



NATIONAL EXAMINATIONS COUNCIL
P.O.BOX 3817 KIGALI

Chemistry I

003

10th Nov 2009 8.30am-11.30am

ORDINARY LEVEL NATIONAL EXAMINATION 2009

SUBJECT : CHEMISTRY I

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. (55 marks)

1. Hydrogen gas is prepared by reacting Zinc metal with hydrochloric acid solution. The gas is collected by upward delivery.
- Describe a chemical test for hydrogen gas. (2 marks)
 - From its method of collection, what can you conclude about the density of hydrogen compared to that of air? (1 mark)
 - Write a balanced chemical equation for the reaction of Zinc with hydrochloric acid. (2 marks)
2. Un polluted air is a mixture of gases.
- State the components of unpolluted air and their approximate percentages. (2 marks)
 - Carbon monoxide is known to be one of the pollutants of air.
 - What is the main source of carbon monoxide in air? (1 mark)
 - Why is carbon monoxide poisonous to humans? (2 marks)
3. The following methods may be used to separate mixtures: filtration, distillation, chromatography, evaporation. State which method you would use to separate:
- Zinc chloride from sea water
 - Pure water from sea water
 - The components of chlorophyll. (3 marks)
4. The elements of W, X and Y have the following atomic numbers $W = 6$, $X = 8$, $Y = 19$.
- Write the electronic configuration of Y. (1 mark)
 - Write down the formula of a compound formed between Y and X. Use Y and X as symbols in the compound. (1 mark)
 - What type of bond is formed when W combines with X? Give a reason. (2 marks)
5. Dilute hydrochloric acid was electrolyzed using carbon electrodes.
- Give the formulae of all the ions present in a solution of sulphuric acid. (2 marks)
 - Which gas is formed at the anode? (1 mark)
 - As electrolysis continues, does the solution become more or less acidic or the acidity remains unchanged? Give a reason. (2 marks)
6. An organic compound of molecular formula C_4H_8 was prepared by heating butanol with concentrated sulphuric acid.
- Give the structural formula of butanol (butanol -1-01) (1 mark)
 - To what class of hydrocarbons does C_4H_8 belong? (1 mark)
 - Give the structural formulae of two isomers of C_4H_8 . (2 marks)
7. Ammonia gas is prepared by heating calcium hydroxide and ammonium chloride. The gas is dried by passing it over calcium oxide.
- Write a balanced chemical equation for the reaction between calcium hydroxide and ammonia chloride. (2 marks)
 - Why is ammonia gas not dried using concentrated sulphuric acid? (1 mark)
 - State one large scale use of ammonia. (1 mark)
8. Organic compounds are classified according to their functional groups. From the compounds represented by the formulae:
- A: CH_3CH_2COOH , B: $CH_3CH_2OH_2$, C: $CH_3CH = CH_2$,
D: $CH_3COOCH_2CH_3$, E: $CH_3CH_2CH_2CH_3$.

Select a letter corresponding to the formula of:

- a) An ester
- b) A carboxylic acid
- c) An alkene.

(3 marks)

9. A scientist suspected that drinking water was contaminated by zinc sulphate.
How would the scientist show by chemical tests that the water contained:

- a) Zinc ions?
- b) Sulphuric ions?

(2 marks)

In each case describe the reagents (chemicals) used and the expected observation for a positive result.

10. Poly(ethene) is a commonly used plastic polymer.

- a) State one advantage of using Poly(ethane) plastic compared to other materials such as metals of glass.
- b) Why is poly(ethene) plastic considered a pollutant in the environment?

(1 mark)

(1 mark)

11. 5.95g of tin (Sn: relative atomic mass = 19) were burned in oxygen to produce 7.55g of an oxide of tin.

- a) Calculate the mass of oxygen in the oxide of tin.
- b) Determine the empirical formula of the oxide of tin.
(O: relative atomic mass = 16)

(1 mark)

(2 marks)

12. Sulphur dioxide is known to be one of the gases which cause acid rain.

- a) Write an equation to show the reaction of sulphur dioxide with water.
- b) In the contact process, sulphur dioxide is converted into sulphuric acid. Give one large scale use of sulphuric acid.

(1 mark)

(1 mark)

13. a) Arrange the following metals in order of reactivity, starting with the most reactive: Zn, Cu, Mg, Ca, Pb.

(1 mark)

b) A piece of magnesium was mixed with copper(ii)sulphate and the mixture was left to stand for about an hour. What observation would be made after half an hour? Explain your reasoning.

(2 marks)

14. a) Name a process which removes carbon dioxide from the atmosphere.

(1 mark)

b) Name a process which releases carbon dioxide into the atmosphere.

(1 mark)

c) In recent years, human activity has caused a large increase of carbon dioxide in the atmosphere. Briefly explain what effect the increase amount of carbon dioxide has on the environment.

(2 marks)

15. The table below shows some of the methods for the preparation of salts.

Reactants	Products
Magnesium oxide + A	Magnesium nitrate + B
C + sodium sulphate	Barium sulphate + D

Identify the compounds A, B, C and D by writing their names.

(4 marks)

A =

C =

B =

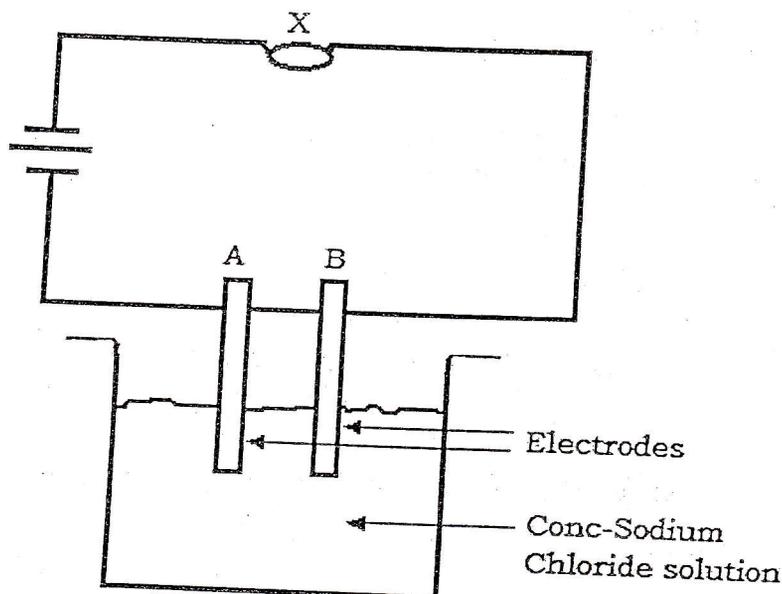
D =

SECTION B: Answer three questions only. (30 marks)

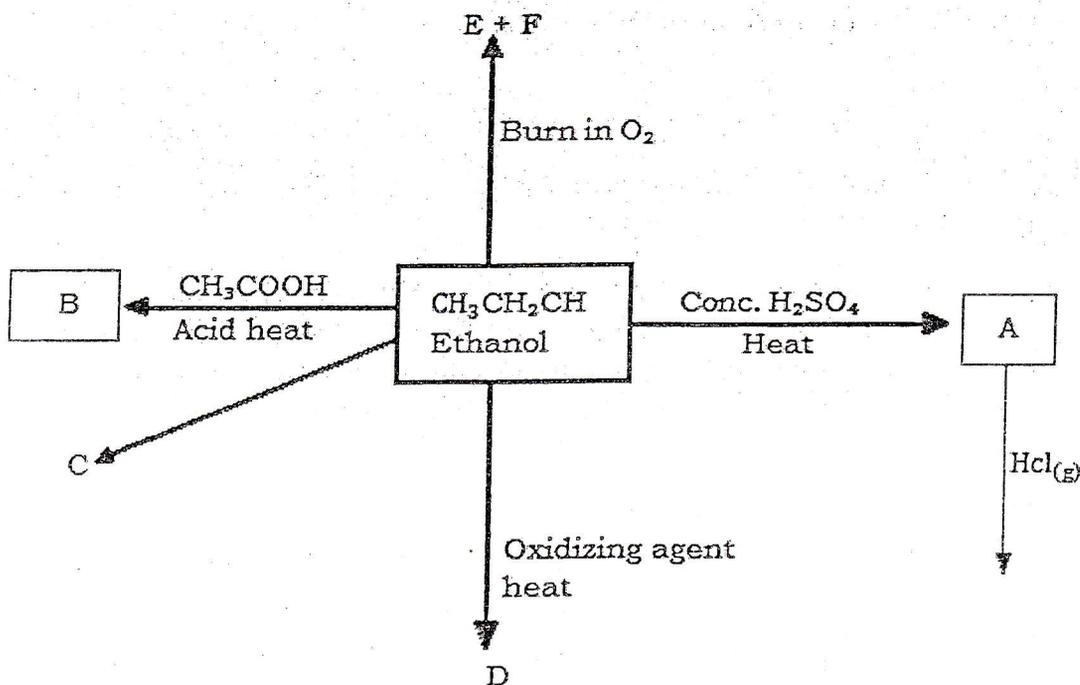
16. Iron is extracted from an iron ore called haematite (Fe_2O_3) in the blast furnace. Iron ore is mixed with coke (carbon), calcium carbonate (limestone) and introduced into the furnace (limestone) and introduced into the furnace. A blast of hot air is blown in from the bottom of the furnace. Coke(carbon) burns to form carbon dioxide which reacts with more carbon to form carbon monoxide.

- Write two balanced equations to show the formation of the two gases. (2 marks)
- Write a balanced equation to show the reaction between Fe_2O_3 and carbon. (2 marks)
- Identify the oxidizing agent and reducing agent in reaction of (b) above. (2 marks)
- What is the function of calcium carbonate? Explain your answer using two equations. (2 marks)
- What is galvanized iron? Why is iron sometimes galvanized? (2 marks)

17. A student carried out electrolysis of concentrated chloride solution using the apparatus shown below:



- What apparatus could be connected at X to show that the solution is an electrolyte? (1 mark)
 - Identify the electrodes labeled A and B. (2 marks)
 - Which gas is formed at electrode B? Write an equation to show its formation. (3 marks)
 - After some time, the solution around one of the electrodes was tested with a red litmus paper. The paper turned blue. Explain in terms of the electrolysis process, why the solution turned red litmus paper blue. (2 marks)
 - Suppose the electrodes A and B are graphite and the electrolyte is a solution of copper(II)Sulphate, give two observations that could be made as a result of electrolysis (apart from observing bubbles of gas). (2 marks)
18. Ethanol is a member of a family of organic compounds Alcohols (Alkanols). Ethanol is prepared by mixing a solution of glucose with yeast, leaving the mixture for a day at a temperature of about 37°C and then isolating ethanol from the mixture.
- Name the process in which ethanol is formed from a solution of glucose. (1 mark)
 - What is the role of yeast? (1 mark)
 - What functional group is present in all alcohols? (1 mark)
 - The diagram below shows reactions of ethanol and other compounds.



- i) Identify the organic compounds (by name or formula) A, B, C and D. (4 marks)
- ii) The formation of E and F is an exothermic reaction. What is an exothermic reaction? (1 mark)
- c) Compound A reacts with hydrogen chloride. Write a chemical equation for the reaction. (2 marks)
19. An experiment was carried out to find the concentration of sulphuric acid solution and to prepare sodium sulphate crystals from the solution. In that experiment, it was found that 25cm³ of 2 mol dm⁻³ sodium carbonate solution neutralized 27cm³ of sulphuric acid. After neutralization the solution was used to obtain crystals of salt.
- a) Write a balanced equation for the reaction of sodium carbonate and sulphuric acid. (2 marks)
- b) How many moles of Na₂CO₃ were in 25cm³ of 2 mol dm⁻³ solution? (1 mark)
- c) Calculate the concentration of sulphuric acid in mol dm⁻³ (to 2 decimal places). (2 marks)
- d) State the name of one indicator you could use in the neutralization process. (1 mark)
- e) Briefly explain how crystals of sodium sulphate could be obtained from the solution after neutralization. (2 marks)
- f) Calculate the mass of sodium sulphate crystals which could be obtained from the solution. (Na = 23, S = 32, O = 16). (2 marks)
20. Magnesium is in group 2 of the periodic table and is represented by the symbol $^{24}_{12}\text{Mg}$, it combines with oxygen to form magnesium oxide. The symbol for oxygen is $^{16}_8\text{O}$.
- a) What do the numbers 24 and 12 in the symbol of Mg represent? (2 marks)
- b) Another type of magnesium is represented by $^{26}_{12}\text{Mg}$. State the name given to the different types of magnesium atoms. (1 mark)
- c) Give the electronic configuration of magnesium and predict in which period of the periodic table it is. (1 mark)
- d) Magnesium combines with oxygen. State the type of bond which is formed and give two properties such a compound shows. (3 marks)

- e) Calcium is below magnesium in the same group of the periodic table. Compare the reactivities of the two metals with water. Write an equation to show how one of the two metals reacts with water.

(2 marks)

SECTION C: Answer only one question. (15 marks)

21. Chlorine gas is prepared by heating Manganese (IV) Oxide (Manganese dioxide) with concentrated hydrochloric acid. The gas is collected by downward delivery. It is highly reactive and a strong oxidizing agent.

- a) Describe a chemical test for chlorine gas. (2 marks)
b) Chlorine is a member of halogens of group 7 in the periodic table. How does the reactivity of halogens change down the group and why? (2 marks)
c) Using balanced equations, show the products formed when chlorine reacts with:

- i) Sodium iodide (2 marks)
ii) Sodium hydroxide solution at room temperature. (2 marks)
iii) Iron (II) chloride (3 marks)

d) Aluminium chloride is prepared from chlorine by passing dry chlorine over hot aluminium. Aluminium chloride sublimes and is collected in the cooler part of the apparatus.

- i) What is sublimation? (1 mark)
ii) Write a balanced equation for the reaction of chlorine with aluminium. (2 marks)
iii) What mass of aluminium chloride is produced from 0.54g of aluminium? (2 marks)
(Cl = 35.5, Al = 27)

(2 marks)

22. A student found a piece of rock which contained copper (II) carbonate. He carried out the following reactions in order to extract copper metal from the rock. Sulphuric acid was added to crushed rock. When the reaction was over, the mixture was filtered. To the filtrate containing copper (II) sulphate, sodium hydroxide solution was added. The precipitate obtained was filtered and the residue obtained was heated strongly to obtain copper (II) oxide which was reduced by heating with hydrogen (copper (II) oxide which was reduced by heating with hydrogen gas).

- a) Write a balanced equation for the reaction of copper (II) carbonate with sulphuric acid. (2 marks)
b) How could the student tell if the reaction was complete? (1 mark)
c) What products were formed when copper (II) sulphate was reacted with sodium hydroxide? (2 marks)
d) Describe the color of the mixture in (c) above. (1 mark)
e) Write a balanced equation for the reaction which involves heating to give copper (II) oxide. (2 marks)
f) Write down a balanced equation for the reaction between copper (II) oxide and hydrogen and identify the oxidizing agent. (3 marks)
g) If 5.0g of copper (II) oxide was used, calculate;
i) The mass of hydrogen gas which reacted with copper (II) oxide. (2 marks)
ii) The mass of copper metal which was produced. (2 marks)

END

SECTION A

<p>Answer to question 1.</p> <p>a) Apply a burning splint (wooden) The gas burns with a pop sound or a pop sound is heard.</p> <p>b) The gas is lighter than air or the gas is less dense than air.</p> <p>c) $Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$</p>	<p>Answer to question 2.</p> <p>a)</p> <table border="1" data-bbox="975 286 1520 577"> <thead> <tr> <th>Compound</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Nitrogen</td> <td>78</td> </tr> <tr> <td>Oxygen</td> <td>20-21</td> </tr> <tr> <td>Carbon dioxide</td> <td>0.03</td> </tr> <tr> <td>Noble gases</td> <td>1</td> </tr> </tbody> </table> <p>b i) Incomplete combustion/burning containing carbon</p> <p>ii) Forms a stable compound with haemoglobin (carboxyhaemoglobin) which prevents circulation of oxygen in blood, thus causing death. Or it interferes with circulation of oxygen in blood, hence causing death</p>	Compound	Percentage	Nitrogen	78	Oxygen	20-21	Carbon dioxide	0.03	Noble gases	1
Compound	Percentage										
Nitrogen	78										
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<p>Answer to question 3.</p> <p>a) Evaporation</p> <p>b) Distillation</p> <p>c) Chromatography</p>	<p>Answer to question 5.</p> <p>a) H, SO_4^{2-}, OH</p> <p>b) Oxygen</p> <p>c) Acidity remains unchanged. Reason: Equal amounts of H^+ and OH^- ions are removed during electrolysis.</p>										
<p>Answer to question 4.</p> <p>a) Y: 2, 8, 8, 1</p> <p>b) X: 2, 6 Hence the formula is Y_2X</p> <p>c) Covalent bond: Reason: Both W and X are non-metals. Or W and X bond by sharing electrons.</p>	<p>Answer to question 7.</p> <p>a) $Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$</p> <p>b) Since NH_3 is alkaline/basic, it would react with H_2SO_4.</p> <p>c) Manufacture of nitric acid, fertilizers etc.</p>										
<p>Answer to question 6.</p> <p>a) $CH_3-CH_2-CH_2-CH_2-OH$</p> <p>b) Alkenes</p> <p>c) $CH_2 = CH-CH_2-CH_3$ $CH_3-CH = CH-CH_3$</p>	<p>Answer to question 9.</p> <p>a) Add aq. Ammonia and aq. Sodium hydroxide until in excess. Observation: A white precipitate which dissolves in excess to give a colorless solution.</p> <p>b) Add dil. HCl, then $BaCl_{2(aq)}$ or dil HNO_3 then $Ba(NO_3)_{2(aq)}$ Observation: A white precipitate insoluble in HNO_3/HCl.</p>										
<p>Answer to question 8.</p> <p>a) D</p> <p>b) A</p> <p>c) C</p>	<p>Answer to question 11.</p> <p>a) The mass of oxygen is $7.55 - 5.95 = 1.6$</p> <p>b) Number of mols if Sn = $5.95 / 119 = 0.05$ mol Number of mol of O = $1.6 / 16 = 0.1$ mol Mole ratio of Sn: O = $0.05 : 0.1 = 1 : 2$ Empirical formula = SnO_2</p>										
<p>Answer to question 10.</p> <p>a) Advantages:</p> <ul style="list-style-type: none"> - Less expensive - Not breakable - Not attacked by chemicals. <p>b) Do not decay or not broken down by microorganisms.</p>	<p>Answer to question 11.</p> <p>a) The mass of oxygen is $7.55 - 5.95 = 1.6$</p> <p>b) Number of mols if Sn = $5.95 / 119 = 0.05$ mol Number of mol of O = $1.6 / 16 = 0.1$ mol Mole ratio of Sn: O = $0.05 : 0.1 = 1 : 2$ Empirical formula = SnO_2</p>										

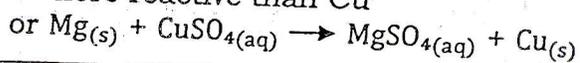
Answer to question 12.

- a) $\text{H}_2\text{O}_{(l)} + \text{SO}_{2(g)} \rightarrow \text{H}_2\text{SO}_{3(aq)}$
- b) To manufacture fertilizers or in car/vehicle batteries.

Answer to question 13.

- a) Ca, Mg, Zn, Pb, Cu
- b) A brown deposit of copper or a blue color fades/turns colorless

Explanation: Mg displaces Cu from the solution since is more reactive than Cu

**Answer to question 14.**

- a) Photosynthesis
- b) Respiration/combustion of fuels containing carbon.
- c) CO_2 acts as a green house gas or CO_2 traps heat radiated from the earth hence causes global warming.

Answer to question 15.

- A = Nitric acid
- B = Water
- C = Barium nitrate or bariunt chloride.
- D = Sodium nitrate or sodium chloride.

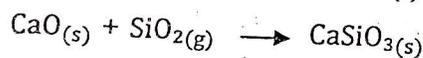
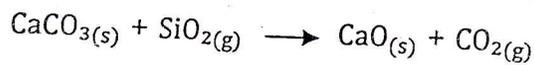
SECTION B**Answer to question 16.**

- a) $\text{C}_{(s)} + \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)}$
- $\text{CO}_{2(g)} + \text{C}_{(s)} \rightarrow 2\text{CO}_{(g)}$
- b) $\text{Fe}_2\text{O}_{3(s)} + 3\text{CO}_{(g)} \rightarrow 2\text{Fe}_{(s)} + 3\text{CO}_{2(g)}$

c) Oxidizing agent is Fe_2O_3

Reducing agent is CO.

d) To remove the impurity of silicon dioxide (SiO_2)

**Answer to question 17.**

- a) Ammeter/bulb
- b) A - Cathode (negative electrode)
B - Anode (positive electrode)
- c) Oxygen/ Cl_2

d) The solution was alkaline/basic.

Electrolysis continued, H^+ ions were converted into H_2 gas, leaving excess of OH^- in the solution around that electrode: hence causing the solution to be alkaline

e) - A brown solid deposited on the cathode (negative electrode).

- The blue color fades of the solution becomes less blue as Cu^{2+} ions are removed.

Answer to question 18.

- a) Fermentation.
- b) It provides a catalyst to increase the rate of fermentation/reaction.
- c) OH group

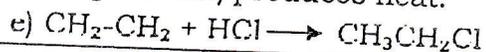
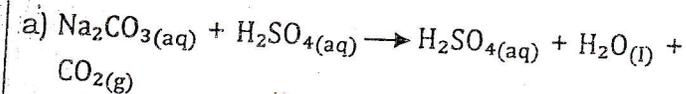
d) i) A - CH_4 or C_2H_6 or ethane

B - $\text{CH}_3\text{COOC}_2\text{H}_5$ or thyl ethanoate

C - $\text{CH}_3\text{CH}_2\text{ONa}$ or Sodium ethanocide

D - CH_3COOH or ethanoic acid.

ii) Exothermic reaction is a reaction which gives out/produces heat.

**Answer to question 19.**

b) Number of mol: $2 \times 25/1000 = 0.050$ moles.

c) Number of moles of $\text{H}_2\text{SO}_4 = 0.050$ mol
(since mole ration of $\text{Na}_2\text{CO}_3 = \text{H}_2\text{SO}_4$)

d) Methyl orange or phenolphthalein

e) Evaporate the solution to saturation, then leave to cool \rightarrow Crystals will form or evaporate to dryness.

f) Number of mol of $\text{Na}_2\text{CO}_3 =$ number of mol of $\text{Na}_2\text{SO}_4 = 0.050$

Molar mass of $\text{Na}_2\text{SO}_4 = (2 \times 23) + 32 + (16 \times 4) = 142 \text{g/mol}$.

Mass of $\text{Na}_2\text{SO}_4 = 0.050 \times 142 \text{g} = 7.1 \text{g}$

<p>Answer to question 20.</p> <p>a) 24 = mass number (number of protons + neutrons)</p> <p>12 = atomic number or number of protons or number of electrons.</p> <p>b) Isotopes</p> <p>c) Mg: 2, 8, 2 Period 3</p>	<p>d) Ionic bond or electrovalent bond. Properties: 1) High m.p of high b.p 2) Conducts electricity in molten state.</p> <p>e) Ca is more reactive than Mg. $\text{Ca}_{(s)} + \text{H}_2\text{O}_{(l)} \longrightarrow \text{Ca}(\text{OH})_{2(l)} + \text{H}_{2(g)}$ Or $\text{Mg}_{(s)} + \text{H}_2\text{O}_{(g)} \longrightarrow \text{MgO} + \text{H}_{2(g)}$</p>
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SECTION C

<p>Answer to question 21.</p> <p>a) - Apply wet red litmus paper. - The litmus paper is bleached/loses color to become white (or blue litmus paper \rightarrow red \rightarrow bleached)</p> <p>b) Reactivity decreases down the group. They become weaker oxidizing agents. Or as the size of atoms increases, they accept electrons less easily.</p> <p>c) i) $\text{Cl}_{2(g)} + 2\text{NaI}_{(g)} \rightarrow \text{NaCl}_{(aq)} + \text{I}_{(g)}$ ii) $2\text{NaOH}_{(aq)} + \text{Cl}_{2(g)} \rightarrow \text{NaCl}_{(aq)} + \text{NaOCl} + \text{H}_2\text{O}_{(l)}$ iii) $2\text{FeCl}_2 + \text{Cl}_2 \rightarrow 2\text{FeCl}_3$</p>	<p>d) i) Sublimation : Change from solid to gas directly. ii) $2\text{Al}_{(s)} + 3\text{Cl}_{2(g)} \rightarrow 2\text{AlCl}_{3(s)}$ iii) $\text{AlCl}_3 = 27 + 3(35.5) = 133.5$ Number of mol of Al = Number of mole of AlCl_3 Number of mol of Al = $0.54/27 = 0.02$ mol Number of mol of AlCl_3 Mass of $\text{AlCl}_3 = 0.02 \times 133.5 = 2.67\text{g}$</p>
<p>Answer to question 22.</p> <p>a) $\text{CuCO}_{3(s)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow \text{CuSO}_{4(aq)} + \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$</p> <p>b) If no more bubble/fizzing/effervescence.</p> <p>c) Copper (II) hydroxide + sodium sulphate Oxidizing agent is CuO.</p> <p>d) Blue solution</p> <p>e) $\text{Cu}(\text{OH})_{2(s)} \rightarrow \text{CuO}_{(s)} + \text{H}_2\text{O}_{(l)}$</p>	<p>f) $\text{CuO}_{(s)} + \text{H}_{2(g)} \rightarrow \text{Cu}_{(s)} + \text{H}_2\text{O}_{(l)}$ Oxidizing agent is CuO.</p> <p>g) i) Mole ratio of $\text{CuO} : \text{H}_2 : \text{Cu} = 1:1:1$ Number of mole of $\text{CuO} = 50/64 + 16 = 5/80 = 0.0625$ mol Number of mol of $\text{H}_2 = 0.0625$ mol Mass of $\text{H}_2 = 0.0625 \times 2 = 0.125\text{g}$ ii) Number of mols of $\text{Cu} = 0.0625$ mol Mass of $\text{Cu} = 0.0625\text{g}$</p>

END