PERAMIHO GIRLS' SECONDARY SCHOOL

FORM THREE FITNESS TEST – SERIES 3

032 **CHEMISTRY**

MARKING SCHEME **August, 2024**

A student required to answer all questions in sections **A** and **B** and two questions in section **C**.

SECTION A: (16 Marks)

1. Answers ***(10 marks)***

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
C	C	B	B	C	D	C	C	B	D

2. Answers ***(06 marks)***

List A	(i)	(ii)	(iii)	(iv)	(v)	(vi)
List B	H	G	A	E	B	D

SECTION B: (54 Marks)

3. (a) • **Boiling**

This method is used to remove **only temporary** hardness of water.
When temporary hard water is boiled calcium and magnesium hydrogen carbonate dissolved in it decomposes to form carbonates, water and carbon dioxide gas.

$$Ca(HCO_3)_2(aq) \xrightarrow{\text{Heat}} CaCO_3(s) + H_2O(l) + CO_2(g)$$
$$Mg(HCO_3)_2(aq) \xrightarrow{\text{Heat}} MgCO_3(s) + H_2O(l) + CO_2(g)$$

• **Distillation**

This process relies on evaporation followed by condensation to purify hard water.
This method softens both temporary and permanent hardness of water.

• **Adding calcium hydroxide (lime water)**

This method is used to remove only temporary hardness of water. **Adding calcium hydroxide (lime water) precipitate out** carbonate of magnesium or calcium.

$$Ca(HCO_3)_2(aq) + Ca(OH)_2(aq) \longrightarrow 2CaCO_3(s) + 2H_2O(l)$$

• **Adding washing soda (Na_2CO_3)**

This method is used to remove both permanent and temporary hardness.
Washing soda precipitates out carbonates of calcium or magnesium.

$$Ca(HCO_3)_2(aq) + Na_2CO_3(aq) \longrightarrow CaCO_3(s) + NaHCO_3(aq)$$
$$CaSO_4(aq) + Na_2CO_3(aq) \longrightarrow CaCO_3(s) + Na_2SO_4(aq)$$
$$MgSO_4(aq) + Na_2CO_3(aq) \longrightarrow MgCO_3(s) + Na_2SO_4(aq)$$

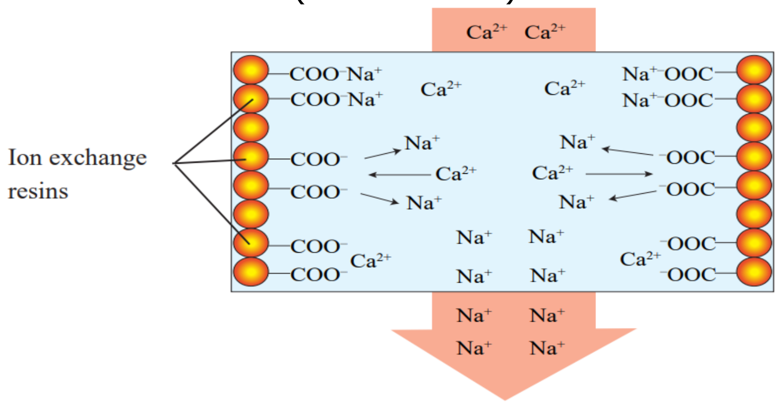
- **Use of ion exchangers**

The resin in ion exchanger contains sodium ions that are weakly attached on it, which are displaced by calcium and magnesium ions when hard water pass through and this makes water to become soft.

Chemical equation: $CaSO_4(aq) + Na_2Y(aq) \longrightarrow CaY(s) + Na_2SO_4(aq)$

(Y is the negatively charged ion exchanger)

Hard water (with Ca^{2+} ions) flows into ion exchanger



Soft water (with Na^{+} ions) flows out from ion exchanger

- **Addition of aqueous ammonia**

This method is used to remove both temporary and permanent hardness of water. When aqueous ammonia is added to temporary hard water, carbonate of magnesium or calcium precipitate out.

$2NH_4OH(aq) + Mg(HCO_3)_2(aq) \longrightarrow MgCO_3(s) + (NH_4)_2CO_3(aq) + 2H_2O(l)$

When aqueous ammonia is added to permanent hard water, hydroxide of magnesium or calcium precipitate out.

$2NH_4OH(aq) + MgSO_4(aq) \longrightarrow Mg(OH)_2(s) + (NH_4)_2SO_4(aq)$ ***(@01 = 03 marks)***

(b) Three (3) disadvantages of using hard water are:

- Wastage of more soap
- Stains in clothes and utensils.
- It spoils the quality some special finishes on clothes.
- Increase boiling point of water hence more fuel is used to boil it.
- Impacts on hair and skin; when hair is cleaned with hard water it becomes dry and rough and also hard water makes the skin dry and itchy.
- Reduction of the lifespans of appliances. ***(@01 = 03 marks)***

(c) Advantage of using hard water

- It provides useful calcium for growth of bones and teeth.
- Formation of lime scale which prevent pipes or tap from rust.
- Better for brewing beer because calcium ion promotes flavour.
- Toxic lead compounds in lead water pipes are less soluble in hard water.
- Help in the formation of strong shells in some aquatic animals.
- It tastes better due to dissolved compounds. ***(@01 = 03 marks)***

4. (a) The Le Chatelier's principle states that, if a system at equilibrium is subjected to a change, processes will occur which tend to counteract the change imposed.
The principle can also be stated as, if a stress is applied to a system at equilibrium, the system re-adjusts, to reduce the effect of the stress imposed. ***(01 mark)***

(b) The reaction is said to be at equilibrium if the rate of forward reaction and backward reaction are equal. ***(02 marks)***

(c) Given the reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -94.9$ kJ/mol

(i) ■ Since the reaction is exothermic, the conversion of sulphur dioxide to sulphur trioxide is favoured by low temperatures. Hence the temperature should be low. ***(01 mark)***

■ The conversion of sulphur dioxide to sulphur trioxide is therefore favored by high pressure because the reaction proceeds with decrease in number of moles. ***(01 mark)***

(ii) ■ It is unfavorable to work under very high pressure because high pressure is expensive and difficult to maintain. ***(01 mark)***

■ It is unfavorable to work under very low temperature because at very low temperature, the rate of reaction is very slow. ***(01 mark)***

(iii) Vanadium pentoxide (V_2O_5) or platinum (Pt) is used as a catalyst. ***(02 marks)***

5. (a) (i) Ionic (electrovalent) bond. ***(01 mark)***
(ii) One electron. ***(02 marks)***
(iii) Group I. ***(02 marks)***

(b) (i) A cation has small size than its parent atom because when electrons are removed the remaining fewer electrons in a cation experience stronger nuclear attractive forces due to weaker electron-electron repulsion. ***(02 marks)***

(ii) Because anion has gained one or more electrons resulting in excess negatively charged particles. ***(02 marks)***

6. (a) Neon does not react with sodium because neon is a noble gas with a full outer electron shell, making it stable and unreactive. On other hand sodium is very reactive; it loses electron easily. ***(03 marks)***

(b) (i) $Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$ ***(02 marks)***

(ii) Sulphur ***(02 marks)***

(iii) • Net ionic equation:
$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$ ***(01 mark)***

• Spectator ions: Na^+ and Cl^- ions ***(01 mark)***

7. (a) (i) After five minutes the colour of the solution become dark purple due to diffusion property of $KMnO_4$ particles. ***(01 mark)***

(ii) After several hours the colour of the solution may change to purple shade; that is lighter than the initial colour. This is because the solution of water and $KMnO_4$ is made up of very tiny particles which get dispersed and spread amongst themselves. ***(01 mark)***

(iii) The two processes which have taken place are;
Diffusion and dispersion. ***(02 marks)***

(iv) From that experiment two conclusions that can be made are;
- Matter is made up of tiny particles
- Particles of matter are constantly moving. ***(02 marks)***

(b) **Given:** • Mass of potassium nitrate (KNO_3) = 50 g
- Volume of water = 250 cm^3
- Density of water, ρ_w = 1 g/cm^3

From the formula

Solubility of salt (solute) = $\frac{100\ \text{cm}^3 \text{ x Mass of solute in grams (g)}}{\text{Volume of solvent (cm}^3)}$ ***(01 mark)***

Solubility of potassium nitrate = $\frac{100\ \text{cm}^3 \text{ x } 50\ \text{g}}{250\ \text{cm}^3}$ = 20 g

Therefore, the solubility of KNO_3 is 20 g/100 grams of water ***(02 marks)***

8. (a) (i) Energy value of a fuel; is the total amount of energy produced/liberated by the complete combustion of unit mass of the fuel in air (oxygen). ***(01 mark)***

(ii)
- A good fuel should have high energy value.
- A good fuel should burn with moderate velocity.
- A good fuel should have average ignition point.
- A good fuel should have low content of non-combustible materials.
- A good fuel should not produce poisonous gases during combustion.
- A good fuel should have high pyrometric burning effect
- A good fuel should be readily available in large quantities.
- A good fuel should be ease to transport, handle and store.
- A good fuel should not have harmful effect in the environment.
- A good fuel should be affordable to most people. ***(@01 = 04 marks)***

(b) **Data given**
- Initial temperature, θ_1 = 25.4 °C = 24.7 + 273 = 298.4 K
- Final temperature, θ_2 = 31.2 °C = 31.2 + 273 = 304.2 K
- Mass of ethanol, M = (59.46 – 56.69) g = 2.77 g = 2.77 x 10^{-3} kg
- Volume of water, V = 200 cm^3 = 2 x 10^{-4} m^3
- Mass of water M_w = Density (ρ) x volume (v) = 1000 kg/m^3 x 2 x 10^{-4} m^3 = 0.2 kg
- Required: Heat value of ethanol? ***(01 mark)***

From:

Heat value = $\frac{M_W \text{ x } C_W \text{ x } \Delta T}{M}$ ***(01 mark)***

Heat value = $\frac{0.2 \text{ kg x } 4.18 \text{ kJkg}^{-1}\text{K}^{-1} \text{ x } (304.2 \text{ K} - 298.4 \text{ K})}{2.77 \text{ x } 10^{-3} \text{ kg}}$ = 1750.4693 kJ/kg

Heat value = 1750.4693 kJ/kg

Therefore, the heat value of ethanol = 1750.4693 kJ/kg ***(02 marks)***

SECTION C: (30 Marks)

9. (a)

(i)	**Compound**	**Name**	**Formula/ Symbol**
	M	Zinc	Zn
	P	Zinc oxide	ZnO
	Q	Zinc oxide	ZnO
(ii)	**Substance**	**Name**	**Formula/ Symbol**
	N	Zinc chloride	$ZnCl_2$
	O	Zinc hydroxide	$Zn(OH)_2$
	T	Hydrogen gas	H_2

(@00$\frac{1}{2}$ = 03 marks)

(@00$\frac{1}{2}$ = 03 marks)

(b) • **Reaction in step 1:** $Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$.

• **Reaction in step 2:** $ZnCl_2(aq) + 2NaOH(aq) \longrightarrow Zn(OH)_2(s) + 2NaCl(aq)$.

• **Reaction in step 3:** $Zn(OH)_2(s) \xrightarrow{\text{Heating}} ZnO(s) + H_2O(g)$. ***(@02= 06 marks)***

(c)

Sodium carbonate	**Sodium bicarbonate**
• Sodium carbonate is commonly known as washing soda.	Sodium bicarbonate is known as baking soda.
• Sodium carbonate is used in industrial applications like glass manufacturing.	Sodium bicarbonate is often used in cooking, baking and as an antacid.
• Sodium carbonate is more alkaline (pH around 11) compared to sodium bicarbonate (pH around 8.4).	Sodium bicarbonate is less alkaline (pH around 8.4) compared to sodium carbonate (pH around 11).
• Sodium carbonate is more soluble in water than sodium bicarbonate.	Sodium bicarbonate is less soluble in water than sodium carbonate.
• Sodium carbonate decomposes at a higher temperature (around 851 °C).	Sodium bicarbonate decomposes at low temperature (around 50 °C).

(@01 = 03 marks)

10. (a) From dilution law: $M_1V_1 + M_2V_2 = MdVd$ ***(01 mark)***

$(10M \times V_1) + (3M \times V_2) = MdVd$

But $Vd = 2000\ cm^3$ and $Vd = V_1 + V_2$

Then: $V_1 = Vd - V_2$

$10 \times (Vd - V_2) + (3 \times V_2) = Md \times 2000$

$10Vd - 10V_2 + 3V_2 = 2000Md$

$10Vd - 7V_2 = 2000Md$ ***(01 mark)***

But: $Vd = 2000\ cm^3$

$10Vd - 7V_2 = 2000Md$

$V2 = 1142.86\ cm^3$

Then, $V_1 = Vd - V_2$

$V_1 = 2000\ cm^3 - 1142.86\ cm^3 = 857.14\ cm^3$

Therefore, 857.14 cm^3 of 10 M HCl should be mixed with 1142.86 cm^3 of 3 M HCl to prepare 2000 cm^3 of 6 M HCl solution. ***(01 mark)***

(b) **Given**: Concentration of solution = 10 % weight by volume

Molar mass of NaOH = 40 g/mol

10 % w/v means 10 g of NaOH solute in 100 cm^3 of solution ***(01 mark)***

From: $\text{Molarity} = \dfrac{\text{Concentration (g/dm}^3)}{\text{Molar mass (g/mol)}}$ ***(01 mark)***

$\text{Molarity} = \dfrac{10\text{ g}}{0.1\text{ dm}^3 \times (40\text{ g/mol})} = 2.5\text{ mol/dm}^3$

Therefore, the molarity of 10 % (w/v) of sodium hydroxide solution is 2.5 mol/dm^3 ***(01 mark)***

(c) Given: Mass of ammonia = 2 g = 0.1176 moles

Mass of oxygen = 4 g = 0.125 moles

(i) Required to determine the limiting reactant:

$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$

For NH_3: 4 moles of $NH_3 \equiv$ 5 moles of O_2

X moles of $NH_3 \equiv$ 0.125 moles of O_2

X = 0.1 moles of NH_3 required to react completely

(But we are given 0.1176 moles of NH_3)

For O_2: 4 moles of $NH_3 \equiv$ 5 moles of O_2

0.1176 moles of $NH_3 \equiv$ X moles of O_2

X = 0.147 moles of O_2 required to react completely

(But we are given 0.125 moles of O_2)

Therefore, oxygen is the limiting reactant because the required amount (0.147 moles) is greater than the given amount (0.125 moles)

(03 marks)

(ii) NH_3 present in excess.

Excess moles of ammonia = (0.1176 – 0.1) moles = 0.0176 moles ***(03 marks)***

(iii) Required to calculate the mass of nitrogen monoxide (NO)

The mass of nitrogen dioxide gas produced depend on oxygen (limiting reactant)

From the reaction: $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$

5 moles of O_2 ≡ 4 moles of NO

0.125 moles of O_2 ≡ X moles of NO

X = 0.1 mole of NO will be produced ***(02 marks)***

From: Number of moles = $\frac{\text{Mass}}{\text{Molar mass}}$

Mass = Number of moles x Molar mass

Mass = 0.1 mole x 30 g/mol = 3.0 g

Therefore, the mass of nitrogen monoxide (NO) produced = 3.0 g

(01 mark)

11. Volumetric analysis is the analytical method that involve measurement of the volume of the solution required to react completely with a definite volume of another solution. The apparatus used in volumetric analysis are always clean in order to avoid contamination that may interfere the reactions. ***(02 marks)***

Volumetric analysis is used in different fields as explained below;

Household Cleaning Products: Volumetric analysis is used to determine the concentration of active ingredients in household cleaning products like bleach or disinfectants.

Food and Beverage Industry: It is used to measure the acidity or alkalinity of food products, such as determining the acid content in fruit juices.

Water Treatment: Volumetric analysis helps in monitoring and controlling the levels of contaminants in water treatment processes, ensuring water quality standards are met. To determine the amount of salts in water

Pharmaceutical Industry: Used to analyze drug formulations to ensure accurate dosages and concentrations in medications.

Quality Control in Manufacturing: Volumetric analysis is employed to check the purity and concentration of chemicals used in various manufacturing processes.

Environmental Monitoring: It is utilized to analyze pollutants in air, soil, and water samples for environmental impact assessments and regulatory compliance.

Medicine: Determination of the concentration of glucose in a blood sample. Determination of amount of acid which can be neutralized by ant-acid tablet

Manufacturing industries: To determine amount of acetic acid in vinegar. Table vinegar should have a minimum amount of 5%. To determine the acidity of fruit juices. To determine the concentration of household ammonia.

Agriculture: To determine composition of different substances in the soil such as; nitrogen, potassium, and phosphorus. To determine soil pH.

Commercial uses: To determine the percentage of iron content in an iron ore. Determination of salt content in brine. To determine the percentage by mass of copper in copper salt. ***(@02 = 12 marks)***

In general; volumetric analysis it is a valuable analytical technique used in chemistry to determine the concentration of a substance in a solution. Volumetric analysis relies on the accurate measurement of volumes of solutions involved in a chemical reaction to determine unknown concentrations. It is widely used in various industries, research laboratories, and educational settings for quantitative analysis purposes. ***(01 mark)***

By: Mwanda A.J.
dottoalphonce@gmail.com
0767660163/0786423533