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545/2

CHEMISTRY

Paper 2

Oct. / Nov. 2020

2 hours



UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Certificate of Education

CHEMISTRY

Paper 2

2 hours

**INSTRUCTIONS TO CANDIDATES:**

Section A consists of 10 structured questions. Answer all the questions in this section.

Answers to these questions must be written in the spaces provided.

Section B consists of 4 semi-structured questions. Answer any two questions from this section. Answers to the questions must be written in the answer booklet(s) provided.

In both sections all working must be clearly shown and must be in blue or black ink.

Any work done in pencil will not be marked except drawings.

Mathematical tables and silent non-programmable calculators may be used.

Where necessary use:

[H=1; C=12; N=14; O=16; Na=23; S=32; Cl=35.5]

1 mole of gas occupies 24 l at room temperature.

1 mole of gas occupies 22.4 l at s.t.p.

For Examiners' Use Only														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total

## SECTION A: (50 MARKS)

Answer all questions in this section.

1. (a) State what would be observed if a bar magnet is brought close to:
- (i) a mixture of iron and sulphur. (01 mark)  
 - Iron is attracted by the magnet and has effect on sulphur.  
 or - A grey solid is attracted by the magnet and no effect on yellow powder.  
 or - Iron (grey) is attracted by the magnet. Iron (II) sulphide. (01 mark)  
 - No observable change - No attraction  
 - No effect  
 Reject: No change
- (b) What is the practical application of the action in (a) (i)? (01 mark)  
 - Used in biotechnology to purify complex mixtures.  
 - Used in protein isolation  
 - Applied in cell separation  
 - Applied in drug delivery.  
 - Applied in biocatalysis  
 - Separation of mixtures
- (c) State a suitable method by which the following substance can be obtained:

- (i) Sugar from its mixture with sand. (01 mark)

Filtration ✓

- (ii) Sodium chloride from its mixture with sodium hydrogencarbonate. (01 mark)

Fractional crystallisation ✓

2. The atomic numbers of elements X, Y and Z are 12, 14 and 17 respectively.

- (a) Write the electronic configuration of the ion formed by:

- (i) X. (½ mark)

2:8 ✓ or 2:8 or 2:8 or 2:8

- (ii) Y. (½ mark)

2:8:8 / 2:8:8 / 2:8:8 or 2:8:8 Rej 2:8

- (b) Element Z can react with elements X and Y to form compounds Q and R respectively.

- (i) Write the formula of the compound that can be formed between Z and:

- X. (01 mark)

XZ<sub>2</sub> / Z<sub>2</sub>X

- Y. (01 mark)

YZ<sub>4</sub> / Z<sub>4</sub>Y

16 - Applied in steel industry to remove magnetic impurities  
 - Applied in removal of metal pieces from machinery to avoid malfunctioning.

- (ii) Which one of the compounds Q and R will conduct electricity when in molten state? (1/2 mark)

Q ✓ Reject: Formula of  $XZ_2 / Z_2X$

- (iii) Give a reason for your answer in (b) (ii). (01 mark)

- Consists of ions ✓

Acc: Q is ionic / electrovalent

Reject: Q is an electrolyte

3. (a) Charcoal was burnt in a charcoal stove as shown in figure 1.

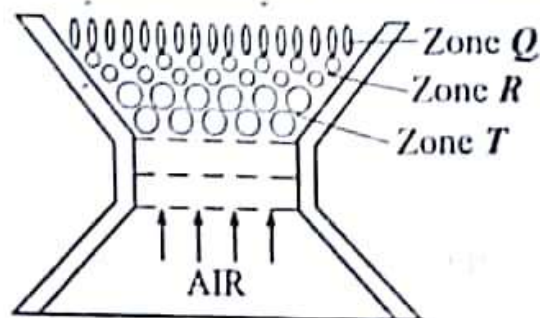


Fig. 1

Name the substance that was produced at zone:

- (i) Q Carbon dioxide / carbon(IV) oxide (01 mark)

Reject: formula

- (ii) R Carbon monoxide / carbon(II) oxide (01 mark)

- (iii) T Carbon dioxide / carbon(IV) oxide (01 mark)

- (b) State;

- (i) the structural difference between charcoal and graphite. (01 mark)

Charcoal	Graphite
- Is amorphous / non-crystalline ✓	- Is crystalline ✓
- Has no definite shape / Irregular shape / shapeless.	- Has hexagonal shape

- (ii) one chemical property in which charcoal resembles graphite.

- Both burn in air / oxygen to give carbon dioxide (01 mark)
- Charcoal burns in oxygen to form carbon dioxide
- Both form carbon monoxide in limited air
- Both burn in excess oxygen to form acidic oxide.
- Both react with hot concentrated acid to form carbon

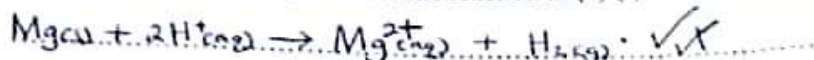
4. (a) (i) State the condition under which hydrochloric acid reacts with magnesium to produce hydrogen. (1/2 mark)

In the dilute state ✓

3 bii Both react with hot concentrated nitric acid to form carbon dioxide  
 - Both react with hot concentrated sulphuric acid to form carbon dioxide  
 Reject: Both are reducing agent / property.

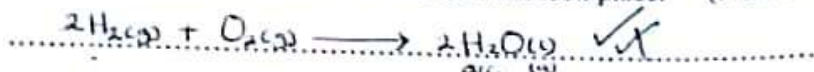


(ii) Write the ionic equation for the reaction in (a) (i). (1½ marks)



(b) A dry sample of hydrogen was burnt in air.

(i) Write the equation for the reaction that took place. (1½ marks)



(ii) State how the product in (b) (i) can be tested. (01 mark)

- By using anhydrous copper(II) sulphate which turns from white to blue ✓

- By using anhydrous cobalt(II) chloride which turns from blue to pink  
 Acc. cobalt chloride / cobalt chloride paper

(iii) State one large scale use of hydrogen. (½ mark)

- Manufacture of ammonia ✓
  - Manufacture of margarine / hydrogenation of vegetable oils / manufacture of fats
  - Filling weather balloons
  - Rocket fuel
  - Hydrogen flame is used for welding
  - Synthesis of hydrochloric acid / hydrogen chloride
5. When a mixture of dilute sodium hydroxide solution and a substance containing a cation Q was heated, a gas X, which gave dense white fumes with hydrogen chloride was evolved.

(a) Identify;

(i) the cation Q. (½ mark)

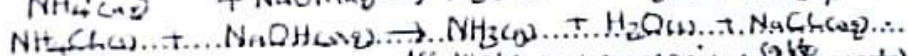
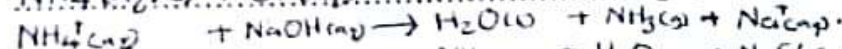
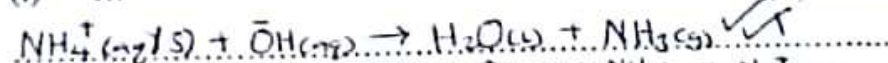
$\text{NH}_4^+$  / Ammonium ion / ammonium / ammonium cation ✓

(ii) gas X. (½ mark)

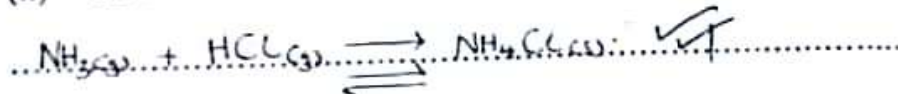
$\text{NH}_3$  / ammonia / ammonia gas ✓

(b) Write the equation for the reaction leading to the formation of;

(i) X. (1½ marks)



(ii) the dense white fumes. (½ marks)



- (c) X was bubbled through a solution containing zinc ions until there was no further change. State what was observed. (1½ marks)

A white precipitate soluble on addition of excess X giving a colourless solution

6. 3.4 g of compound Z consists of 1.0 g calcium, 0.8 g sulphur and the rest being oxygen.

- (a) (i) Calculate the empirical formula of Z.

(O=16; S=32; Ca=40)

Mass of oxygen = 3.4 - 1.8 = 1.6g (02 marks)

Elemental composition: Ca S O

Moles:  $\frac{1.0}{40} = 0.025$ ,  $\frac{0.8}{32} = 0.025$ ,  $\frac{1.6}{16} = 0.1$

Mole ratio:  $\frac{0.025}{0.025} = 1$ ,  $\frac{0.025}{0.025} = 1$ ,  $\frac{0.1}{0.025} = 4$

Simplest ratio: 1 : 1 : 4

- (ii) Deduce the molecular formula of Z.

(Formula mass of Z=136)

CaSO<sub>4</sub>

(01 mark)

(CaSO<sub>4</sub>)<sub>n</sub> = 136

40n + 32n + 64n = 136

$\frac{136n}{136} = \frac{136}{136}$

n = 1

Molecular formula of Z is CaSO<sub>4</sub>

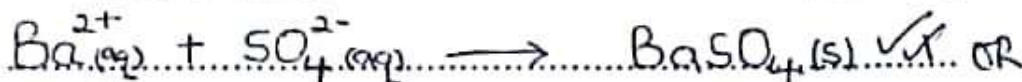
- (b) (i) Name one reagent that can be used to identify the anion in an aqueous solution of Z.

Acidified Barium nitrate (01 mark)

Acidified Barium chloride

Lead(II) nitrate solution

- (ii) Write an ionic equation for the reaction that would take place if aqueous solution of Z was treated with the reagent you have named in (b) (i). (1½ marks)



7. Figure 2 shows an electrochemical cell.

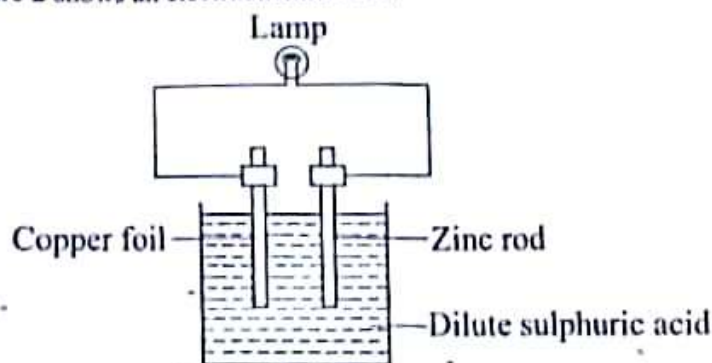


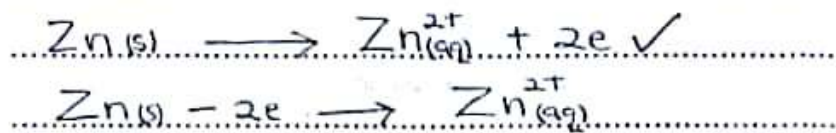
Fig.2

- (a) State what is observed at the copper foil. (½ mark)

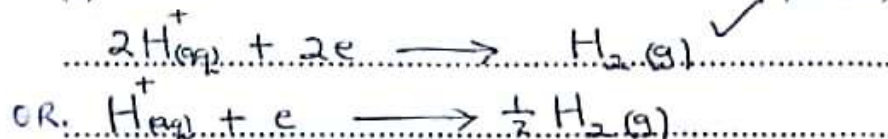
Bubbles of a colourless gas / effervescence.  
Acc. Gas bubbles / Hissing / fizzing sound.

- (b) Write the equation(s) for the reaction at the;

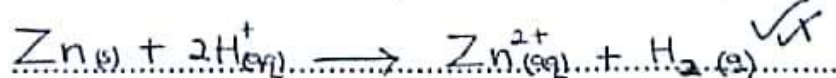
- (i) cathode. (01 mark)



- (ii) anode. (01 mark)

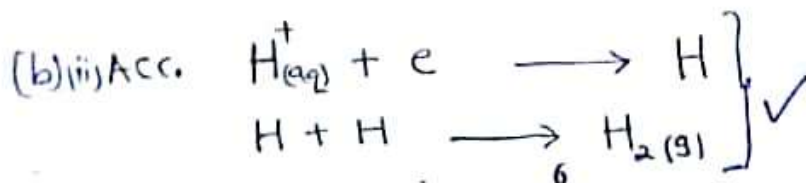


- (c) Write the overall cell reaction equation. (1½ marks)



- (d) State one application of an electrochemical cell. (½ mark)

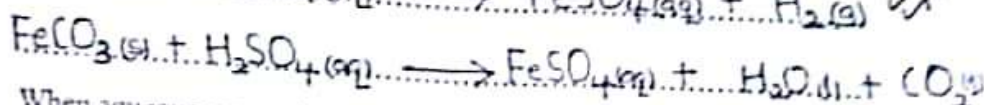
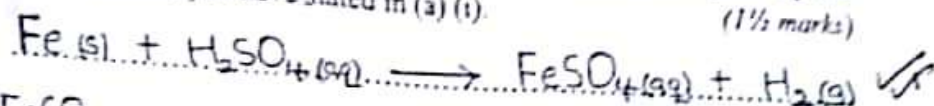
- Manufacture of dry cells ✓  
- Manufacture of wet cells  
- Manufacture of batteries  
- Manufacture of lead acid accumulators





8. (a) (i) State a suitable method of preparing iron(II) sulphate. (01 mark)  
 - Action of acid on metal / metal carbonate ✓  
 or - Action of dilute sulphuric acid on iron
- (ii) Write the equation to show formation of iron(II) sulphate by the method you have stated in (a) (i). (1½ marks)

No other alternative.



- (b) When aqueous ammonia was added to iron(II) sulphate solution, a green precipitate which turned brown on standing was formed.

- (i) Write the formula of the substance that appeared as the green precipitate. Acc. Iron(II) ion oxidised to (01/02 mark) ✓  
 $\text{Fe(OH)}_2$  ✓ Acc.  $\text{Fe(OH)}_3$  (s) ✓

- (ii) Give a reason why the green precipitate turned brown. (01 mark)

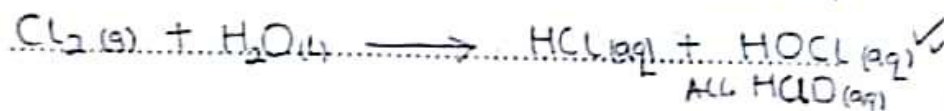
Iron(II) hydroxide which is green is oxidised by oxygen from the air to form Iron(III) hydroxide ✓

- (iii) Name one substance, other than air, that would turn the green precipitate brown. Concentrated Nitric acid (½ mark)

Re's Coloured oxidising agents:

chlorine ✓  
 Hydrogen peroxide  
 Solid sodium peroxide  
 sodium peroxide solution

9. (a) Chlorine dissolves in water to form hypochlorous acid.
- (i) Write the equation for the reaction leading to the formation of hypochlorous acid. (1½ marks)



- (ii) State what would be observed if a handkerchief stained with black ink was soaked in hypochlorous acid. (½ mark)

The stain would be bleached / removed.

The handkerchief would turn white

- (b) Hypochlorous acid solution was exposed to bright sunlight.

State what happened. The hypochlorous acid (1½ marks) ✓  
 decomposes into oxygen and hydrochloric acid (2 marks) ✓  
 The yellowish green / greenish yellow / pale yellow colour of solution fades / turned to colourless

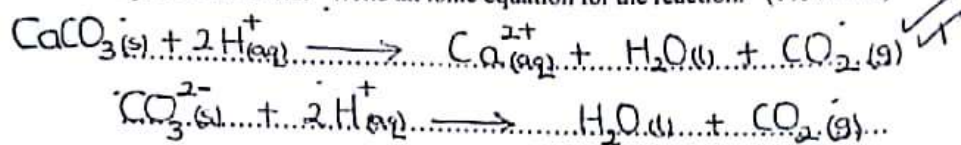
Turn Over

10. (b) Acid T produces a larger volume of carbon dioxide in every short/less time ✓

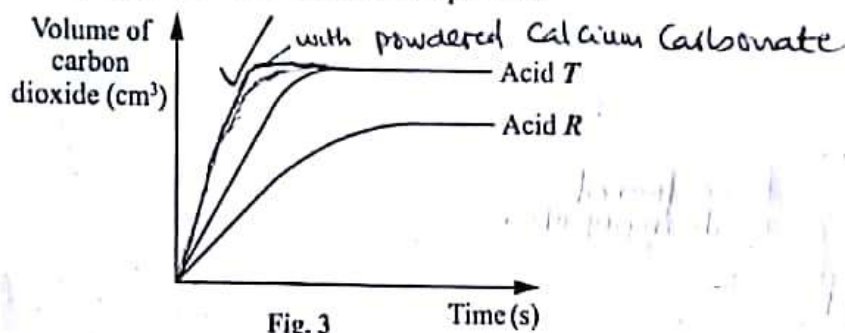
- (c) State what would be observed if chlorine was bubbled into potassium bromide solution then tetrachloromethane added to the resultant mixture. (1½ marks)

The colourless solution turns red/reddish brown and eventually dark-red liquid separates out ✓

10. (a) Carbon dioxide is produced by the reaction of calcium carbonate with hydrochloric acid. Write an ionic equation for the reaction. (1½ marks)



- (b) The sketch graphs in figure 3 show variations in volumes of carbon dioxide evolved with time, when equal masses of calcium carbonate lumps were reacted separately with 50 cm³ portions of 1.0 M solutions of monobasic acids T and R at room temperature.



- (i) Which one of the acids is a stronger acid? (½ mark)

Acid T ✓

- (ii) Give reasons for your answer in (b) (i). (02 marks)

Acid T yields/gives/produces more/higher/larger volume of carbon dioxide gas. ✓

It also reacts with the carbonate faster and the reaction reaches completion earlier than when acid R is used ✓

- (iii) Sketch, on the same axes of figure 3, the graph that would be obtained when an equal mass of calcium carbonate powder was reacted with 50 cm³ of a 1.0 M acid T at room temperature. (01 mark)

Acid T gives a higher volume of carbon dioxide gas. ✓

Also a graph of T takes a shorter time than that of R OR Graph of T is steeper than that of R ✓



## SECTION B (30 MARKS)

Answer any two questions from this section.  
Additional question(s) answered will not be marked.

11. Sulphuric acid is manufactured from sulphur dioxide by the contact process.

- (a)
  - (i) Name **one** substance from which the sulphur dioxide used in the contact process can be prepared. (01 mark)
  - (ii) Write an equation to show how the substance you have named in (a) (i) is converted into sulphur dioxide. (1½ marks)
  - (iii) With the aid of equation(s), describe how sulphur dioxide is converted into sulphuric acid. (6½ marks)
- (b) State how concentrated sulphuric acid reacts with the following substances, and in each case, write the equation for the reaction:
  - (i) Sulphur. (02 marks)
  - (ii) Sucrose ( $C_{12}H_{22}O_{11}$ ). (02 marks)
- (c)
  - (i) Name **one** fertilizer manufactured from sulphuric acid. (½ mark)
  - (ii) Write an equation to show how the fertilizer you have named in (c) (i) is formed. (1½ marks)

12. (a) Describe the reactions of magnesium with;

- (i) water. (2½ marks)
  - (ii) oxygen. (02 marks)
  - (iii) chlorine. (02 marks)
- (b) Aqueous sodium hydrogencarbonate was added to a solution containing magnesium ions, and the mixture heated. Explain what happened;
  - (i) before the mixture was heated. (03 marks)
  - (ii) after the mixture was heated. (3½ marks)
- (c)
  - (i) Name **one** reagent that can be used to differentiate magnesium ion from lead(II) ion. (01 mark)
  - (ii) State what would be observed if magnesium ion and lead(II) ion are treated separately with the reagent you have named in (c) (i). (01 mark)

13. (a) (i) State two substances which when reacted together can form soap. (01 mark)
- (ii) Briefly describe how a sample of solid soap can be prepared in the laboratory. (04 marks)
- (b) Describe how soap removes dirt from clothes. (04 marks)
- (c) Give reasons why detergents do not form scum with hard water. (01 mark)
- (d) Explain why it is not advisable to dispose of detergents in water bodies. (05 marks)

14. (a) Methanol undergoes combustion according to the following equation.
- $$2\text{CH}_3\text{OH}(l) + 3\text{O}_2(g) \longrightarrow 2\text{CO}_2(g) + 4\text{H}_2\text{O}(l); \Delta H = -726 \text{ kJ mol}^{-1}$$
- What is meant by the expression " $\Delta H = -726 \text{ kJ mol}^{-1}$ "? (01 mark)
- (b) When 0.87 g of methanol was burnt, the heat evolved raised the temperature of  $500 \text{ cm}^3$  of water by  $7.0^\circ\text{C}$ . Calculate the enthalpy of combustion of methanol. ( $H = 1$ ;  $C = 12$ ;  $O = 16$ ; density of water =  $1 \text{ g cm}^{-3}$ ; specific heat capacity of water =  $4.2 \text{ J g}^{-1} \text{ K}^{-1}$ .) (3 ½ marks)
- (c) The Standard Enthalpy of Combustion of methanol is  $-726 \text{ kJ mol}^{-1}$ . Compare the experimental value obtained in (b) with the standard value. Explain your answer. (3 ½ marks)
- (d) The enthalpy of some straight chain alcohols are shown in the table 1.

Table 1

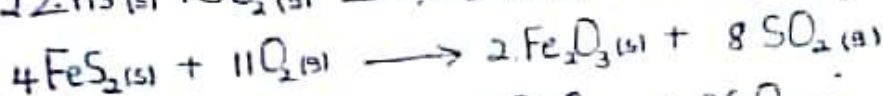
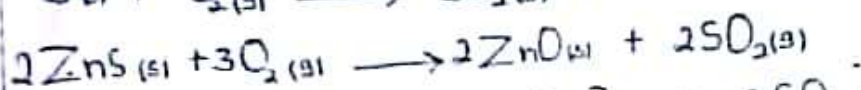
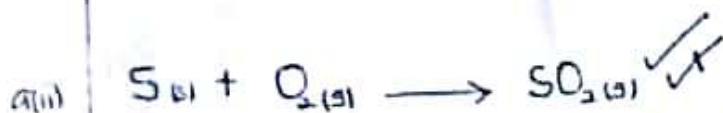
Alcohol	$\text{CH}_3\text{OH}$	$\text{C}_2\text{H}_5\text{OH}$	$\text{C}_3\text{H}_7\text{OH}$	$\text{C}_4\text{H}_9\text{OH}$	$\text{C}_5\text{H}_{11}\text{OH}$	$\text{C}_6\text{H}_{13}\text{OH}$
Formula mass	32	46	60	74	88	102
Enthalpy of combustion ( $\text{kJ mol}^{-1}$ )	726	1371	2017	2673	3331	3984

- (i) Copy the table and fill in the values for the formula masses of the alcohols. ( $H = 1$ ;  $C = 12$ ;  $O = 16$ .) (1½ marks)
- (ii) Plot a graph of enthalpy of combustion against formula mass. (04 marks)
- (iii) State how the enthalpies of the straight chain alcohols vary with their formula masses. (½ mark)
- (iv) Use your graph to determine the enthalpy of a straight chain alcohol of formula mass 116. (01 mark)



11 (a) - Sulphur ✓

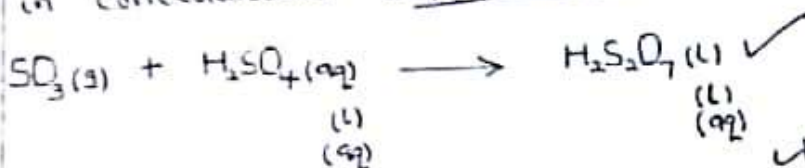
- Zinc sulphide / Zinc blende
- Iron disulphide
- Iron pyrites
- Lead(II) sulphide / Galena



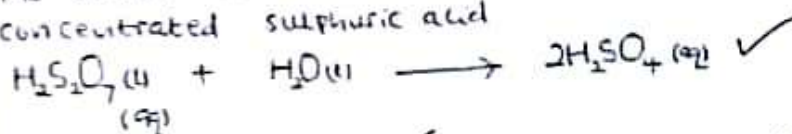
(ii) Sulphur dioxide and oxygen are passed over heated Vanadium(V) oxide catalyst at high pressure to form sulphur trioxide ✓



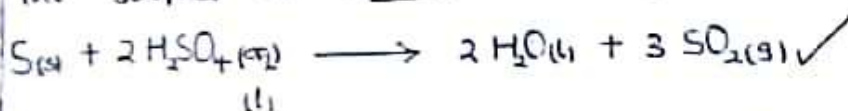
The gaseous products are then cooled and dissolved in concentrated sulphuric acid to form oleum ✓



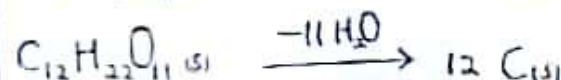
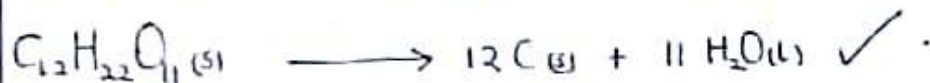
The oleum is then diluted with water to form concentrated sulphuric acid



b(i) The sulphur is oxidised to sulphur dioxide ✓

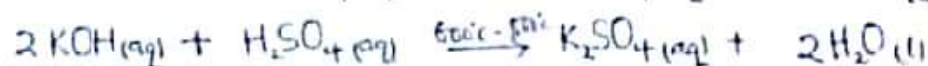
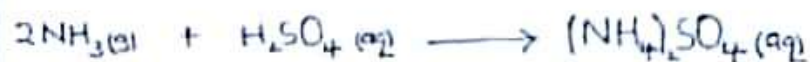
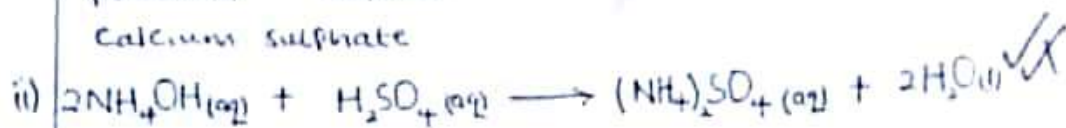


(ii) The sucrose is dehydrated to carbon ✓





- C(ii) Ammonium sulphate ✓  
 potassium sulphate  
 calcium sulphate



- 12(a) Magnesium does not <sup>slowly</sup> readily react with cold water giving off bubbles of a colourless gas of hydrogen and a colourless solution of Magnesium hydroxide formed  
 $Mg(s) + 2H_2O(l) \longrightarrow Mg(OH)_2(aq) + H_2(g)$  ✓

But when magnesium is heated, it burns in steam with a bright white flame forming a white solid residue of Magnesium oxide and liberating hydrogen gas  
 $Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$  ✓

- (ii) Magnesium burns in oxygen with a bright white flame forming a white solid of Magnesium oxide

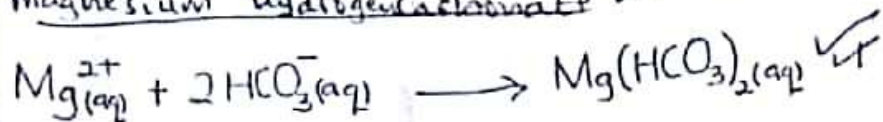


- (iii) Magnesium burns in chlorine forming white fumes or solid of Magnesium chloride

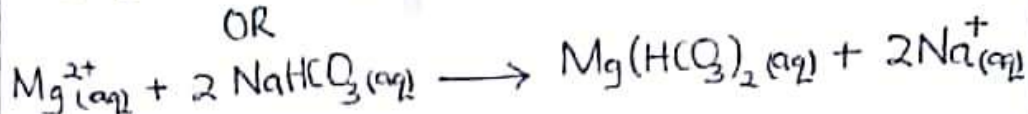




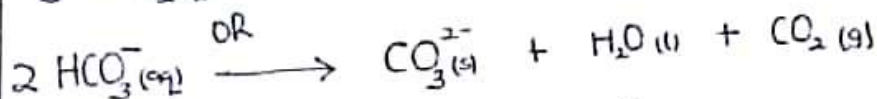
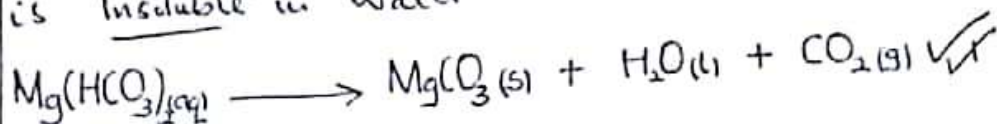
12) (i) Before heating, there is no observable change because Magnesium ion reacts with the hydrogen carbonate ions to form Magnesium hydrogen carbonate which is soluble.



OR



(ii) On heating, a white precipitate is formed because the Magnesium hydrogen carbonate decomposes to form Magnesium carbonate which is insoluble in water.



(i) potassium iodide solution ✓  
Acc. potassium iodide

(ii) Lead(II) ions give a yellow precipitate ✓  
Magnesium ions give no observable colour change ✓

Acc. - excess sodium hydroxide

- Dilute hydrochloric acid

- Dilute sulphuric acid

- sodium chloride solution

- sodium sulphate solution

- Any named soluble salt of a sulphate or chloride.

- 13a(i) - Fat or oil / Lipids / Glycerols / Glycerides  
- Sodium hydroxide / Potassium hydroxide / caustic soda / caustic potash

Acc. Any named fat or oil such as palm oil, sunflower oil or pork

- (ii) - Fat or oil is boiled with sodium or potassium hydroxide.

- After boiling, the soap is removed from the solution by adding a saturated / concentrated solution of sodium chloride (brine)

This makes it to precipitate / solidify / salt out / salt out / separate out and the solid soap can be separated by filtration / skimmed out / scooped off and the soap is washed with a small amount of water.

- (b) - Soap has affinity for both dirt and water  
- When cleaning clothes, the water soluble end of the soap molecule is attracted to the water while the long hydrocarbon chain is attracted to the dirt  
- This end dissolves the dirt and the polar end / hydrophilic end surrounds it to prevent it from attaching itself back to the cloth

- (c) Detergents do not form scum because they form soluble calcium and magnesium salts in water

- (d) ~~Do~~ Detergents contain phosphates.  
- When poured into water bodies, these phosphates act as nutrients / food for certain algae  
- The algae will increase in water and use up all the oxygen in the water with the result that the aquatic plants and animals will eventually die  
- By their nature of being non-biodegradable, they lower surface tension of water hence resulting into suffocation of aquatic life; leading to death



142) When one mole of methanol burns completely in air/oxygen, 726 kJ of heat is liberated/given out/evolved/produced/lost to the surroundings.

Reject:- When -726 kJ is used

- The reaction is exothermic.

b)

$$\text{RFM of CH}_3\text{OH} = \frac{12 + 4 + 16}{32}$$

$$\begin{aligned}\text{Moles of methanol burnt} &= \frac{0.87}{32} \\ &= 0.0271875 \text{ mol.}\end{aligned}$$

$$\begin{aligned}\text{Heat absorbed by water} &= mc\theta \\ &= 500 \times 4.2 \times 7 \\ &= 14700 \text{ J} \\ &= \frac{14700}{1000} \text{ kJ} \\ &= 14.7 \text{ kJ}\end{aligned}$$

0.0271875 mol of methanol evolve 14.7 kJ

$$\begin{aligned}\text{1 mol evolves} &= \frac{14.7 \times 1}{0.0271875} \text{ kJ} \\ &= 540.6896 \text{ kJ}\end{aligned}$$

$$= 540.6896 \text{ kJ}$$

$$\approx -540.69 \text{ kJ/mol OR}$$

Enthalpy of combustion  
of methanol

$$-540.7 \text{ kJ/mol OR}$$

$$-541 \text{ kJ/mol}$$

C The value obtained in (b) (540.69 kJ/mol) is less than the standard (726 kJ/mol) because some of the heat is lost to the surroundings given that there is no lagging/shielding/insulation. Also, there are chances of incomplete combustion of the methanol and it evaporates readily/very volatile.

14 di) Enthalpies of combustion of the alcohols increase with increase in formula mass.

OR  
Enthalpies of combustion of the alcohols is directly proportional to formula mass.

OR  
Enthalpies of combustion of alcohols increases with an increase in number of carbon atoms.

di)

Alcohol	$\text{CH}_3\text{OH}$	$\text{C}_2\text{H}_5\text{OH}$	$\text{C}_3\text{H}_7\text{OH}$	$\text{C}_4\text{H}_9\text{OH}$	$\text{C}_5\text{H}_{11}\text{OH}$	$\text{C}_6\text{H}_{13}\text{OH}$
Formula mass	32	46 ✓	60	74 ✓	88	102 ✓
Enthalpy of combustion ( $\text{KJ mol}^{-1}$ )	726	1371	2017	2673	3331	3984

dm)

4560 KJ/mol



