THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

032/1 **CHEMISTRY 1**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2004**

Instructions

1. This paper consists of sections A, B and C with total of thirteen questions

1. (i) Which of the following sets of laboratory apparatus contains direct measuring items?

A. Crucible, Kipp's apparatus and volumetric flask
B. Test tube, beaker and gas jar
C. Thistle funnel, separating funnel and beaker
D. Burette, pipette and measuring cylinder
E. Volumetric flask, distillation flask and evaporating dish

Direct measuring items are apparatus that provide precise volume measurements. A burette, pipette, and measuring cylinder are used for accurate volume measurement in the laboratory.

Correct answer: D

(ii) Chloride ions (Cl^-) differ from chlorine atoms in that the ions have one more ---- than the atom.

A. more proton
B. less proton
C. more electron
D. less electron
E. more neutron

A chloride ion (Cl^-) has gained one extra electron compared to a neutral chlorine atom, making it negatively charged.

Correct answer: C

(iii) Hard water which is softened just by boiling contains dissolved

A. calcium carbonate
B. calcium chloride
C. magnesium sulphate
D. sodium carbonate
E. calcium hydrogen carbonate

Temporary hardness in water is caused by dissolved calcium hydrogen carbonate, which decomposes upon boiling, forming insoluble calcium carbonate and removing hardness.

Correct answer: E

(iv) A wasp sting is alkaline. The solution to help ease the pain by neutralizing the alkali would be one with a pH of:

A. 5

B. 7
C. 8
D. 10
E. 13

An alkaline sting can be neutralized by an acidic solution. A solution with a pH of 5 is slightly acidic and can neutralize the alkaline venom.

Correct answer: A

(v) Five separate 1 g samples of magnesium were placed in different beakers each containing 50 cm^3 of dilute sulphuric acid. The mixture which showed the fastest reaction rate at the start was the one containing magnesium

A. block
B. granules
C. powder
D. ribbon
E. turnings

Powdered magnesium has the largest surface area, leading to the fastest reaction with acid due to increased collision frequency.

Correct answer: C

(vi) The compound CH_3CH_2Cl is named as

A. carbon dichloride
B. methyl chloride
C. methylene chloride
D. ethyl chloride
E. propyl chloride

The given compound has two carbon atoms and a chlorine atom attached to the ethyl group. It follows the IUPAC naming as ethyl chloride.

Correct answer: D

(vii) Which of the following actions would result in an increase in the temperature of the earth?

A. Increase of distance from the sun
B. Removal of water vapour from the atmosphere
C. Increase of cloud cover

D. Removal of noble gases from the atmosphere
E. Increase of the carbon dioxide content of the atmosphere

Carbon dioxide is a greenhouse gas that traps heat in the Earth's atmosphere, leading to global warming and an increase in temperature.

Correct answer: E

(viii) Denitrifying bacteria

A. remove nitrogen from the atmosphere
B. oxidize nitrogen of the atmosphere
C. add nitrogen into the atmosphere
D. fix nitrogen in the soil through plants
E. add carbon dioxide into the atmosphere

Denitrifying bacteria convert nitrates in the soil back into nitrogen gas, releasing it into the atmosphere.

Correct answer: C

(ix) During the electrolysis of molten aluminum oxide, 3 Faradays were needed to deposit one mole of aluminum. The number of electrons of aluminum will be

A. 6.02×10^{12}
B. 1.86×10^{13}
C. 1.86×10^{18}
D. 180.6×10^{23}
E. 180.6×10^{33}

From Faraday's laws, 1 Faraday corresponds to 1 mole of electrons, and aluminum has a 3+ charge, so 3 Faradays are needed for one mole of Al atoms, equaling Avogadro's number of electrons.

Correct answer: C

(x) In plant nutrition nitrogen, phosphorus, and potassium are classified as ---- nutrients or elements.

A. micro
B. feeder
C. macro
D. trace
E. supplementary

Nitrogen, phosphorus, and potassium are required in large amounts by plants, making them macronutrients.

Correct answer: C

2. Match the responses in List B with the words or phrases in List A by writing the letter of the correct response beside the item number.

list A

(i) potassium and sodium
(ii) lead oxide
(iii) to put off flammable liquid fire
(iv) pollution
(v) chromatography
(vi) ferrous sulphate
(vii) electrovalent bond
(viii) normal salt
(ix) vanadium (v) oxide
(x) molar solution

list B

a. a method for separating dyes
b. stored under water
c. a compound in which all ionizable hydrogen have been replaced
d. a catalyst in the contact process
e. is reddish brown when hot and yellow when cold
f. a catalyst in the haber's process
g. is yellow when hot and white when cold
h. the act of making air, water and soil unfit for use
i. a compound in which part of ionisable hydrogen have been replaced
j. use sand and carbon dioxide
k. stored under kerosene
l. each atom donates electrons to be shared
m. sublimes when heated
n. turned reddish brown on the surface when exposed to air
o. a solution of known concentration
p. use water and carbon dioxide
q. a solution that contain one mole of a solute in one dm^3
r. add vapour into the atmosphere
s. is formed between opposite charged ions
t. is a method used for separating two liquids with different boiling points

correct answers

(i) b

(ii) g
(iii) j
(iv) h
(v) a
(vi) e
(vii) s
(viii) c
(ix) d
(x) i

3. (a) Write ionic equations for the following:

(i) Laboratory preparation of ammonia gas and hydrogen chloride.

$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$

(ii) Precipitation of barium sulphate from barium chloride and sodium sulphate; and silver chloride from a soluble chloride.

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$

(iii) Neutralization of a strong acid and a strong alkali.

$H^{+}(aq) + OH^{-}(aq) \rightarrow H_2O(l)$

(b) Consider the following elements of group seven in the order in which they appear in their group in the periodic table: F, Cl, Br, and I.

(i) Which element is the most electronegative?

Fluorine (F)

(ii) Name the least electronegative element.

Iodine (I)

(iii) Which element has the largest atom?

Iodine (I)

(iv) Write the electronic configuration of the chlorine atom.

Cl: 2, 8, 7

(c) Define electronegativity.

Electronegativity is the ability of an atom to attract bonding electrons towards itself in a chemical bond.

4. (a) Sodium, magnesium, zinc, copper, and silver are five metals which appear in this order in the activity series; sodium being the most reactive and silver the least reactive. Which one of these metals is

(i) Likely to tarnish most rapidly when exposed to air?

Sodium

(ii) Most likely to be found free in nature?

Silver

(iii) Least likely to react with steam?

Silver

(b) Two of the metals in 4(a) above are usually extracted by electrolysis of their molten chlorides. Name the two metals and give one reason for using this method.

Metals: Sodium and Magnesium
Reason: These metals are very reactive and cannot be extracted by reduction with carbon, so electrolysis is required.

(c)

(i) Name the positive and negative electrodes of an electrolytic cell.

Positive electrode: Anode
Negative electrode: Cathode

(ii) To which electrode will sodium ions in an aqueous dilute solution of sodium chloride migrate during electrolysis?

Cathode

(iii) What other ions will migrate to the electrode stated in 4(c)(ii)?

Hydrogen ions (H^+)

(iv) Which ions will be discharged at the electrode stated in 4(c)(ii)? Give reasons for your answer.

Hydrogen ions (H^+) will be discharged because hydrogen is lower than sodium in the electrochemical series, meaning hydrogen ions are preferentially reduced.

5.(a) In the reactions below, state whether the substances underlined are undergoing oxidation or reduction.

(i) $S + O_2 \rightarrow SO_2$

Sulfur (S) is oxidized.

(ii) $H_2S + Cl_2 \rightarrow 2HCl + S$

Sulfur (S) is reduced, and chlorine (Cl_2) is reduced.

(iii) $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$

Manganese (Mn) is reduced, and chlorine (Cl_2) is oxidized.

(iv) $Cu^{2+} + 2e^- \rightarrow Cu$

Copper (Cu^{2+}) is reduced.

(b)(i) Write the electronic configurations of the elements with atomic numbers 11, 15, and 18.

Sodium (11): 2, 8, 1
Phosphorus (15): 2, 8, 5
Argon (18): 2, 8, 8

(ii) Which element is the most reactive and which is the least reactive?

Most reactive: Sodium (Na)
Least reactive: Argon (Ar)

(c) compound formed when elements with atomic numbers 12 and 9 combine.
Compound: Magnesium fluoride (MgF_2)

6. (a) Figure 1 below represents the laboratory preparation of hydrogen chloride gas.

(i) Name the parts labelled A, B, C, and D.

A - Delivery tube
B - Solid reactant (e.g., sodium chloride)
C - Concentrated sulphuric acid
D - Gas jar containing hydrogen chloride gas

(b) (i) Do you think the gas can be collected over water? Give reasons for your answer.

No, because hydrogen chloride gas is highly soluble in water.

(ii) Explain the test for the gas.

Hydrogen chloride gas turns blue litmus paper red due to its acidic nature.

(iii) What is the function of liquid C?

Liquid C (concentrated sulphuric acid) acts as a dehydrating agent and helps in liberating hydrogen chloride gas from the solid reactant.

(iv) Name the method used to collect the gas.

Downward delivery (because hydrogen chloride is denser than air).

(v) Write a balanced chemical equation for the reaction taking place during the preparation of hydrogen chloride gas.

$NaCl(s) + H_2SO_4(l) \text{ -----> } NaHSO_4(s) + HCl(g)$

(c)(i) Write chemical equations of the reaction between ammonia gas and hydrogen chloride gas.

$NH_3(g) + HCl(g) \text{ -----> } NH_4Cl(s)$

(ii) Write chemical equations of the reaction between hydrogen chloride gas and water.

$HCl(g) + H_2O(l) \text{ -----> } H_3O^+(aq) + Cl^-(aq)$

7.(a) Define the term mole.

A mole is the amount of a substance that contains exactly 6.022×10^{23} elementary entities (atoms, molecules, or ions). It is the SI unit for the quantity of matter and is based on Avogadro's number.

(b) What would be the molarity of the solution if 46 g of sodium hydroxide (NaOH) were dissolved in 2000 cm^3 of the solution?

Molarity (M) is given by:

M = (mass of solute) / (molar mass × volume in dm^3)

Molar mass of NaOH = (23 + 16 + 1) = 40 g/mol

Moles of NaOH = 46 g / 40 g/mol = 1.15 moles

Volume of solution = 2000 cm^3 = 2.0 dm^3

M = 1.15 moles / 2.0 dm^3
= 0.575 M

(c) 8.50 g of a sample of iron required just 75 cm^3 of 3.00 M HCl to dissolve it and give a neutral solution. Calculate the percentage purity of the sample of iron.

Step 1: Write the balanced chemical equation

$Fe + 2HCl \rightarrow FeCl_2 + H_2$

Step 2: Calculate moles of HCl used

Moles = concentration × volume
= 3.00 M × (75 cm^3 / 1000)
= 0.225 moles

Step 3: Find moles of iron

From the equation, 2 moles of HCl react with 1 mole of Fe, so:

Moles of Fe = 0.225 moles / 2
= 0.1125 moles

Step 4: Calculate mass of pure Fe

Mass = moles × molar mass
= 0.1125 × 56
= 6.3 g

Step 5: Calculate percentage purity

% Purity = (mass of pure Fe / mass of sample) × 100
= (6.3 g / 8.50 g) × 100
= 74.1%

(d) 5.00 cm^3 of sulphuric acid solution from an automobile battery required 17.48 cm^3 of 1.95 M NaOH solution to neutralize the acid. Determine the concentration of the battery acid in

(i) mole dm^{-3}

Step 1: Write the balanced chemical equation

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Step 2: Calculate moles of NaOH

Moles = concentration × volume
= 1.95 × (17.48 / 1000)
= 0.0341 moles

Step 3: Find moles of H_2SO_4

From the equation, 1 mole of H_2SO_4 reacts with 2 moles of NaOH, so:

Moles of H_2SO_4 = 0.0341 moles / 2
= 0.01705 moles

Step 4: Calculate concentration of H_2SO_4

M = moles / volume
= 0.01705 / (5.00 / 1000)
= 3.41 M

(ii) gram dm^{-3}

Mass concentration = molarity × molar mass

Molar mass of H_2SO_4 = (2 × 1) + (32) + (4 × 16) = 98 g/mol

Mass concentration = 3.41 × 98
= 334.18 g/dm³

8.

(a) Chemical analysis shows that the empirical formula of a compound is CH_2O and its relative molar mass is 60.

(i) Calculate its molecular formula.

Empirical formula mass = (12 × 1) + (1 × 2) + (16 × 1) = 30

Molecular formula = (Molar mass / Empirical formula mass) × Empirical formula

= (60 / 30) × CH_2O
= $C_2H_4O_2$

(ii) Name the compound formed and write its open structural formula.

Compound: Ethanoic acid (Acetic acid)

Structural formula:

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     O
     ||
CH3 - C - OH
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(b) Write balanced chemical equations of the reactions between the compound named in 8 (a) (ii) above and

(i) Sodium metal

$CH_3COOH + Na \rightarrow CH_3COONa + \frac{1}{2}H_2$

(ii) Ethanol

$CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$

(iii) Sodium hydroxide

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

(c) State the common names of the chemical reactions represented by the equations in 8 (b)(ii) and 8 (b)(iii) above.

(i) Esterification
(ii) Neutralization

9.(a) What do you understand by each of the following?

(i) Soil reaction
Soil reaction refers to the acidity, neutrality, or alkalinity of the soil, usually measured by its pH level. It affects nutrient availability and microbial activity.

(ii) Liming
Liming is the process of adding calcium-containing materials such as lime ($CaCO_3$) or slaked lime ($Ca(OH)_2$) to soil to neutralize its acidity and improve its fertility.
(b)(i) Differentiate active acidity from potential acidity.
Active acidity refers to the concentration of hydrogen ions (H^+) in the soil solution, whereas potential acidity refers to the reserve acidity held by soil particles that can be released over time.
(ii) What is a fertile soil?
A fertile soil is one that has adequate nutrients, proper moisture content, good aeration, and an appropriate pH to support plant growth.

(iii) State four factors that affect soil fertility.
- Availability of essential nutrients
- Soil pH level
- Organic matter content
- Water retention capacity

(c)(i) Name four nitrogenous fertilizers.
- Ammonium nitrate (NH_4NO_3)
- Urea ($CO(NH_2)_2$)
- Ammonium sulphate ($(NH_4)_2SO_4$)
- Calcium ammonium nitrate (CAN)

(ii) What is manure?

Manure is organic material derived from animal waste or decomposed plant matter used to improve soil fertility.

(iii) Name four types of organic manure.

- Farmyard manure
- Green manure

- Compost manure
- Vermicompost

10.(a) Why was there a loss of mass?

The loss of mass occurred due to the production of carbon dioxide gas, which escaped from the reaction mixture.

(b) Write the equation for the reaction.
$CaCO_3 + 2HCl$ ----------> $CaCl_2 + CO_2 + H_2O$

(c) State three different ways in which the reaction could have been made more rapid.
- Using powdered calcium carbonate instead of chips to increase surface area
- Increasing the concentration of hydrochloric acid
- Raising the temperature of the reaction mixture

(d) Why did the mass remain constant after 10 minutes?
The reaction had reached completion, meaning all the reactants had been used up, and no more gas was being released.

(e) Write the name and the formula of the two ions remaining in the final solution.
- Calcium ion (Ca^{2+})
- Chloride ion (Cl^-)

(f) The solution was then evaporated to dryness in the same beaker, and the mass of the beaker and the remaining solid was 97.63 g. Next day the mass was 98.63 g. Explain what had occurred to cause the change and name the phenomenon.
The increase in mass was due to the absorption of moisture from the air by the solid calcium chloride ($CaCl_2$), which is hygroscopic. The phenomenon is called deliquescence.
11.

(a) Complete the table above by calculating the

(i) Quantity of electricity passed in experiments 1, 2, 3, and 4.

Quantity of electricity (Q) is given by the formula:

$Q = I \times t$

Where:
I = Current (A)
t = Time (s)

For all experiments:
I = 1 A
t = 2 s

Q = 1 × 2 = 2 C

Quantity of electricity for all experiments: 2 C

(ii) Electrochemical equivalent of the elements in 1, 2, 3, and 4.

Electrochemical equivalent (Z) is given by:

Z = mass deposited / quantity of electricity

For hydrogen:
$Z = (2.0892 \times 10^{-3}) / 2$
$= 1.0446 \times 10^{-3}$ g/C

For oxygen:
$Z = (1.658 \times 10^{-3}) / 2$
$= 8.29 \times 10^{-4}$ g/C

For copper:
$Z = (6.587 \times 10^{-3}) / 2$
$= 3.2935 \times 10^{-3}$ g/C

For silver:
$Z = (2.236 \times 10^{-3}) / 2$
$= 1.118 \times 10^{-3}$ g/C

(b) If the Faraday constant is given as 96,500 C, calculate the chemical equivalents of

Chemical equivalent (E) is given by:

E = Z × F

(i) Hydrogen:
$E = (1.0446 \times 10^{-3}) \times 96,500$
= 0.1008 g

(ii) Oxygen:
$E = (8.29 \times 10^{-4}) \times 96,500$
= 0.0800 g

(iii) Copper:
$E = (3.2935 \times 10^{-3}) \times 96,500$
$= 0.318$ g

(iv) Silver:
$E = (1.118 \times 10^{-3}) \times 96,500$
$= 0.108$ g

(c) What relationship is there between an electrochemical equivalent of an element and its chemical equivalent?

The electrochemical equivalent (Z) is directly proportional to the chemical equivalent (E). The chemical equivalent is obtained by multiplying the electrochemical equivalent by the Faraday constant. This means that elements with higher chemical equivalents also have higher electrochemical equivalents.

12.

(a) Indicate clearly whether a chemical or physical change is involved in the following processes.

(i) The addition of sodium metal to water.

Chemical change – A new substance (sodium hydroxide) is formed, and hydrogen gas is released with an exothermic reaction.

(ii) Dissolving of sodium chloride in water.

Physical change – The salt dissolves but retains its chemical identity. No new substance is formed.

(iii) The heating of magnesium in air.

Chemical change – Magnesium reacts with oxygen to form magnesium oxide (MgO), a new substance.

(iv) The heating of ammonium chloride.

Physical change – Ammonium chloride undergoes sublimation, changing from solid to gas without forming a new substance.

(v) The addition of concentrated sulphuric acid to water.

Physical change – The acid dissolves in water without forming a new substance, although it releases heat.

(b) Name two non-metallic oxides which cause pollution to the atmosphere.

- Carbon dioxide (CO_2)
- Sulphur dioxide (SO_2)

(c) 25 cm^3 of sulphuric acid were neutralized by 27 cm^3 of 0.1 M sodium hydroxide. What is the concentration of the acid solution in terms of

(i) mol/dm^3

Step 1: Write the balanced chemical equation

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Step 2: Calculate moles of NaOH

Moles = concentration × volume
= 0.1 × (27/1000)
= 2.7×10^{-3} moles

Step 3: Find moles of H_2SO_4

From the equation, 1 mole of H_2SO_4 reacts with 2 moles of NaOH, so:

Moles of H_2SO_4 = $(2.7 \times 10^{-3}) / 2$
= 1.35×10^{-3} moles

Step 4: Calculate concentration of H_2SO_4

M = moles / volume
= $(1.35 \times 10^{-3}) / (25/1000)$
= 0.054 M

(ii) g/dm^3

Mass concentration = molarity × molar mass

Molar mass of H_2SO_4 = 98 g/mol

Mass concentration = 0.054 × 98
= 5.29 g/dm^3