

NATIONAL EXAMINATIONS COUNCIL
P.O.BOX 3817 KIGALI

Chemistry III

025

13th Nov 2006 8.30am-11.30am

ORDINARY LEVEL NATIONAL EXAMINATION 2006

SUBJECT : CHEMISTRY III

TIME : 3 HOURS

INSTRUCTIONS:

- This paper consists of **THREE** Sections A, B and C.
- Answer **ALL** the questions in section A. (**55 marks**)
- Answer **THREE** questions in section B. (**30 marks**)
- Answer only **ONE** question in section C. (**15 marks**)
- Calculators may be used.

SECTION A: Answer ALL questions.

1. Hydrogen gas was passed over hot copper (II) oxide until the reaction was over.

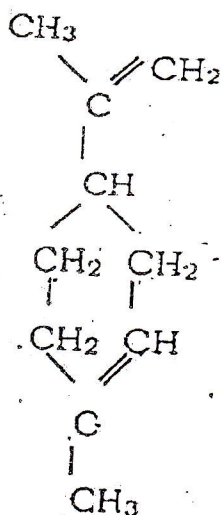
- a) Write a balanced equation for the reaction. (1 mark)
- b) Identify the oxidizing agent in the reaction. (1 mark)
- c) Name the salt formed when copper (II) oxide reacts with sulphuric acid. (1 mark)

2. This question concerns the following solutions:

$\text{CuSO}_4(\text{aq})$, $\text{KCl}(\text{aq})$, $\text{H}_2\text{SO}_4(\text{aq})$, $\text{AgNO}_3(\text{aq})$, $\text{NH}_3(\text{aq})$, $\text{MgSO}_4(\text{aq})$. Each solution may be used once or not at all. Choose from the above list the formula of a solution which:

- a) is alkaline (1 mark)
- b) is used to test for chloride ions (1 mark)
- c) forms a white precipitate when mixed with barium nitrate solution. (1 mark)
- d) Produces hydrogen gas when added to magnesium. (1 mark)

3. Limonene is a liquid hydrocarbon found in an orange peel. Its structure shown below:



- a) What is meant by term "hydrocarbon"? (1 mark)
 - b) What is the molecular formula of limonene? (1 mark)
 - c) Some limonene was mixed with a few drops of aqueous bromine (bromine water). What color change would you see in the aqueous bromine? (1 mark)
 - d) Which functional group present in the structure of limonene is responsible for reacting with bromine? (1 mark)
4. a) What is meant by "hard water"? (1 mark)
- b) Explain the difference between permanent hardness and temporary hardness of water. (2 marks)
 - c) Using a relevant equation, explain how temporary hard water can be changed into soft water. (2 marks)
5. Magnesium and nitrogen combine to form a compound called magnesium nitride. Magnesium has atomic number 12 and nitrogen has atomic number 7.
- a) Give the electronic arrangement of magnesium. (1 mark)
 - b) State the type of bond formed when magnesium combines with nitrogen. (1 mark)
 - c) Give the formula of magnesium nitride. (1 mark)

6. Sodium (Na) is obtained by the electrolysis of molten sodium chloride.
- Explain why sodium chloride conducts electricity in the molten state but not in the solid state. (2 marks)
 - Give an equation for the reaction at the cathode during this electrolysis. (1 mark)
 - Give an equation for the reaction at the anode during this electrolysis. (1 mark)

7. The table below shows the results of tests carried out on salt X. Study the table and answer the questions which follow.

Tests on salt X solution	Observations
Add dilute NaOH solution	A white precipitate which dissolves in excess reagent.
Add dilute ammonia solution	A white precipitate which dissolves in excess reagent.
Add barium nitrate solution	A white precipitate
Add silver nitrate solution	No observable change.

- Give the name or the formula of the cation in X. (1 mark)
 - Give the name or the formula of the anion in X. (1 mark)
 - What can you conclude from the test in (d) in the above table? (1 mark)
 - What type of hydroxide is formed by the cation in X? (1 mark)
8. C_4H_{10} is a hydrocarbon which belongs to a class of alkanes.

- Give the name of the above alkane. (1 mark)
- Write down the structural formulae of 2 isomers of C_4H_{10} and name the branched isomer. (2 marks)

9. Phosphine, PH_3 , is a compound which has similar properties to those of ammonia gas. The atomic number of P is 15 and that of H is 1.

- What type of bond is formed between P and H? (1 mark)
- Draw a diagram to show bonding in PH_3 . You may show electrons in the outer shell only. Use a cross (x) to show electrons from P and a dot (.) to show electrons from H. (2 marks)

10. The following methods are commonly used to separate mixtures: filtration, chromatography, simple distillation and fractional distillation.

State the method that would be used to:

- Separate ethanol and water. (1 mark)
- Separate the dyes in ink. (1 mark)
- Obtain pure water from sea water. (1 mark)
- Separate chalk particles and water. (1 mark)

11. The molecular formula of ethanoic acid is $C_2H_4O_2$.

- Write the structural formula of ethanoic acid. (1 mark)
- What observation would be made if the above acid is mixed with sodium carbonate solution? (1 mark)
- What type of organic compound is formed when ethanoic acid is reacted with ethanol? (1 mark)

- State two conditions necessary for iron to rust. (2 marks)
- In which way is rusting similar to respiration? (1 mark)

13. Ethane is a useful organic compound which can be converted into many other organic products. One such product is poly(ethane)

- Poly(ethane) is a polymer, explain the meaning of the term polymer. (1 mark)

- b) Ethane is "unsaturated" where as poly(ethane) is saturated. What is meant by "unsaturated" with reference to ethane? (1 mark)
- c) State one use of poly(ethane). (1 mark)
14. Aluminium chloride is prepared by reacting chlorine with hot aluminium according to the equation: $2 \text{Al}_{(s)} + 3 \text{Cl}_{2(g)} \longrightarrow 2 \text{AlCl}_{3(s)}$
- a) Calculate the mass of AlCl_3 that would be produced from 0.54g of Aluminium. (2 marks)
- b) What is the volume of Cl_2 (measured at r.t.p) that would react with 0.54g of aluminium? ($\text{Al} = 27$, $\text{Cl} = 35.5$, 1 mole of any gas at r.t.p (room temperature and pressure) has a volume of 24dm^3 or 24000cm^3) (2 marks)
15. Incomplete combustion of carbon produces carbon monoxide. Carbon monoxide is also produced by a charcoal stove (sigiri) when there is insufficient air (oxygen)
- a) Why is carbon monoxide poisonous when it is inhaled (breathed in)? (2 marks)
- b) Write a balanced equation for the reaction between carbon and oxygen to form carbon monoxide. (1 mark)
- c) Why is it advisable to use a charcoal stove (sigiri) in a well ventilated room? (2 marks)

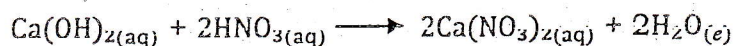
SECTION B: Answer THREE questions from this section.

16. When ammonium chloride (NH_4Cl) is heated with calcium hydroxide ($\text{Ca}(\text{OH})_2$), a salt, water and ammonia gas are produced.
- a) Write a balanced equation for the reaction between ammonium chloride and calcium hydroxide. (2 marks)
- b) Ammonium salts often sublime when heated. What is meant by the term sublimation? Calculate the percentage by mass of nitrogen in NH_4Cl . ($\text{N} = 14$, $\text{H} = 1$, $\text{Cl} = 35.5$) (2 marks)
- c) Ammonia gas is manufactured on a large scale by the Haber process according to the equation:
- $$\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$$
- How is nitrogen obtained for use in the Haber process? (1 mark)
- d) State the temperature range and the catalyst used in the above process. (2 marks)
- e) State one large scale use of ammonia. (1 mark)
17. Diamond and graphite are macromolecular forms of carbon. Their physical properties are different because they have different structures.
- a) What name is generally used to describe different forms of the element? (1 mark)
- b) In terms of their different structures, explain briefly the physical properties shown by graphite and diamond below:
- i) Graphite is soft and can be used as a lubricant while diamond is a very hard substance. (4 marks)
- ii) Graphite is a good conductor of electricity while diamond is a poor conductor of electricity. (4 marks)
- iii) State one use of diamond. (1 mark)

18. An experiment was carried out to determine the mass of calcium oxide in a solid sample. The sample was dissolved in water to make 25.0cm³ of calcium hydroxide. This solution required 7.50cm³ of nitric acid to just neutralize it. The concentration of nitric acid was 0.050 mol dm⁻³ (0.050M)

a) Write an equation for the reaction between calcium oxide and water to form calcium hydroxide. (1 mark)

The equation for the reaction between Ca(OH)₂ and HNO₃ is:



i) Calculate the number of moles of nitric acid. (1 mark)

ii) How many molcs of Ca(OH)₂ were in 25.0cm³ of the solution? (1 mark)

iii) The number of moles of Ca(OH)₂ is equal to the number of moles calcium oxide (CaO). Use your answer in (ii) to calculate the mass of CaO in the original sample. (Ca = 40, O = 16) (3 marks)

c) Carbon dioxide gas is passed through calcium hydroxide solution (lime water). A white precipitate is observed. More carbon dioxide is passed through the precipitate which dissolves to give a colorless solution. Explain these observations as fully as you can, using equations to show the reaction taking place. (4 marks)

19. Aluminium is a widely used metal. It is extracted by electrolysis of a molten mixture of aluminium oxide and cryolite. The electrolytic cell uses graphite anodes and graphite lining as the cathode.

a) Why is cryolite used in this process? (1 mark)

b) Write equations to show what is formed at the
i) Cathode ii) Anode (4 marks)

c) Why do the graphite anodes have to be replaced after a period of time? (1 mark)

d) How might this process of extraction affect the environment? (2 marks)

e) Give one use of aluminium and explain one property of aluminium on which this use is based. (2 marks)

SECTION C: Answer only ONE question from this section

20. a) Oxygen gas is prepared by adding hydrogen peroxide solution drop by drop to manganese (IV) oxide in a flat-bottomed flask. The gas is collected over water.

i) Draw a labeled diagram to show the preparation and collection of oxygen gas. (5 marks)

ii) What is the role of manganese (IV) oxide in this reaction? (1 mark)

b) Different elements are burned in gas jars of oxygen and each product is shaken with water. Each mixture is tested with litmus paper to find out if it is acidic or alkaline. In each case, state whether the mixture is acidic or alkaline and write an equation for the reaction between the oxide and water.

i) Sulphur (2 marks)

ii) Sodium (2 marks)

iii) Carbon (2 marks)

c) Give one large scale use of oxygen. (1 mark)

d) Each year, a lot of money is used to protect iron against corrosion/rusting. State two methods used to prevent rusting. (2 marks)

Answer to question 7. a) Zn^{2+} b) SO_4^{2-} c) No Cl^- ion is present. d) Amphoteric.	Answer to question 8. a) Butane b) <pre> H H H H H - C - C - C - C - H H H H H </pre>	Answer to question 9. a) Covalent bond b) <pre> H H - X - P - X H H </pre>
Answer to question 10. a) Fractional distillation. b) Chromatography. c) Simple distillation d) Filtration	Answer to question 11. a) <pre> H H - C - C - O - H H O </pre>	b) A gas which turns lime water milky. c) An ester.

Answer to question 12.

- a) Presence of: i) Moisture/water
ii) Air (O_2)
b) Both use oxygen to take place.

Answer to question 13.

- a) A polymer is a large molecule built from hundreds or thousands of small unit molecules called monomers joined together.
b) Unsaturated hydrocarbon are hydrocarbons which contain less than the maximum amount of hydrogen atoms due to having double or triple bond and so react addition reaction.
c) Poly (ethene) is used in the manufacture of polythene bags.

Answer to question 14. a) From the equation: $2 \text{ moles of Al} \rightarrow 2 \text{ moles of AlCl}_3$ Moles of Al = $\frac{0.54}{27} = 0.02$ • Rmm of $AlCl_3 = 27 + 35.5 \times 3 = 133.5 \text{ g/mol}$ Mass of $AlCl_3 = 133.5 \times 0.02 = 2.67 \text{ g}$	b) $(2 \times 27) \text{ g of Al} \rightarrow 2 \times 133.5 \text{ g of AlCl}_3$ $133.5 \text{ g of Al} \rightarrow \frac{2 \times 133.5}{2 \times 27}$ $0.54 \text{ of Al} \rightarrow \frac{133.5}{27} \times 0.54 = 2.67 \text{ g of AlCl}_3$ $= 720 \text{ cm}^3 \text{ of Cl}_3.$
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Answer to question 15.

- a) Because it causes suffocation
b) $2C_{(s)} + O_{2(g)} \rightarrow 2CO$
c) To prevent incomplete burning of charcoal which can produce carbon monoxide.

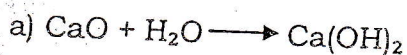
SECTION B:

Answer to question 16. a) $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2H_2O$ b) Sublimation is the change of state from solid directly to gas or vice-versa. • % of nitrogen = $\frac{14}{53.5} \times 100 = 26.2\%$	c) By fractional distillation of liquid air. d) $450^\circ - 500^\circ C$, catalyst, divided iron. e) Ammonia is used in the manufacture of artificial fertilizers.
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Answer to question 17.

- a) Allotropy
- b) i) Graphite crystals consist of layers of carbon atoms, and each carbon atom is joined to other by covalent bonds.
- ii) Graphite contains delocalized (free and mobile) electrons which are responsible for graphite to conduct electric current. Diamond has no delocalized electrons.
- iii) Uses of diamond:
- Used for drilling and cutting hard cutter substances e.g used as glass
 - Used for making rings and ear rings.

Answer to question 18.



b) i) Number of moles of nitric acid = $\frac{0.05 \times 7.5}{1000}$
 $= 3.75 \times 10^4$

ii) From the equation:

1 mole of HNO_3 react with 1 mole of Ca(OH)_2

1 mole of HNO_3 reacts with $\frac{1}{2} \times 3.75 \times 10^4$
 $= 1.875 \times 10^4$

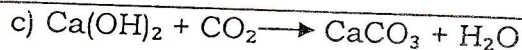
iii) Number of moles of $\text{Ca(OH)}_2 =$ Number of moles of CaO .

Number of moles of $\text{CaO} = 1.875 \times 10^4$

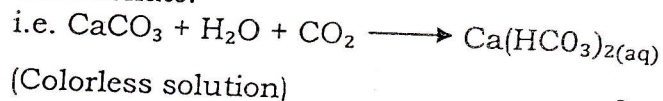
But mass = Number of moles \times Rmm

Rmm of $\text{CaO} = 40 + 16 = 56$

Mass of $\text{CaO} = 1.875 \times 10^4 \times 56 = 105 \times 10^4$

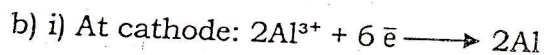


When more CO_2 is passed through, the white precipitate dissolves to give a colorless solution which is calcium bicarbonate.



Answer to question 19.

a) To reduce the melting point of Aluminium oxide.



c) Since they are carbon, they react with oxygen produced forming CO_2 gas.

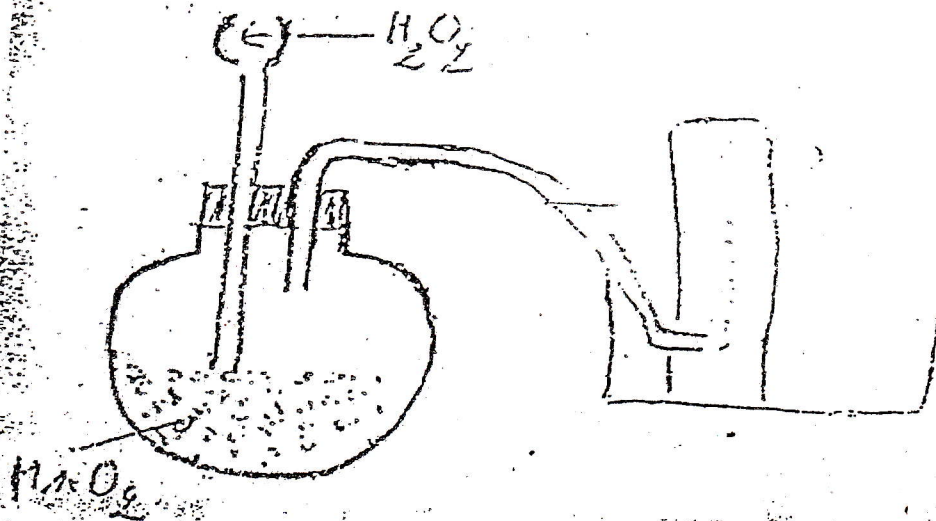
- d) - Soil erosion
- Air pollution (CO_2) from oxidation of carbon anode)

e) Used in the manufacture of air craft since it is the lightest metal.

SECTION C:

Answer to question 20.

a) i)



- ii) It acts as a catalyst.
- b) i) Acidic, $\text{SO}_2 + \text{H}_2\text{O} \longrightarrow \text{H}_2\text{SO}_3$
- ii) Alkaline, $\text{NaO} + \text{H}_2\text{O} \longrightarrow 2\text{NaOH}$
- iii) Acidic, $\text{CO}_2 + \text{H}_2\text{O} \longrightarrow \text{H}_2\text{CO}_3$
- c) Oxygen is used for respiration in living organisms
Liquid oxygen is used as fuel for space rockets.
- d) - Oiling
- Painting

Answer to question 21.

- a) i) Acid : HCl .
Metal : Mg
- ii) Acid : HNO_3
Substance : PbO
- iii) Acid : H_3COOH
Substance : NaOH .
- b) i) $\text{ZnCO}_3 + \text{H}_2\text{SO}_4 \longrightarrow \text{ZnSO}_4 + \text{CO}_2 + \text{H}_2\text{O}$
- ii) To ensure that all the acid was used up.
- iii) Lead II sulphate is insoluble.
- iv) By heating Zinc crystals first and condense the vapour produced. Add the condensed vapour to anhydrous copper II sulphate. If copper II sulphate turns blue, then the condensed vapour is water.
- v) First find Rmm of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$
 $65 + 32 + 16 \times 4 + 7(1 \times 2 + 16) = 287$
% of water = $\frac{126}{287} \times 100 = 43.9\%$.

END.