

Examinations Council of Lesotho



2023 Examiner's report Chemistry Paper 2 (0197/02)



INTRODUCTION

This report serves to share information on the examiners' observations during the marking of **Chemistry Paper 2 (0197/02)** in the November 2023 examinations. The document gives comments on the candidates' general performance, strengths and weaknesses. Problematic topics and areas on which teachers must put emphasis are also highlighted. It provides detailed feedback on individual questions by stating the expected responses, candidates' common errors and recommendations where necessary.

GENERAL COMMENTS

Generally, the performance of candidates in Chemistry (0197/02) is slightly lower than their predecessors. Most candidates were able to express themselves using correct language, which was clear, relevant, and precise. They used appropriate scientific terminology as well. Almost all candidates attempted all the questions, however there were questions where candidates obtained low marks. The performance displayed knowledge with understanding, handling information and problem solving across the centres. However, the main challenge was that most candidates failed to attain full marks in handling and problem-solving questions because they did not analyze and do some calculations correctly.

COMMENTS ON INDIVIDUAL QUESTIONS

1. The Haber process produces ammonia as shown by the following equation:



- (a) State the meaning of the symbol, $\rightleftharpoons$ [1]

Expected response: reaction is reversible/coexistence of both forward and reverse reactions

Attempt: Many

Performance: Very good

- (b) State the source from which nitrogen is obtained, and the technique used to obtain it. [2]

Expected response: air; fractional distillation (of liquefied air);

Attempt: Many

Performance: Very good

Common mistakes/misconceptions: source: atmosphere

(c) A transition element is used in the Haber process as part of conditions.

(i) Name this element. [1]

Expected response: iron

Attempt: Many

Performance: Very good

Common mistakes/misconceptions: nickel

(ii) Describe the role of the element in the process. [1]

Expected response: (acts as) a catalyst

Attempt: Many

Performance: Very good

(d) The operating conditions in the Haber process are the temperature of about 400 °C and 200-300 atm of pressure.

State and explain the effect of increasing pressure to 1000 atm on the yield of ammonia. [3]

Expected response: equilibrium shifts to the right/product side OR concentration/yield of ammonia increases; more moles/molecules of gas on the reactant side than product side; equilibrium shifts to the side with few gas moles/molecules

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: Confusion of rate of reaction with equilibrium.

Recommendations: Teachers should make emphasis on the difference between rate and equilibrium, more focus on the factors that affect each.

(e) Describe the difference between particles in liquid ammonia and in nitrogen gas in terms of their movement and forces of attraction.

Expected response: strong force of attraction between particles of liquid ammonia/particles are held tightly while there is a weak force of attraction between particles of gaseous nitrogen/particles are held loosely; Particles in liquid ammonia

move slowly/fairly free but clustered while particles in the gaseous nitrogen move faster/free and separate; [2]

Attempt: Many

Performance: Good

Common mistakes/misconceptions: random movement of particles in gases.

Recommendations: Teachers it should be noted that :

- comparison should be made based on only one point at a time.
- random movement is not for gas particles **only**.

2. Proteins are natural polymers. Plastics are man-made polymers.

(a) Define the term polymer [1]

Expected response: large molecule made up of many small molecules known as monomers;

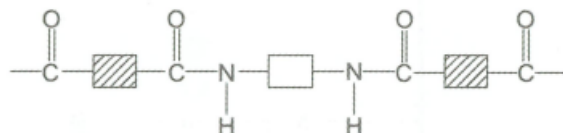
Attempt: Many

Performance: Fair

Common mistakes/misconceptions: definition of polymer as a reaction

Recommendations: differentiate between polymerisation and polymer

(b) Part of the structure of nylon is shown.



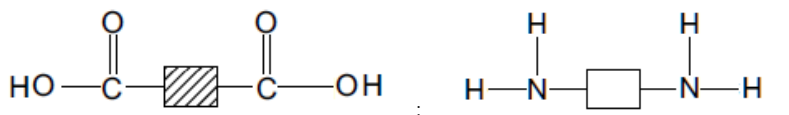
(i) Complete the structures of the two monomers of nylon.

Show all the atoms and bonds in the functional groups.



[2]

Expected response:



Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconceptions: not all atoms and bonds were shown particularly between oxygen and hydrogen (O-H).

Recommendations: practice on graphical structures of organic compounds

- (ii) Proteins and nylon have the same linkages.
State the difference between the structure of protein and the structure of nylon. [1]

Expected response: amino and acid groups in the same monomer for protein vs in different monomers for nylon ;

Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconceptions: Candidates compared the shape of the two molecules not the structure

Recommendations: Teachers should encourage learners to practice more on identifying what the question really requires.

- (iii) Name the type of polymerisation used to produce protein. [1]

Expected response: condensation polymerisation;

Attempt: Many

Performance: Good

Common mistakes/misconceptions: addition/synthetic polymerisation

- (iv) State the molecule removed when the protein is formed. [1]

Expected response: water;

Attempt: Many

Performance: Very good

Common mistakes/misconceptions: hydrogen

- (v) Describe how the use of plastics may lead to environmental problems. [2]

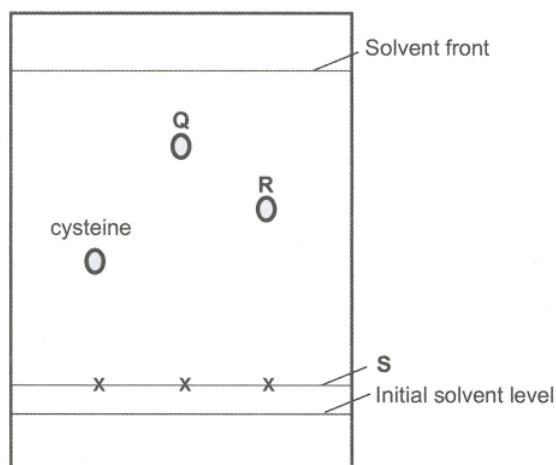
Expected response: plastics are non-biodegradable; littering leads to land and water pollution; burning leads to air pollution;

Attempt: Many

Performance: very good

- (c) A solution of amino acids obtained after hydrolysis of a protein was analysed in the laboratory.

Fig 2.1 shows part of a chromatogram obtained during the analysis.



- (i) Name the line labelled S. [1]

Expected response: baseline/starting line/origin;

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: pencil line, solvent line, starting point

Recommendations: learners should be encouraged to use correct terminology

- (ii) State the most soluble amino acid.

Expected response: Q; [1]

Attempt: Many

Performance: very good

Common mistakes/misconceptions: cysteine

- (iii) Table 2.1 shows R_f values of some amino acids. R_f value for cysteine is missing.

Table 2.1

amino acid	R _f value
Arginine	0.2
Cysteine	
Histidine	0.1 1
Leucine	0.73
Methionine	0.55

Determine the R_f value of cysteine from Fig. 2.1. [3]

Expected response: Measurements: 2.2 cm, 5.5 cm;
calculation of R_f: $2.2\text{cm} \div 5.5\text{ cm}$; 0.4 ;

Attempt: Many

Performance: unsatisfactory

Common mistakes: units omitted, measuring from base line/initial solvent level to bottom or top of spot.

Recommendations: learners should be encouraged to use correct units

(iv) Use Fig. 2.1 and Table 2.1 to identify the amino acids Q and R. [2]

Expected response: Q leucine; R methionine;

Attempt: Many

Performance: Unsatisfactory

3. Methane, CH₄, can be used as fuel.

(a) State **one** source of methane. [1]

Expected response: decomposition of vegetation; waste gases from digestion in animals; natural gas/fossil fuels/petroleum/crude oil;

Attempt: Many

Performance: very good

Common mistakes/misconceptions: petrol, burning of fossil fuels

Recommendations: emphasis should be made on difference between petroleum and petrol

(b) Most atoms form bonds to be stable.

(i) Draw the dot-and-cross diagram to show bonding in a methane molecule.

Use valence shells only. [2]

Expected response: 1 carbon + 4 hydrogen atoms each overlapping with another atom+ correct number of valance electrons; correct sharing;

Attempt: Many

Performance: very good

(ii) Name an element in the Periodic Table whose atoms do not form bonds. [1]

Expected response: helium/neon/argon

Attempt: Many

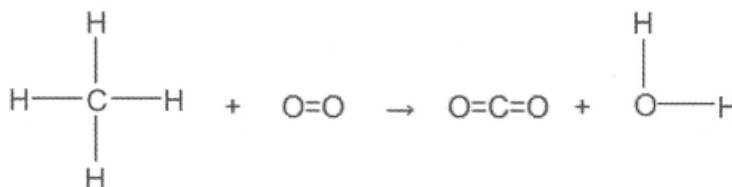
Performance: good

Common mistakes/misconceptions: krypton/xenon

Recommendations: learners should be made aware that some noble gases form compounds

(c) Combustion of methane is an exothermic reaction.

The following unbalanced equation represents the combustion of methane.



(i) Define exothermic reaction. [1]

Expected response: reaction that gives out energy;

Attempt: Many

Performance: good

Common mistakes/misconceptions: reaction that produce energy

Recommendations: learners should be made aware of the fact that energy can be changed from one form to another but NOT produced

(ii) Water is one of the products of this reaction.

Describe a chemical test for water.

Test and Positive result: [2]

Expected response: add to blue anhydrous cobalt(II) chloride/

blue cobalt paper; turns pink; OR

Add to white anhydrous copper(II) sulfate; turns blue

Attempt: Many

Performance: good

Common mistakes/misconceptions: omission of 'anhydrous', wrong colours of compounds, omission of the oxidation state of copper and cobalt in copper(II) sulfate and cobalt(II) chloride respectively.

Recommendations: learners should be made aware that the substances are to be dry (anhydrous) when testing for presence of water

- (d) Table 3.1 shows the bond energies for the bonds involved in the combustion of methane.

Table 3.1

bond	bond energy in kJ/mol
C=O	803
C-H	435
O-H	
O=O	497

- (i) According to a balanced chemical equation, 1 methane molecule reacts with 2 oxygen molecules.

State the number of molecules of carbon dioxide and water in a balanced equation. [1]

Expected response: CO₂ molecules 1; H₂O molecules 2

Attempt: Many

Performance: very good

- (ii) Calculate the energy needed to break bonds of the reactant molecules. Show your working. [2]

Expected response: 4 C-H bonds in methane requires: $4 \times 435 = 1740$ kJ/mol **and** 2 O=O bonds in oxygen requires: $2 \times 497 = 994$ kJ/mol; energy for bond breaking = $1740 \text{ kJ/mol} + 994 \text{ kJ/mol} = 2734 \text{ kJ/mol}$;

Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconception: 2237 KJ/mol

- (iii) Calculate the energy needed to form bonds of carbon dioxide molecule.[1]

Expected response: $2 \times 803 = 1606$ kJ/mol

Attempt: Many

Performance: good

Common mistakes/misconception: 803 KJ/mol

- (iv) The energy change for complete combustion of methane is -728 kJ/mol. Calculate O-H bond energy in H₂O. [2]

Expected response: $-728 = 2734 - (4 \times \text{O-H} + 1606)$;

$\text{O-H} = 1856/4 = 464 \text{ kJ/mol}$;

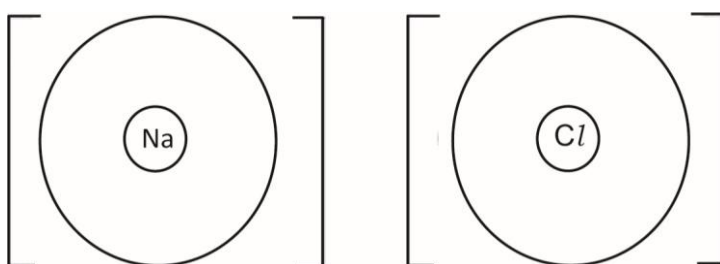
Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconception: using 2 O-H bonds instead of 4

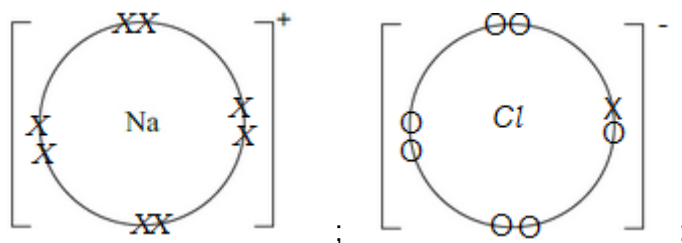
4. A student prepared crystals of sodium chloride, NaCl(s) , from crystals of sodium carbonate, $\text{Na}_2\text{CO}_3\text{(s)}$ and a dilute hydrochloric acid, HCl(aq) .

- (a) Complete the dot-and-cross diagram to show bonding in sodium chloride. Show outer shells only.



[2]

Expected response:



Attempt: Many

Performance: Fair

Common mistakes/misconceptions: charges were omitted, charges were wrong and placed at the wrong position. Confusing representation of oxidation number

Recommendations: importance of correct conventions should be emphasized

- (b) Describe how the student prepared crystals of sodium chloride, from crystals of sodium carbonate and dilute hydrochloric acid. [2]

Expected response: prepare a solution of sodium carbonate ;

Titrate acid with a base/add acid to a base containing an indicator;

React correct volumes of acid and base without indicator;

(When the reaction is over) heat the reaction mixture to saturation point;

Leave to cool to allow crystallization;

Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconceptions: assumed sodium carbonate to be an insoluble base

- (c) The student dissolved 150 g of sodium carbonate in 1 dm³ of water in a volumetric flask.

- (i) Calculate the number of moles of 150g of Na₂CO₃.

[M_r Na₂CO₃, 106]

[1]

Expected response: 150/106, no of moles=1.42mol

Attempt: Many

Performance: good

- (ii) Determine the concentration, in mol/dm³, of sodium carbonate in the volumetric flask. [1]

Expected response: 1.42 mol/dm³

Attempt: very good

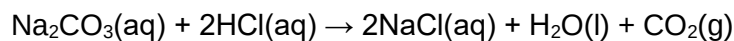
Performance: very good

Common mistakes/misconceptions: none

Recommendations: none

- (iii) From the volumetric flask, the student reacted 10 cm³ of sodium carbonate with 50 cm³ of 0.1 mol/dm³ of hydrochloric acid.

The equation represents the reaction:



- Calculate the number of moles of Na₂CO₃ in 10 cm³ of Na₂CO₃(aq). [1]

Expected response: $1.42 \times 10 / 1000 = 0.014 \text{ mol}$

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: 0.05 mol

- Calculate the number of moles of HCl in 50 cm³ of 0.1 mol/dm³ HCl(aq). [1]

Expected response: $0.1 \times 50 / 1000 = 0.005 \text{ mol};$

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: 0.05

- Determine a limiting reactant. [4]

Expected response: mole ratio $\text{Na}_2\text{CO}_3 : \text{HCl}$ 1: 2 ;

0.014 mol Na_2CO_3 need $2 \times 0.014 = 0.028$ mol HCl ;

0.005 mol HCl available ;

So HCl limiting ;

Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconceptions: Not using molar ratio from the equation.

- 5 Sulfuric acid and ethanoic acid both react with sodium hydroxide, a strong base.
Sulfuric acid is a strong acid and ethanoic acid is a weak acid.

- (a) Estimate the pH value of ethanoic acid. [1]

Expected response: 3 to 6

Attempt: Many

Performance: very good

- (b) Describe the effect of aqueous sodium hydroxide on litmus paper. [1]

Expected response: turns red litmus paper blue/ has no effect on blue litmus paper

Attempt: Many

Performance: very good

- (c) Explain how a strong acid differs from a weak acid. [1]

Expected response: strong acid fully dissociates in water vs weak acid partially dissociates in water

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: reference to pH, concentration

- (d) Write an ionic equation to represent the reaction between a strong acid and a strong base. [1]

Expected response: $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$

Attempt: Many

Performance: Unsatisfactory

- (e) Another weak acid from ants contains 0.06g Carbon, 0.01 g Hydrogen and 0.16g Oxygen.

- (i) Determine the empirical formula of the acid. [2]

Expected response: mass ratio: C : H: O 0.06: 0.01: 0.016 AND

Mole ratio: 0.05 : 0.01: 0.01 ;

Simple mole ratio: 1:2:2 AND

And empirical : CH_2O_2 ;

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: CHO

- (ii) The relative molecular mass of this acid was determined to be 46. Determine its molecular formula. [1]

Expected response: empirical formula mass = 46

$n = 46/46 = 1$

molecular formula same as empirical formula = CH_2O_2

Attempt: Many

Performance: Fair

- (iii) State the name of this acid. [1]

Expected response: methanoic acid

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: ethanoic acid, carboxylic acid

Recommendations: learners should be exposed to a variety of carboxylic acids

6. A student performed an experiment to investigate the rate of a reaction between zinc granules and dilute hydrochloric acid.

- (a) Name any **one** piece of apparatus inside which a reaction between zinc granules and dilute hydrochloric acid occurs during the investigation. [1]

Expected response: conical flask/side-arm conical flask + stopper ;

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: beaker, test tube

Recommendations: proper use of pieces of apparatus

(b) A gas is produced during the reaction.

(i) State the name of the gas. [1]

Expected response: hydrogen

Attempt: Many

Performance: Fair

(ii) Describe a test for this gas.

Test and results of the investigation. [2]

Expected response: test: introduce a lighted or burning splint
observation: pop/squeaky sound

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: test for oxygen, chlorine and carbon dioxide

(c) Fig 6.1 shows a graph of the results.

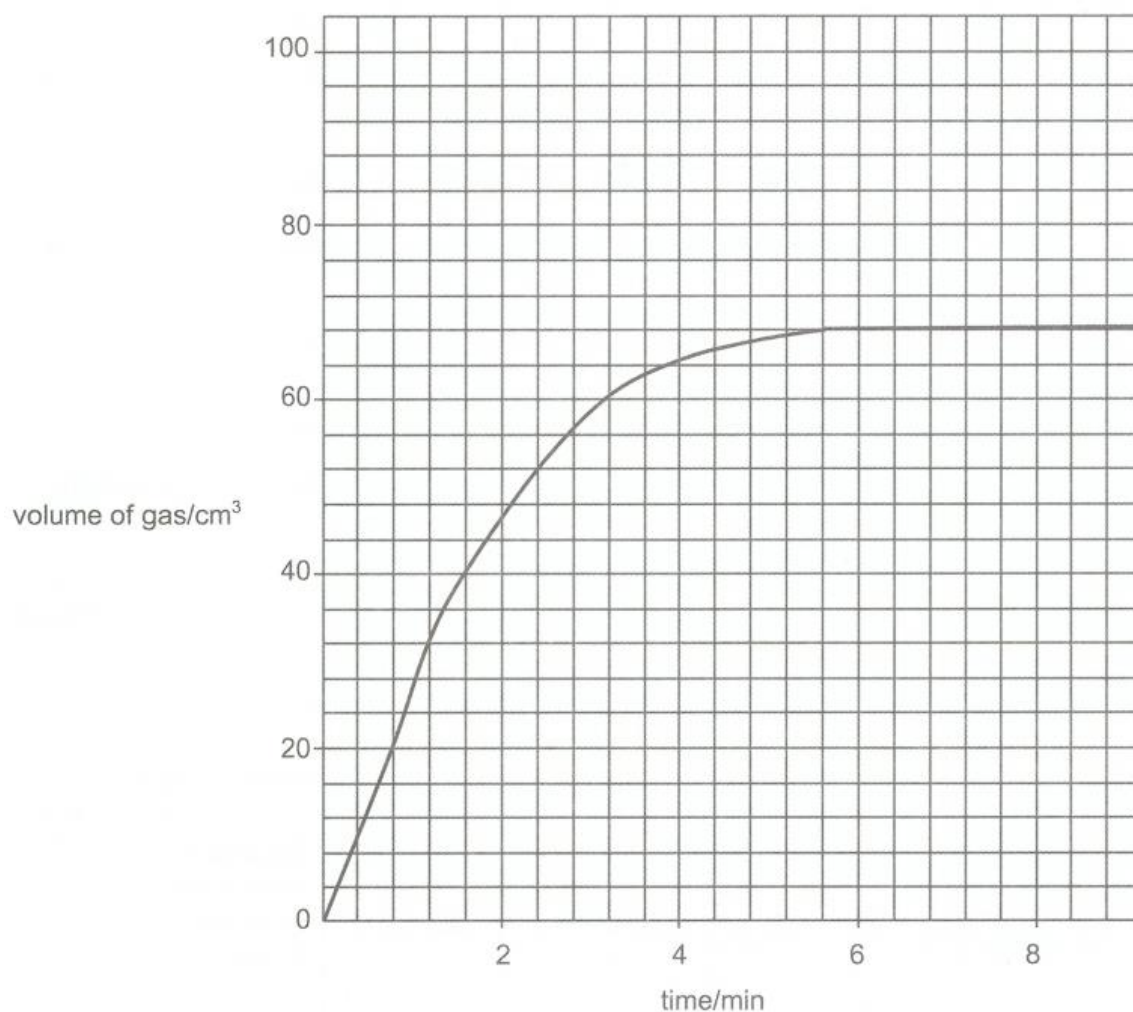


Fig.6.1

- (i) State the volume of gas produced during the second minute. [1]

Expected response: $46 \pm 1 \text{ cm}^3$

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: 64.68 cm^3

- (ii) Describe how the rate of the reaction changed with time, using fig 6.1. [2]

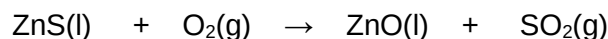
Expected response: initially fast; slows down with time; finally goes to zero;

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: rate increase with time

- (d) Zinc is extracted from its ore, zinc blende (ZnS), by roasting the ore in excess air in a furnace. The reaction is represented by the equation.



- (i) Explain, in terms of change in oxidation states, why sulfur is oxidised in this reaction. [1]

Expected response: oxidation number increases from -2 to +4 OR loss of electrons from sulfur atom

Attempt: Many

Performance: Unsatisfactory

Common mistakes/misconceptions: wrong oxidation numbers, missing oxidation numbers

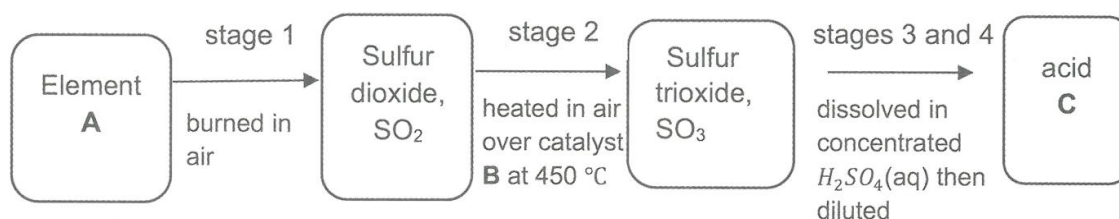
- (ii) Write a balanced equation to show reduction of zinc oxide, ZnO, by carbon monoxide, CO. [1]

Expected response: $\text{ZnO} + \text{CO} \rightarrow \text{Zn} + \text{CO}_2$

Attempt: Many

Performance: very good

- 7 The diagram shows stages in the contact process.



- (i) State the names of element A, catalyst B and an acid C. [3]

Expected response: A: sulfur; B: vanadium (V) oxide/vanadium pentoxide/V₂O₅; C: sulfuric acid

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: vanadium

- (ii) Write a balanced chemical equation for the formation of sulfur trioxide in stage 2. Include state symbols. [2]

Expected response: $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$ **OR** $\text{SO}_2(\text{g}) + 1/2\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: O for O_2 , omission of state symbols, leaving equation unbalanced

- (iii) State **one** use of acid C. [1]

Expected response: dehydrating agent when concentrated; catalyst; laboratory reagent; acid in car batteries ;removes oxidation on metals before painting/pickling; anodizing of aluminium; making detergents, fibres, fertilizers ,paints, dyes ;

Attempt: Many

Performance: very good

- (iv) State **one** effect of sulfur dioxide. [1]

Expected response: breathing problems/acid rain

Attempt: Many

Performance: very good

- (i) State **two** products of electrolysis of a solution of acid C.

Expected response: hydrogen; oxygen [2]

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: water, H^+ , OH^-

- (ii) Suggest a reason why graphite is a suitable material to make the electrodes.[1]

Expected response: inert; electrical conductor

Attempt: Many

Performance: very good

- (iii) Define the term electrolysis. [1]

Expected response: the breakdown of an ionic compound, molten or in aqueous solution, by passage of electricity

Attempt: Many

Performance: Fair

Common mistakes/misconceptions: candidates omitted “molten or ‘in

aqueous solution”

Recommendations: emphasis should be made on state of an electrolyte

Conclusion:

The performance is slightly lower than in 2022r, even though most candidates attempted all the questions with good command of English language and correct use of scientific terminology and conventions.

Recommendations

It is recommended that learners be exposed to experimental work frequently as part of their learning process as it helps with understanding and assimilation of concepts. Also, teachers need to scrutinize concepts that appear tricky to learners and come up with strategies to reduce and eventually eliminate recurring mistakes, e.g. equilibrium and rate of reaction. In completion, it is advised that teachers go through such reports as the report to schools and use them as part of their teaching tool.