does increasing the amount of yeast affect the rate of fermentation?
b) The fermentation of glucose is exothermic. How might this inherent property of the reaction affect the rate if the heat is not dissipated?
c) State two factors, other than yeast concentration and temperature, that could affect the rate of fermentation.

172. Fish farmers in Kajjansi faced frequent fish kills in their ponds during hot,still nights. An aquaculturist from the Ministry of Agriculture explained that the dissolved oxygen (O_2) levels dropped because the respiration rates of fish and other organisms increased with temperature. Furthermore, without wind to mix the water, oxygen from the air couldn't dissolve quickly enough to replenish what was consumed. The solution was to use electric air pumps to bubble air through the water, thereby increasing the concentration of the dissolved oxygen reactant and preventing the "reaction" of fish suffocation.

Task:

a) Explain the two factors that caused the decreased oxygen levels in the pond at night.
b) How does bubbling air through the water increase the rate of oxygen transfer into the water?
c) Sketch a graph to show how the rate of a reaction typically depends on the concentration of a reactant.

173. Vendors at the Mbale market noticed that the vibrant colors of their Kitenge fabrics were fading quickly when displayed in direct sunlight.A textile chemist explained that the dyes were undergoing photochemical degradation, and the intense ultraviolet (UV) light in sunlight was providing the activation energy for these reactions. The chemist recommended using UV-protective sprays on the fabrics and displaying them under shades or canopies. This simple intervention significantly slowed down the fading reaction, protecting the vendors' valuable stock.

Task:

a) Explain the role of UV light in increasing the rate of the color-fading reaction.
b) Suggest why different colors on the same fabric might fade at different rates.
c) Name the factor affecting the reaction rate that is being controlled by using a protective spray.

174. pharmaceutical company in Kampala was developing effervescent antacid tablets that would fizz and dissolve rapidly in water.The formulation chemists were experimenting with different particle sizes of citric acid and sodium bicarbonate. They found that using finely powdered ingredients created a much faster initial fizz, which was desirable. However, they had to balance this with the need for the tablets to be mechanically strong enough for packaging and transport. This involved optimizing the rate of the reaction for both user experience and product stability.

Task:

a) Write a balanced chemical equation for the reaction between citric acid (a triprotic acid can be generalized as H^+) and sodium bicarbonate (HCO_3^-) that produces the fizz.
b) Explain why a tablet made from powdered reactants fizzes faster than one made from coarse crystals.

175. Researchers in Kabuwoko ss were preparing fragrances from esters derived from either $40cm^3$ of propan-1-ol or $30cm^3$ of butan-2-ol to be used in the manufacture of perfumes for project work. Prior to the project, some learners mixed the two alcohols and obtained $70cm^3$ of a solution and no heat change was observed at 313K. On analysis, the solution contained 25% propan-1-ol in pure butan-2-ol and vapor pressures of pure butan-2-ol and pure propan- 1-ol as 64.2mmHg and 97.1mmHg respectively. This made all the researchers concluded that the solution formed was ideal and obeyed Raout's law.

Tasks

a) With reference to Roults law and concept of ideal solutions, explain why all the researchers concluded that the solution was ideal (05 scores)
b) Calculate the total pressure of the solution. (06 scores)
c) Calculate the vapor composition of each pure component and suggest which is more volatile.
d) Suggest precautions which must be undertaken when carrying out the research above? (03 scores)

176. Ethanol and acetone(CH_3COCH_3) mixture is used to make cleaning agents due to their ability to dissolve various substances. A solution was prepared by mixing 10g of ethanol and 18g of acetone at 363K and at this temperature, the total vapor pressure above the liquid

surface was measured to be 553mmHg. If the saturated vapor pressure of pure ethanol and acetone at that same temperature was 200mmHg and 300mmHg respectively,

Tasks.

a) State the deviation from Raoults law sown by the solution. (All your working must be shownb)
b) Explain your answer in (a) above. (04 scores)
c) Sketch the vapor pressure composition diagram for this solution. (04 scores)
d) Sketch a boiling point composition diagram for this solution (04 scores)

177. While carrying out a practical on application of methanol and cyclohexane, the boiling points and percentage composition by mass of methanol in the liquid mixture and in the vapor above the mixture of methanol and cyclohexane are given in the table below,

Boiling point of mixture($_oC$)	70	60	55	57	61
% composition of CH3OH in liquid mixture	12	13	50	82	94
% composition of CH3OH in vapor above the mixture	27	47	56	69	83

Tasks

a) Use the data to plot a boiling point composition diagram for the solutions of cyclohexane in methanol (Boiling points of pure cyclohexane and pure methanol are $810C$ and $650C$respetivel
b) Use your graph to determine the composition of the azeotropic mixture and azeotropic temperature (03 scores)
c) State the type of deviation from Raoults law shown by the mixture above and explain your answer (05 scores)
d) Suggest risks and safety precautions to be followed when handling the above practical. (04 scores)

178. During an analysis of organic compounds, S.5 students of Sechel High School tried to react the compounds with bromine water, fluorine in the presence of UV light, and an acid in the presence of water.

The compounds analyzed were:

a) ETHENE

b)ETHANE

c) CHLOROETHANE

d)BENZENE

Task:

a) With reason(s) which of the above compounds reacted with bromine

(i)water

(ii)chlorine

b) Why do you think compound (d) reacts with Chlorine only in presence of a catalyst?
c) Identify and suggest a possible mechanism for the reaction of (a) with bromine water.
d) Identify and name a type of reaction exhibited in (iii) above.

179. A class of S.5 students burnt An organic compound x . During the experiment, they observed that 0.4639 g of x gave 1.119 g of Carbon dioxide and 0.56 g of water. They also tried to vaporize 0.1 g of x and found out that it occupied 54.5 cm^3 at 208 ^0C and 48.3 (Likely 48.3kP}

Task:

a) Determine the empirical formula of the glucose molecule.
b) Use the above results to deduce the molecular formula of glucose.

180. A S.3 student wants to make a project of making an electron cell. She has 2 salts i.e. potassium iodide and potassium chloride. This student has to choose one of these salts for use as an electrolyte, however she didn't know which salt to use, On contacting her teacher, she was given the information below to advise and guide her in the project.

Task:

i) As a senior student help this S.S student to:

a) Explain at least any factor in the scenario that may affect the solubility of the salts.

b) Use a suitable Energy level diagram(s) to determine the lattice energy of each electrolyte.

c) Determine Enthalpy of solution for each salt.

181. In the process of making anti acids to treat heartburn using magnesium, the pharmacist was tasked by the pharmaceutical company to determine the actual relative atomic mass of the magnesium sample. Using the mass spectrometer, he analyzed the sample and recorded the information below.

Isotopes	**Isotopic masses**	**Relative abundance (%)**
Mg-24	23.985	78.99
Mg-25	24.986	10.00
Mg-26	25.983	11.01

Task

a) As a young chemist, explain to your group discussion members the meaning of

i)Isotopes (1 score)

ii) Relative abundance (1 score)

iii) Relative atomic mass (1 score)

b) Determine the actual relative atomic mass of magnesium (2 scores)

182. Lithium, carbon, oxygen and fluorine with atomic numbers 3,6,8 and 9 can randomly bond with each other at right conditions to form products of different properties depending on the types of bonds found in those compounds. These properties determine their application in daily life.

Task

a) Using the outermost energy levels only, show how lithium and oxygen, carbon and oxygen, carbon and fluorine atoms can bond (3 scores)

b) Draw and name the structures adopted by compounds formed between carbon and oxygen and carbon and fluorine (3 scores)
c) suggest the physical states of the substances formed between lithium and oxygen and carbon and fluorine. Explain your response (4scores)
d) Scientists left a radioactive substance in a nuclear plant to decay but radioactive wastes were released into the nearby environment due to a leak. The local authorities are concerned about the potential health risks to the community. Measurements indicate that the leak is emitting radiations.

183. AgroTech Minerals Ltd. has developed a new inorganic fertilizer labeled X in Hydrated Form. Laboratory analysis shows that the solid contains 9.37% magnesium, 10.93%nitrogen, and 42.18% water of crystallization and rest being oxygen. Molar mass of X is 256g. 5.0 kg of the fertilizer was available for sale, the manager sought to know the amount in mass of nitrate nutrient in X that would be delivered to maize. Keen to know about environmental hazards, X was burnt in absence of air and decomposed with brown gas of nitrogen dioxide according to equation:

Equation 1: $2\ Mg(NO_3)_2(s) \rightarrow 2\ M(s) + 4\ NO_2(g) + O_2(g)$

The company sought to know the volume at s.t.p of the brown gas produced from burning 1.0 kg of the fertilizer and assess the environmental impacts of the emissions and mitigations.

Due to available rocks containing magnesium in the area, the company manager further seeks to evaluate the industrial synthesis of the fertilizer X from magnesium oxide:

Equation 2: $Mg\ (s) + 2\ HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l).$

The supplier reported that he would potentially supply 10.0 kg of magnesium oxide per day,and the manager intends to know how much fertilizer would be available in one month and also possible environmental impacts of using the fertilizer and mitigations.

Task

As a learner of Chemistry, help the company to know;

(a)The molecular formula of compound X

b) Mass of nitrate nutrient in X that would be delivered to maize.

(i)The volume at s.t.p of the brown gas produced from burning the fertilizer.

(ii) The environmental impact of the brown gas emissions and mitigation.

(iii)Mass of the fertilizer produced in one month.

c) Possible environmental impact of using the fertilizer and their mitigations

184. An aluminium smelting company in Jinja uses a substance called aluminium fluoride as aflux to lower the melting point of cryolite during aluminium extraction.

However, the production unit is facing high energy costs, and the environmental team reportschallenges in dissolving waste AlF_3 residues before disposal. The research chemist istasked to analyse the thermochemical feasibility of both forming and dissolving AlF_3 using available thermodynamic data to determine whether these processes are spontaneous or energy-intensive.

Across a certain article the following data was discovered by the researcher:

Standard enthalpy of formation of $AlF_3(s)$ -1301 kJ mol^{-1}

Enthalpy of atomization of aluminium $+314$ kJ mol^{-1}

Bond dissociation energy of fluorine $+158$ kJ mol^{-1}

First, second, and third ionization energies of Al $+577$, $+1820$, and $+2740$ kJ mol^{-1} respectively

First electron affinity of fluorine -348 kJ mol^{-1}

Hydration enthalpies aluminium and fluoride Ions -4690 , -364 kJ mol^{-1} respectively

The researcher struggles to use this information to construct and interpret an energy cycle diagram,perform calculations, evaluate the feasibility of the key processes and properties that suit aluminium fluoride for use in the process. You have been contacted for help.

Tasks; As a student of chemistry, help the researcher;

a) Analyse the data to construct an energy cycle diagram for the formation of solid substance

(b) Know the lattice energy of substance.

(c) Evaluate whether the dissolution of the substance in water is thermodynamically feasible and spontaneous under standard condition

d) State the properties that make the substance suitable to serve the above purpose

e) Suggest the possible impact and mitigation of the substance to the environment.

185. A chemical company in Kampala manufactures halide compounds in disinfectants. To improve production efficiency,the company is studying the first ionization energied(I.E) of elements.

The ionization energy of an element indicates the amount of energy required to remove one mole of electronsom one mole of gaseous atoms to form one mole of positively charged gaseous ions.

Elements with low ionization energy lose electrons easily and thus form positive ions readily,making them more suitable for halide formation with group(VII) elements.Those with high ionization energy are less reactive and less suitable for this purpose.

The company is analyzing period 3 elements to identify the most suitable for halide production.

ELEMENT	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
Atomic number(nm)	11	12	13	14	15	16	17	18
First I.E (kJmol^{-1})	496	738	578	786	1012	1000	1251	1521
Melting point(^{o}C)	98	650	660	1414	44	115	-101.5	-189.4

The manager seeks to analyse the data to make informed decisions by plotting a graph of first ionization energy against atomic numbers for period 3 elements.He is also interested in understanding the variations in the melting points of some elements.

You are required to;

a) Describe and explain the trend and irregularities in the first ionization energies across period 3

b) Evaluate which element is the most suitable for industrial halide production,giving reasons.
c) State and explain the trend the melting points of the non-metals in the table above.

Task; As a learner of chemistry,make a write-up you will use to help the company.

186. A chemical research laboratory in Uganda is investigating a gaseous hydrocarbon X obtained from a petrochemical facility. Elemental analysis shows that X contains 11.11% hydrogen by mass, its vapour density is 27 and on treatment withTollens' reagent gave positive test.Hydrogenation of X with 1 mole of hydrogen and 1 mole of X over a lindlar's catalyst produced a carbon–carbon double bond. When the resulting compound of hydrogenation is treated with concentrated sulphuric acid and water, it forms Y,which is further oxidized using hot acidified potassium dichromate to yield a compound Z. Z gives a negative test with Tollens' reagent.

Multi-step synthesis from but-1-ene, propene, and ethene are explored to generate X and its derivatives,which are important for producing alcohols, carbonylcompounds, and polymer intermediates in Uganda's chemical industry, while safetyconsiderations such as flammability and waste management are observed.

An analyst, wishes to know molecular formula X, all structural isomers of X with IUPAC names, identity of X, Y, and Z, write equations to be involved, mechanisms for formation ofY, propose multi-step synthesis of X from but-1-ene, propene, and ethene, and discuss theindustrial applications, environmental impact, andmitigations of X, Y, and Z. You have been contacted for your help.

Task: As a student of Chemistry, prepare a presentation you will use to help the firm.

187. You are part of a national science competition where your school has been tasked with solving a mystery involving a malfunctioning industrial machine used in metal processing. The machine separates metals based on their reactivity and electronic configuration, but it has stopped working correctly due to a suspected programming error in how it identifies elements.

Your team is given a list of six elements used in the machine's sorting system:

Iron (Fe, 26)

Magnesium (Mg, 12)

Calcium (Ca, 20)

Manganese (Mn, 25)

Potassium (K, 19)

Zinc (Zn, 30)

Task

a) You must reprogram the machine to correctly sort these elements by confirming their electronic configurations.
b) The machine accidentally classified manganese and zinc in the same category. Based on their configurations, explain why this is incorrect
c) Suggest how the machine should differentiate elements with partially filled d-orbitals from those with filled ones

188. An environmental agency is investigating air pollution near an industrial zone. They suspect illegal flaring of hydrocarbons at night. A portable eudiometer is used to sample gases released during a suspected flare event. A 100.0 mL gas sample is collected and analyzed. The gases are assumed to be primarily from the combustion of a gaseous hydrocarbon fuel.

The sample is reacted with excess oxygen in the eudiometer and sparked. After the reaction:

Total gas volume drops from 100.0 mL to 70.0 mL.

The remaining gases are passed through aqueous KOH. After absorption, the volume drops further to 50.0 mL.

The agency believes that incomplete combustion may be occurring, releasing carbon monoxide (CO), a toxic gas, into the environment.

Task:

(a) . Using the data, determine the molecular formula of the hydrocarbon (assume it completely combusted in this reaction).

(b) . Identify how much carbon dioxide was produced.

c) Critically evaluate whether the combustion was complete or incomplete. Use the volumes to support your answer.

d) Propose a practical societal solution to prevent the release of toxic gases from industrial flares, based on the chemical behavior observed

189. A local government is launching a campaign to reduce the overuse of fertilizers in farming.

As part of a pilot study, a team of chemists analyzes the amount of ammonium nitrate (NH_4NO_3) being used by farmers in a rural area.

One farmer reports using 500 kg of ammonium nitrate per season. The chemists want to understand the potential impact on the local water supply, since excess nitrates can lead to eutrophication in nearby lakes.

Tasks:

a) Calculate the number of moles of ammonium nitrate in 500 kg.
b) Determine the number of nitrogen atoms delivered to the soil.
c) Assuming 10% of the nitrate leaches into water systems, calculate how many moles of nitrate ions enter the environment.

(d) . Based on your results, discuss how chemistry can help address environmental concerns related to fertilizer overuse

190. In an exercise that was done by S.5 students in S.5 North class, a student wrote the electronic configuration of an element Q as 1s2 2s2 2p6 3s2 3p6 3d10 4s2 4p6 4d10 5s2 5p5.

a i) Which block in the Periodic Table does this element belong to? (2scores)

ii) Which group and period does it belong to? (2scores).
iii) Identify this element. (1score)

191. An analysist exploded 142cm^3 of a hydrocarbon Y(CxHy), molecular mass 58g with excess oxygen and cooled it to room temperature, the volume of the residual gas was 694cm^3.On treatment with concentrated potassium hydroxide, the volume decreased to 126cm^3.

a) Determine the molecular formula of Y.

b) Write the structural formula and IUPAC name of all possible isomers of Y.

192. A material scientist wanted to design a new alloy for aerospace applications. Among the factors to be considered is screening effect, atomic radius, ionic radius and ionization energy. An element with a lower ionization energy is the best choice to consider. The following elements sodium, magnesium and aluminium are under investigation.

Tasks.

a) What is meant by the terms screening effect, atomic radius and ionization energy.(3scores)
b) Explain the variation of atomic radius and ionization energy across these elements.(8scores)
c) Identify the element which could be the best choice for the intended purpose.(give a justification for your choice) (4mks).

193. A compound has the molecular formula C_6H_{14}. The student is tasked with identifying possible structural isomers of this compound, considering it is part of the alkane series.

a) Draw the structural isomers of C_6H_{14} that are possible, and name them using IUPAC nomenclature.

b) Explain the types of isomerism shown by these compounds. Specifically, focus on structural isomerism and provide examples from the isomers you drew. (6 scores)

c) Discuss the concept of functional group isomerism. How does it differ from structural isomerism, and provide an example of functional group isomerism. (4 scores)

d) Evaluate how the unique bonding properties of carbon contribute to the formation of isomers in organic compounds. (2scores)

194. In a university chemistry research facility, a new delivery of elemental samples arrives, but some of the labels are faded or missing. The only visible information includes atomic numbers: 19, 25, 17, and 10. The head researcher is responsible for ensuring proper chemical storage and safety measures to prevent any mishandling.

Task:

The head researcher has asked you to determine the electronic configurations of the elements and/or their ions, clarify their position in the Periodic Table (Group, Period, and Block), and predict and analyze their reactivity. Write a brief message in response to the researcher's request.

195. A research company developing new cosmetic aerosols is working with a hydrocarbon compound of molecular formula C_4H_{10}. Laboratory tests reveal the compound has structural isomers, each with differing boiling points.

The team wants to select the most volatile (lowest boiling point) form for effective aerosol dispersion and you have been identified as the suitable person for consultation.

Task: As a learner who is well equipped with the knowledge of organic chemistry,

Write a brief report:

a) Describing the different structural isomers of C4H10 and their similar chemical behavior.
b) In your report, include a recommendation for which isomer is most appropriate for use in the product and justifying your answer.

196. A chemical research laboratory in Uganda is investigating a gaseous hydrocarbon X obtained from a petrochemical facility. Elemental analysis shows that X contains 11.11% hydrogen by mass, and its vapour density is 27, suggesting a molecular mass of 54 g. Hydrogenation of X with 1 mole of hydrogen and 1 mole of X over a nickel catalyst at 150°C produced a carbon– carbon double bond. When X is treated with concentrated sulphuric acid and water, it forms Y, which is further oxidized using hot acidified potassium dichromate to yield a compound Z.

Z can also be tested with Tollens' reagent to confirm its functional group. Multi-step synthesis from but-1-ene, propene, and ethene are explored to generate X and its derivatives, which are important for producing alcohols, carbonyl compounds, and polymer intermediates in Uganda's chemical industry, while safety considerations such as flammability and waste management are observed.

An analyst, wishes to know molecular formula X, all structural isomers of X with IUPAC names, identify of X from its hydrogenation reaction, identify of Y from hydration of X, and identify of Z from oxidation of Y, write equations for hydration of X, dibromination followed by alcohol formation and mechanisms, oxidation of Y to Z, and reaction of Z with Tollens' reagent, propose multi-step synthesis of X from but-1-ene, propene, and ethene, and discuss the industrial applications, environmental impact, and mitigatigations of X, Y, and Z. you have been cotacted for your help.

Task: As a student of Chemistry, prepare a presentation you will use to help the firm.

197. Ngambo, the forensics scientist has been entrusted by the Kabale police department to recreate a crime scene material involving a metallic alloy used in a suspicious device. The alloy is suspected to be a reactive but relatively stable material, crafted from elements in the alkali group and the alkaline earth metals. However, it's believed that the suitable elements needed is chosen depending on its atomic radius which varies from one element to another.

Ngambo now needs your expertise in understanding the variation in atomic radius down the groups in the periodic table to select an appropriate element for reconstructing the alloy.

Task; using your knowledge of the periodic table, help Ngambo,

a) Select an element from either the alkali group or the alkaline earth metals to form a reactive but relatively stable alloy.
b) Explain how the variation in atomic radius down each group influences the choice and predict how the atomic radius affects the alloys reactivity and stability for forensic reconstruction.
c) Compare the reactivity of your chosen elements, explaining how the difference in atomic radius impacts the alloys properties.
d) Briefly explain to Ngambo why the atomic radius increase down the group.(03 scores)

198. A research company developing new cosmetic aerosols is working with a hydrocarbon compound of molecular formula C_4H_{10}.

Laboratory tests reveal the compound has structural isomers, each with differing boiling points.

The team wants to select the most volatile (lowest boiling point) form for effective aerosol dispersion and you have been identified as the suitable person for consultation.

Task: As a learner who is well equipped with the knowledge of organic chemistry,

Write a brief report:

a) Describing the different structural isomers of C_4H_{10} and their similar chemical behavior.
b) In your report, include a recommendation for which isomer is most appropriate for use in the product and justifying your answer.

199. A beverage company is developing a new energy drink designed to stay liquid even in cold weather. A chemist suggests adding an appropriate amount of glucose to the formula to lower its freezing point without affecting taste.

To estimate how much glucose to use, they test a sample containing 180 g of glucose ($C_6H_{12}O_6$) dissolved in 1 kg of water. They observe a decrease in freezing point by 1.86°C.

Task: As a chemistry student who has studied about colligative properties of solutions, help the company chemist,

a) Calculate the molality of the glucose solution.
b) Use the freezing point depression constant (Kf = 1.86°C·kg/mol) to confirm the freezing point depression.
c) Why does the identity of the solute (glucose vs. NaCl) matter for the magnitude of freezing point depression?

200. A S.5 science student mixes 5.0 g of calcium carbonate ($CaCO_3$) with hydrochloric acid. A gas is released, and a fizzing reaction occurs. The student is concerned on how much gas is released and as a senior student, you have been contacted for help

Task: As a senior student,

a) Write the balanced chemical equation for the reaction.
b) Calculate the number of moles of calcium carbonate used.
c) Determine the volume of carbon dioxide gas evolved at room temperature and pressure (molar gas volume = 24 dm^3/mol).

201. A worker of a certain university laboratory completely burnt 10cm^3 of a certain gaseous hydrocarbon T in 60cm^3 of oxygen. After explosion and cooling, the residual gaseous occupied 50cm^3. After absorbing with sodium hydroxide solution, 30cm^3 of the gaseous products remained. This worker got confused with the values he obtained and failed to identify the burnt gaseous hydrocarbon.

a) As a form five student of chemistry, help the worker to determine the molecular formula of T

b) Identify T by its chemical structure and name (02 marks)

c) The worker wanted T from ethanol. Write an equation to show how T can be obtained from ethanol and indicate steps taken to arrive at T (02 marks)

d) This worker was telling his colleagues that T can be converted to an alkyne P of the same carbon content like T. however, he was not well versed with the steps taken. As an advanced student of chemistry, help the worker the steps taken to obtain P from T indicating the reagents used and the conditions. (03 marks)

e) This worker had but-1-ene and T. he wanted to select the best compound to use. The best compound is the one with higher boiling point however, he didn't know the one with higher boiling point and why. As a student of chemistry, help the worker to identify the compound with higher boiling point and explain why? (05 marks)

202. The Agricultural Industrial Processing Report (2024) identifies significant stoichiometric inefficiencies during the carbonation stage at Kakira Sugar Works, where carbon dioxide is bubbled through lime treated cane juice to remove impurities. The process follows:

Equation 1. 5: $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

During a typical operating cycle, 4,500 dm^3 of carbon dioxide was supplied at 30 °C and 1 atm. From this operation, 235 g of calcium carbonate was recovered. The lime solution used had a concentration of 1.50 $moldm^{-3}$.

Isotopic analysis of calcium indicated Ca-40 (96.90%) and Ca-44 (2.10%).

In addition, an organic chemical impurity formed during juice clarification was isolated and on combustion of a 0.300 g sample produced 0.660 g of carbon dioxide and 0.270 g of water and a molecular mass of 160.13g.

Management at Kakira got so concerned and so seeks a full stoichiometric evaluation to improve process efficiency, optimise reagent use, and minimise environmental discharges associated with incomplete carbonation.

Task; As a learner of Chemistry, assist the management:

(i) Calculate the accurate relative atomic mass of calcium.

(ii) Determine the molecular formula of the impurity.

b) Calculate the moles of carbon dioxide supplied and hence determine the mass of calcium carbonate expected in the reaction in order to advise the company whether the precipitation is efficient or not.

(i) Briefly describe how 1.50 $moldm^{-3}$ calcium hydroxide solution is prepared for use

(ii) Calculate the minimum volume of calcium hydroxide needed to react completely with the carbon dioxide supplied.

(iii)Analyse how important is the stoichiometric reaction above to the environment.

203. The Ministry of Energy is conducting a feasibility study for a small modular nuclear reactor (SMR). Candidate fuels include Thorium (Z = 90) and Uranium (Z = 92), whose electron configurations determine their oxidation states in high-temperature fuel processing. According to the feasibility report, Uranium-238 in fuel undergoes alpha decay to produce Thorium-234, which then undergoes beta decay to Protactinium-234. For decay-rate analysis, a research test cell contains 6.0 g of Th-234, stored for 72 days, and the isotope has a half-life of 24 days.

Questions

a) Deduce the electron configurations of Th and U and explain their influence on oxidation states in fuel chemistry.
b) Write the nuclear equations for the alpha decay of U-238 and beta decay of Th-234, explaining changes in nucleon numbers.
c) Suggest the suitability of the substances towards their real life use.
d) Determine the mass of Th-234 remaining after the specified storage period.
e) Evaluate environmental challenges associated with incorporating radioisotopes into Uganda's future energy mix.

204. Following long-term phosphate-fertilizer use in Eastern Uganda, NEMA carried out a wetland contamination study. Samples showed that Radium-226 with a half-life of 1600 years, initially present at 5.0×10^6 atoms in the analysed sample. It was also found that accumulation of Radon-222, was by alpha decay of Ra-226.

Further analysis of the wetland revealed that there is contamination from transition-metal ions Fe^{2+}, Fe^{3+}, and Zn^{2+}, whose electron configurations determine their mobility in reducing wetland environments.

However, NEMA must model the remaining Ra-226 after 4800 years and evaluate ethical issues before publishing community-impact reports. You have been approached for help.

Task; As a learner of chemistry, help NEMA officers;

a) Write the electronic configurations of Fe^{2+}, Fe^{3+} and Zn^{2+} and analyse how these influence complex formation in wetland conditions.
b) Write the nuclear equation for the decay of Ra-226 to Rn-222 and explain the rea life applications of the change in nucleon number.
c) Determine the fraction of Ra-226 remaining after the period.
d) Assess the environmental, public-health impacts, and mitigation measures NEMA must consider before releasing the radioactivity findings.

205. A steel-fabrication plant in Jinja conducts weld inspections using Cobalt-60, which emits gamma rays after beta decay. The Co-60 used has a half-life of 5.27 years and an initial activity of 4.8×10^8 disintegrations per second.

For safety audits, the plant must determine the remaining activity in Co-60 sources that have been stored for 15.8 years before disposal.

New technicians must also study the electron configurations of Cobalt (Z = 27), Co^{2+}, Co^{3+}, Nickel (Ni^{2+}), to understand corrosion resistance and alloy performance.

Task; As a learner of chemistry, help the manager;

a) Write the electronic configurations of the given ions and explain how these electronic structures influence alloy behaviour.
b) Write the nuclear equation for the β^- decay of Co-60 and explain the significance of the associated gamma emission in radiographic testing. (4 marks)

c) Determine the activity of the Co-60 source after the stated storage duration.

(i) Evaluate the industrial benefits of using Co-60 in manufacturing plants.

(ii) Suggest the environmental concerns and mitigations of using Co-60 in manufacturing plants.

206. A food-processing plant in Jinja uses a gamma-emitting radiotracer, Y-198, to test for leakage and flow uniformity in automated beverage-filling lines. The isotope emits γ-radiation and is detected by automated sensors as it moves through the pipe network. After each test run, residual tracer is collected in a shielded storage container until it decays to a safe disposal level.

Due to concerns about long exposure times for technicians, the plant requests a decay analysis. A sample of Y-198 was placed in the decay chamber and its activity recorded at regular intervals. The measurements are shown below:

Time, t (hours)	6	10	14	18	22	26	30	34
Activity, A(MBq)	120	92	70	53	40	30	23	17

Engineers believe Y-198 undergoes first-order decay and would want to estimate the decay constant (λ). They also request chemical support to explain whether the isotope's electronic configuration changes during radioactive decay. They have approached you for assistance.

Task; As a learner of chemistry, help the Engineering team;

a) State the electronic configuration of a neutral atom of Y (atomic number = 79).
b) Explain whether forming the isotope Y-198 changes the electronic configuration of element Y.

(i) Analyze the data to determine the decay constant λ of Y-198.

(ii) Determine the half-life of the isotope.

c) Calculate the time required for the activity to fall to 8 MBq.
d) Explain any other industrial application and environmental concerns and safety measure associated with the use of the substance in food-processing industries.

207. A factory producing metallic cans in Jinja uses a γ-emitting source, Y-60, for thickness monitoring. Y-60 has an initial activity of 500 MBq and a half-life of 5.3 years. The detector records the count rate passing through each can; lower count rate indicates a thicker wall. Technicians observed that after 10.6 years, the activity of Y-60 had decreased significantly, causing unreliable readings. However they are unaware on how deal with these changes. They have contacted you for your assistance.

Task; As a leaner of chemistry, the research team;

a) Determine the remaining activity after 10.6 years.

b)Explain why γ-radiation is suitable for thickness monitoring.

c) State the electronic configuration of cobalt (Z = 27), the element from which Y-60 is produced.

d) Comment on the effect of radioactive decay on the electronic configuration of the cobalt nucleus.

State one industrial application and one health or environmental impact of using γ-sources.

208. At the Uganda Heart Institute, biomedical engineers are redesigning sensors used for monitoring electrical signals during cardiac examinations. Five materials have been recommended by an expert to be evaluated whether sodium chloride (NaCl) can be used in electrolyte gels, aluminium metal (Al) can be used for electrode pads, glucose ($C_6H_{12}O_6$) is present in physiological fluids, water (H_2O) can be the main solvent in body tissues, and ethanol (C2H6O) can be the main agent in cleaning solutions for bloods.

The institute seeks to know the bonding of all four substances. Relate these features to electrical conductivity, solubility, and mechanical properties. Justify the suitability of each material for its application. Compare the molecular structure and shape using VSEPR for water and ethanol to explain their difference in Polarity, Solvation and Boiling point in order to predict if substances fit there purposes.

The research committee invites you to assist in this program.

Task; As a learner of chemistry, write a presentation you will use upon invitation.

209. The Nile Breweries maintenance division is reviewing cleaning chemicals used for internal washing of stainless-steel beverage pipelines. Their evaluation focuses on four substances: carbon dioxide (CO_2) used for pressure cleaning, ammonia (NH_3) used in detergent solutions, oxygen gas (O_2) used in aeration systems, and ethanol (C_2H_5OH) used as a sterilizing agent.

The company wishes to understand the bonding and molecular structure of the four substances, analyze how their polarity, shape and intermolecular forces affect their behavior in industrial cleaning, include a VSEPR explanation for ammonia and ethanol to predict bond angles and polarity, and evaluate which chemical would offer the safest and most effective cleaning performance for beverage pipelines. You have been invited for assistance.

Tasks: As a learner of chemistry, write a presentation you will use upon invitation.

210. During an environmental audit in Jinja Municipality, inspectors investigated pollutants released from informal metal working garages. Four major substances were identified: sulphur dioxide (SO_2) produced from burning sulphur, nitrogen monoxide (NO) emitted from welding equipment, calcium ions (Ca^{2+}) washed from metal finishing waste, and magnesium hydroxide ($Mg(OH)_2$) formed when workshop ash mixes with rainwater. Reports reveal that SO_2 forms acidic solutions, NO readily forms nitrogen dioxide in air, Ca^{2+} precipitates with carbonates in soil, and $Mg(OH)_2$ is a solid with limited solubility. Environmental officers seek to analyze the bonding, structure, and polarity of all four pollutants. Discuss the environmental significance of molecular geometry using VSEPR for SO_2 and NO. Explain how these features influence solubility, mobility, and reactivity, and propose scientifically appropriate strategies for reducing the environmental impact of these substances.

Task; As a learner of chemistry, write a presentation you will use upon invitation.

211. A renewable energy company in Tororo is testing materials for a low cost rechargeable battery system to be distributed in rural households. The study compares the suitability of four substances: graphite, sodium chloride (NaCl), magnesium oxide (MgO), and distilled water a used in preparing battery electrolytes.

Engineers note that graphite is good for electrodes, NaCl only good for electrolytes, MgO is good for higher temperature environments and water stabilizes ions but may corrode metallic parts.

The design team requests a scientific evaluation to analyze the bonding and structure of all four substances. Relate these features to conductivity, thermal stability and reactivity, include VSEPR diagram for water to explain hydrogen bonding and its significance as a solvent. And justify which materials are most suitable for incorporation into a durable, efficient, and affordable rural battery system.

Task; As a learner of chemistry, write a presentation you will use upon invitation.

212. A technical report from Moroto Agro Chem Industries (U) Ltd indicates that the company is optimizing its large scale ammonia production system, a key raw material used in fertilizers, cleaning agents and pH-control formulations.

During pilot testing, the industrial chemists introduced 1.00 mole of nitrogen gas and 3.00 moles of hydrogen gas into a 2.00 dm^3 high-pressure reactor. The mixture was compressed to 100 atm and heated to 400°C, allowing equilibrium to be established according to the reversible reaction:

Equation 1: $N_2(g) + 3H_2(g) \rightleftharpoons 2\ NH_3$ $\Delta H = -92$ kJ/mol

Gas analysis later revealed that the equilibrium mixture contained 25% ammonia by volume,

prompting management to evaluate how changes in operating variables such as pressure, temperature and catalysts might influence the position of equilibrium, the value of the equilibrium constant, and the rate of attainment of equilibrium in the reactor.

The company also manufactures buffered cleaning solutions by passing a equilbrium mixture through hydrochloric acid.

To test the stability of one formulation, the Quality Assurance Unit prepared a 0.001 M ammonia solution and needed to determine its pH, as well as verify how the mixture behaves when ammonium chloride is added to create an ammonia to ammonium chloride buffer system. Because the buffer is used to maintain constant pH in enzyme based cleaning agents, the Plant Manager must be confident that the solution must suit its purpose. You have been invited to assist in analysing the equilibrium data, pH, and functioning of the buffer system.

Task: As a learner of Chemistry, help the company to know;

a) The equilibrium constant for the gaseous reaction (Kp).
b) How the equilibrium system is affected by:
c) Passing equilibrium mixture through hydrochloric acid.
i) Introducing a catalyst.
iii) Increasing temperature.
iv) Increasing pressure.
d) Calculate the pH of the solution obtained. ($\boldsymbol{Kb} = \mathbf{1.8 \times 10\text{-}5}\boldsymbol{moldm}\mathbf{\text{-}3}$).
e) How the buffer system works.

f) Environmental impacts of the gaseous or aqueous equilibria and their mitigations.

213. A report from Kabong Chemical Works (U) Ltd revealed that the company is improving its sulphuric acid production process, an essential raw material used in fertilizers and lead acid batteries.

In one of the experiments, the company's chemists reacted 0.425 moles of sulphur dioxide with

0.294 moles of oxygen gas in a 1.60 dm^3 sealed vessel. The gases were heated in the presence of a catalyst, and equilibrium was established according to the reversible reaction:

Equation 1: $2\ SO2(g) + O2(g) \rightleftharpoons 2\ SO3 \quad \Delta H = -196$ kJ/mol

After analysis, it was discovered that 52% of the oxygen gas had reacted this made the

management curious how operating conditions influence both the position of equilibrium and rate of attainment of equilibrium in the process, and environmental effects of emissions.

Sulphur trioxide, is always converted to sulphuric acid, the plant's key product. For quality control, 25 cm^3 of 0.05 M sulphuric acid was diluted with 750 cm^3 of pure water, and the resulting solution was tested for acidity. To confirm whether the product meets safety and concentration standards, the manager must know the pH of diluted acid sample.

The acid is used to produce lead(II) sulphate used in battery plates. The company's environmental unit reported that only 0.035g/dm^3 of it dissolves water at 17 °C, and the manager sought to know its solubility product, so as to predict the effects of waste discharge on nearby water sources. Concerned about these findings, the Plant Manager has invited you.

Task; As a learner of Chemistry, help the company to know;

a) The equilibrium constant for the gaseous reaction (Kc).
b) Explain effect on the position of equilibrium, the value of Kc, and the rate of attainment of equilibrium by:
   i) adding more Sulphur dioxide gas.
   ii) introducing a catalyst.
   iii) increasing temperature.
   iv) increasing pressure.
c) Calculate the pH of the solution obtained
d) Determine the solubility product of lead(II) sulphate.
e) Environmental impacts of the gaseous or aqueous equilibria and their mitigations.

214. Dr. Akello, a nuclear physicist at Makerere University Uganda, is conducting an experiment involving a radioactive isotope with a half life of 150 seconds. She needs to determine the percentage of the isotope that will be remain after 600 seconds to ensure the safety of her team and the accuracy of her results.

Task; As a senior five student with the knowledge of Radioactivity, help her determine the percentage of the isotope that will remain after 600 seconds.

215. A researcher is studying a radioactive isotope used in medical imaging. The isotope has a half life of 3.11 hours and is known to have an activity of 1000 decays per second at a specific point in time during the experiment.

The researcher needs to determine the activity of the isotope one hour later to adjust the imaging parameters accordingly.

Task; Using the principles of radioactive decay, calculate the activity of of the isotope one hour later after the initial measurement.

216. A researcher is studying the radioactive decay of Radium-226 in a laboratory setting. Initially, she has a sample of 2 grams of Radium-226. Given that it takes 1620 years for 0.03 moles of Radium-226 to decay to 0.015 moles.

Task

As a chemistry learner of senior five, find how many moles of Radium-226 will be left after 6 years.

217. The reactivity of elements in the periodic table is greatly dependent on the atomic radius (atomic size) of each element. This varies periodically across a period and down a group of elements. This fact makes chemistry very difficult to understand for many students

You are invited to facilitate senior four students of your school in a grand chemistry seminar

Task

Using accurate electronic configuration of each element; explain to the students this information, giving reference to group II elements (Be, Mg and Ca) and period 3 elements (Na to Cl)

218. In absence of laboratory technician and chemistry teacher, you are left in charge to prepare 4l ($4000cm^3$) of 2M (2 moles in $1000cm^3$) sodium carbonate solution from powder of anhydrous sodium carbonate salt, Na_2CO_3 and water; and to provide each learner with $100cm^3$ of this solution for experimental investigation

The experimental procedure demands each learner to dilute the $100cm^3$ of sodium carbonate solution with more water to make 150cm3; and to react this solution with $100cm^3$ of hydrochloric acid provided to each. This acid was made by adding $25cm^3$ of water to $75cm^3$ of a 2.5M HCl to dilute it

Task:

a) Determine the mass of anhydrous sodium carbonate salt you will dissolve to make 4000cm3 of the standard solution to supply the class
b) Guide the students to understand the concentration of their new diluted solution of each of the sodium carbonate and hydrochloric acid (in moles per 500cm3)
c) Make the students understand the amount of mass (in grams) present in every 50cm3 of each of the two solutions finally diluted for the experimental use

219. A company specializes in producing fuel additives for a camping stove fuel. They are considering using a compound with molecular formula C_5H_{12} as part of their additive formulation.

However, on doing research they found out that the compound has different forms in which it's capable of existing, with different physical properties but similar chemical properties.

The company wants to know which form of this compound would be better for their fuel mixture basing on boiling point. The best fuel additive should be one that has the lowest boiling point. All forms work for the application, but one is more suitable due to its physical and chemical properties.

Task. Write a message;

a) Enlighten the company on the different forms of the compound, any similar chemical property they exhibit.
b) Advising and explaining to them on which form would be best suited for their fuel additive formulation.

220. chemical company in Tororo manufactures halide compounds used in disinfectants. The first electron affinity (EA) of an element indicates how readily it gains an electron to form stable anions. Elements with more negative EA values are more reactive and suitable for halide formation, while those with low or positive EA are less effective.

The company is analysing Group VII and Period 3 elements to identify the most suitable for halide production and is also considering an unknown element X between aluminium and silicon.

Group/period	**Group VII**				**Period 3**							
Element	F	Cl	Br	I	Na	Mg	Al	Si	P	S	Cl	Ar
Atomic number	9	17	35	53	11	12	13	14	15	16	17	18
First EA (kJ/mol)	−354	−370	−348	−320	−21	+67	−44	−135	−72	−200	−364	0

The manager seeks to analysis the data to make informed decisions by plotting first electron affinity vs. atomic number for Group VII and Period 3 elements separately. Describe and explain trends and all irregularities in electron affinity across Period 3 and down Group VII. Evaluate which elements are(is) most suitable for industrial halide production, giving reasons. Predict the likely electron affinity of element X and comment on its potential suitability for forming halides.

Task

As a chemistry student, make a write up you will use to help the company.