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UNIVERSITY OF SWAZILAND

FACULTY OF EDUCATION

MAIN EXAMINATION PAPER 2010

B. Ed. II/PGCE

November/December 2010

Title of paper: Curriculum Studies: Chemistry

Course number: EDC 279

Time allowed: 3 hours

Instructions:

1. This paper contains FIVE questions.
2. Question 1 is COMPULSORY. You may then choose ANY TWO questions from questions 2, 3, 4, 5.
3. Marks for each question are indicated at the end of the question.
4. Any piece of material or work which is not intended for marking purposes should be clearly CROSSED OUT.
5. Ensure that responses to questions are NUMBERED CORRECTLY.

Special Requirements

Eight page attachment

SECTION A

QUESTION 1

This question is compulsory

a) Practical work is an essential aspect of teaching of chemistry. Discuss **four** ways that may be used to justify the use of practical work in teaching chemistry. [14]

b) Attached is a section of the SGCSE Physical Science 2011-2012 Syllabus 6888.

Using the attached syllabus section and the attached information: **19 Electricity and matter** (Hughes, A. M. (1981). *Chemistry in balance*, University Tutorial Press, Pg 161-167)

i) ***describe*** practical work activities that you might use to achieve the following syllabus content outcomes:

a. describe the plating of metals.

b. predict the likely products of the electrolysis of a specified binary compounds in the molten state or in aqueous solution. [16]

ii) identify and specify the following elements of science that pupils might develop as they work on the activities you outlined in b) i) above, and justify your identification:

Scientific knowledge

Processes of science [10]

SECTION B

Choose and answer any two questions

QUESTION 2

a) Debates on the nature of science indicate that science may be viewed as a "body of stable but tentative knowledge, as well as a process of inquiry". Discuss this statement and briefly indicate its implications for teaching science. [10]

b) Science is considered an important subject that all pupils in schools should study. Discuss why the study of chemistry should be part of the school curriculum. [20]

QUESTION 3

Some student teachers indicate in their lesson plans that they intend to use the discussion method in presenting their lessons but then use the question and answer method when delivering the lesson.

a) Briefly discuss the two methods showing their similarities and differences in the context of teaching science. [10]

b) How might you use the two methods in teaching JC Science *Topic 10. Water and Life* (See syllabus section below). [20]

10. Water and Life

Learners should be able to:

(a) state the sources of water e.g. rivers, wells, springs, boreholes, rain
(b) state the uses of water (domestic and industrial)
(c) list physical properties of water
(d) describe processes which cause movement of chemicals, diffusion through stomata in leaves, osmosis through roots hairs and cells, transpiration through leaves
(e) define transpiration as the loss/ diffusion of water vapour from the leaves through stomata into the atmosphere
(f) investigate; (i) the effects of uneven distribution of stomata on the leaf surfaces using wax or Vaseline; (ii) transpiration -presence of stomata, which surface has openings; (iii) diffusion-evaporation gas production

QUESTION 4

"... there is no single magical formula for motivating students. Many factors affect a given student's motivation to work and to learn... interest in the subject matter, perception of its usefulness, general desire to achieve, self-confidence and self-esteem ..." (Davis, 1999).

Discuss how each of the factors cited above might affect a pupil's motivation. [30]

QUESTION 5

The attached test paper is a Form 4 Chemistry test that was designed by a student teacher during teaching practice. The Periodic Table of Elements was provided by the teacher.

Study the test and use the syllabus assessment objectives and specification grid and syllabus section on *Topic C5. Atoms Elements and compounds*, ***attached***, to perform the following tasks

a) Construct a table of specification for the test [20]

b) Critique the test and comment on its

content validity

construct validity [10]

QUESTION 5

Form 4 **7 July 2010**

Chemistry test **60 minutes**

Question 1

a) Explain the difference between Ionic and covalent bonding. Discuss in what ways the electronic structure of a noble gases is important in both of these theories of bonding(4)

b) With reference to the structures and bonding of Diamond and Graphite,
   i. Which of this macromolecules conducts electricity and Why? (3)
   ii. State one use for both Graphite and Diamond, relate them to their properties (4)

c) Using dot and cross diagrams shows the electron arrangement of the following compounds and the line formula.
   I. CO_2 (2)
   II. N_2 (2)
   III. CH_3OH (2)
   IV. C_2H_4 (2)
   V. HCl (1)

Question 2

a) State four properties of metals (4)
b) What is meant by malleability and ductility (2)
c) Explain, using a diagram why magnesium conducts electricity and heat (3)

Question 3

Atoms of elements **X, Y** and **Z** have 16, 17 and 19 electrons respectively, atoms of Argon have 18 electrons.

a) Determine the formulae of compounds formed by the combination of the following elements;
   I. **X** and **Z**
   II. Y and **Z**
   III. **X** with itself (3)

b) In each of the cases shown in a) i)-iii) above, name the type of chemical bond formed. (3)

c) Explain the differences in properties (**Volatility (m.p. and b.p.)** and **electrical conductivity**) of both **ionic** and **covalent** compounds. (5)

4

ASSESSMENT OBJECTIVES

Assessment Objectives in Physical Science are:

A Knowledge with Understanding
B Handling Information and Solving Problems
C Experimental Skills and Investigations

A description of each Assessment Objective follows.

A KNOWLEDGE WITH UNDERSTANDING

Learners should be able to demonstrate knowledge and understanding in relation to:
1. scientific phenomena, facts, laws, definitions, concepts and theories;
2. scientific vocabulary, terminology and conventions (including symbols, quantities and units);
3. scientific instruments and apparatus, including techniques of operation and aspects of safety;
4. scientific quantities and their determination;
5. scientific and technological applications with their social, economic and environmental implications.

The Curriculum Content defines the factual material that candidates may be required to recall and explain. Questions testing this will often begin with one of the following words: define, state, describe, explain (using your knowledge and understanding) or outline. (See Appendix: Glossary of Terms.)

B HANDLING INFORMATION AND SOLVING PROBLEMS

Learners should be able, in words or using other written forms of presentation (i.e., symbolic, graphical and numerical), to:
6. locate, select, organize and present information from a variety of sources;
7. translate information from one form to another;
8. manipulate numerical and other data;
9. use information to identify patterns, report trends and draw inferences;
10. present reasoned explanations for phenomena, patterns and relationships;
11. make predictions and hypotheses;
12. solve problems, including some of a quantitative nature.

These Assessment Objectives cannot be precisely specified in the Curriculum Content because questions testing such skills are often based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: discuss, predict, suggest, calculate, explain or determine. (See Appendix: Glossary of Terms.)

C EXPERIMENTAL SKILLS AND INVESTIGATIONS

Learners should be able to:
13. use techniques, apparatus and materials (including the following of a sequence of instructions where appropriate);
14. make and record observations, measurements and estimates;
15. interpret and evaluate experimental observations and data;
16. plan and carry out investigations, evaluate methods and suggest possible improvements (including the selection of techniques, apparatus and materials).

Specification Grid

The approximate weightings allocated to each of the Assessment Objectives in the assessment model are summarised in the table below.

Assessment Objectives	**Weighting**
A Knowledge with understanding	50% (not more than 25% recall)
B Handling information and solving problems	30%
C Experimental skills and investigations	20%

Teachers should take note that there is an equal weighting of 50% for skills (including handling information, solving problems, practical, experimental and investigative skills) and for knowledge and understanding. Teacher's schemes of work, and the sequence of learning activities should reflect this balance, so that the aims of the syllabus may be met, and the candidates prepared for the assessment.

QUESTION 5

C5. Atoms, elements and compounds	
C5.1 Basic chemistry - define element. - name and give symbols of the first 20 elements of the Periodic Table. - define compound. - name and give formulae of simple compounds. - describe the Periodic Table as a method of classifying elements (see C9.1). - define atoms and molecules as smallest particles of elements and compounds. - describe differences between elements, mixtures and compounds and between metals and non-metals. - describe alloys as a mixture of a metal with other elements e.g., brass as a mixture of a metal with other elements. - describe the simple structure of atoms in terms of, neutrons, protons and electrons. **C5.2 Atomic structure and the Periodic Table** - state relative charges and approximate relative masses of protons, neutrons and electrons. - define proton (atomic) number and nucleon number. - explain, for the first 20 elements, the basis of the Periodic Table using the proton number and the simple structure of atoms. - deduce information from the notation $^{a}_{b}X$ for an atom. - describe the build up of electrons in shells. - describe the significance of the outermost electrons and the noble gas electronic configuration. - define isotopes. (The ideas of the distribution of electrons in s- and p-orbitals and in d-block elements are **not** required. Note that a copy of the Periodic Table will be provided in Papers 1, 2 and 3.) **C5.3 Bonding: the structure of matter** **C5.3.1 Ions and ionic bonds** - describe the formation of ions by electron loss or gain.	

- describe the formation of ionic bonds between the alkali metals and the halogens. **C5.3.2 Molecules and covalent bonds** - describe the formation of single covalent bonds in H_2, Cl_2, H_2O, CH_4 and HCl as the sharing of pairs of electrons leading to the noble gas configuration. - describe the differences in volatility (including m.p. and b.p.), solubility and electrical conductivity between ionic and covalent compounds. **C5.3.3 Macromolecules** - describe the 'structure' of graphite and of diamond. **C5.3.4 Metallic bonding**	- describe the formation of ionic bonds between metallic and non-metallic elements. - describe the electron arrangement in more complex molecules such as N_2, C_2H_4, CH_3OH and CO_2 - relate these structures to melting point, conductivity and hardness. - describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use these to describe the electrical conductivity and malleability of metals.

QUESTION 1

C11. Electricity and chemistry	
- describe electrolysis. - describe the electrode products formed in the electrolysis of copper chloride (aqueous solution) between inert electrodes (platinum or carbon). - state the general principle that metals or hydrogen are formed at the negative electrode and that oxygen or halogens are formed at the positive electrode. - outline the manufacture of aluminium from pure aluminium oxide, and that of chlorine and sodium hydroxide from concentrated aqueous sodium chloride (starting materials and essential conditions should be given). - describe the plating of metals.	- describe the electrolysis of dilute sulphuric acid (as essentially the electrolysis of water). - describe electrolysis in terms of the ions present and reactions at the electrodes in examples given. - predict the likely products of the electrolysis of a specified binary compound in the molten sate or in aqueous solution. - construct equations for the electrode reactions involved in the manufacture of aluminium, chlorine and sodium hydroxide.

19 Electricity and matter

Electricity is a very convenient form of energy. We use it in our homes for lighting, heating, cooking, washing clothes and for many other things. One of the big advantages of electricity is that it can easily be controlled. It can be turned on or off at the flick of a switch.

Electricity can be easily controlled because it passes through some materials but not through others.

A substance that allows electricity to pass through it is called a *conductor* of electricity.
A substance that does not allow electricity to pass through it is called a non conductor or *insulator*.

19.1 Conductors and insulators

If you were given a selection of substances in the laboratory and asked to divide them into conductors and insulators it would be a fairly easy job. All you would need to do is to connect up the apparatus shown in Fig 19.1.

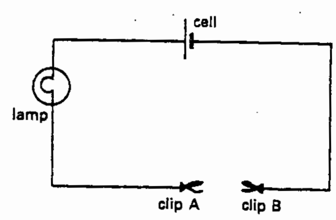

Fig 19.1

You would connect clips A and B to the substances you were testing. If the substance was a conductor the lamp would glow. If it was an insulator the lamp would not light up.
Table 1 shows some conductors and insulators that you might find in the laboratory.

CONDUCTORS	INSULATORS
Copper, aluminium, zinc, iron, steel, graphite, salt water, aqueous copper (II) sulphate, dilute hydrochloric acid, dilute sulphuric acid, aqueous sodium hydroxide	Sulphur, oxygen, iodine, carbon dioxide, ethanol, water, wax, polythene, PVC, copper (II) sulphate crystals, sodium chloride crystals, sugar, any pure acids, a solution of sugar in water

Table 1

Insulators

Looking at the insulators in Table 1 you will see they can be divided into a number of groups.

1. *Non metal elements*: all non metal elements except graphite are insulators. They will not conduct electricity in any state; solid, liquid or gas.

2. *Covalent compounds*: all covalent compounds are insulators. It does not matter whether they are solids like wax and sugar, liquids like ethanol and water, or gases like carbon dioxide. Pure acids fit into this group. So do the plastics, such as PVC, which are so widely used as insulators.

3. *Ionic solids*: ionic substances like sodium chloride and copper (II) sulphate are insulators, but only when they are solids.

Conductors

Looking at the conductors in Table 1 you will see they can also be divided up into a number of groups.

1. *Metals*: all metals conduct electricity when solid or molten. Some metals are better conductors than others.
   Aluminium and copper are two of the best conductors. This is why they are so widely used for electrical wiring.

2. *Acidic solutions*: pure acids are covalent but when they dissolve in water they form ions and become conductors.

3. *Ionic compounds*: ionic compounds like sodium chloride conduct electricity when they are molten, or dissolved in water, but not when they are solid.

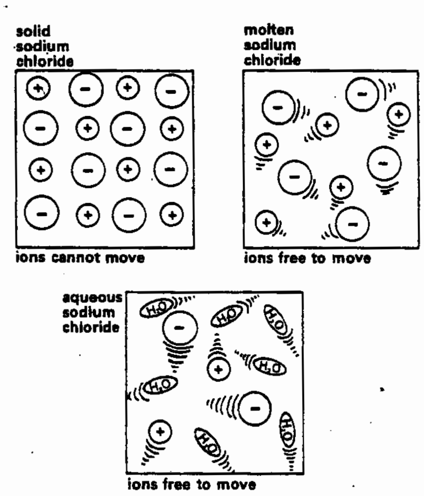

Fig 19.2

19.2 How do conductors conduct?

For a substance to conduct electricity, it must contain charged particles which are free to move. In metals (and graphite) the charged particles are electrons. The electrons that are free to move are the outer shell electrons or valence electrons. It is these valence electrons that carry an electric current through metals.

Apart from metals (and graphite) all other conductors contain ions. It is these ions that carry the electric current through the substance. Ionic solids such as sodium chloride do not conduct electricity because the ions are firmly held and cannot move. Only when molten or dissolved in water are the ions free to move.

When electricity passes through a metal, the metal is not affected. However, when electricity passes through an ionic substance (either molten or in solution) the substance is broken down in some way.

A substance that conducts electricity but is decomposed by the electricity is known as an *electrolyte*.

19.3 Passing electricity through electrolytes

Fig 19.3 shows an apparatus suitable for passing electricity through an electrolyte.

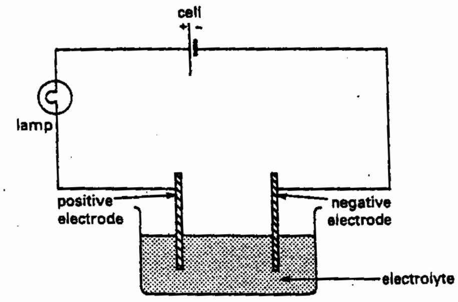

Fig 19.3

When electricity is passed through an electrolyte, the electricity enters and leaves the electrolyte via electrical contacts. These contacts are known as *electrodes*.

The positive electrode is known as the *anode*.
The negative electrode is known as the *cathode*.

The ions in the electrolyte are attracted towards the electrodes.

Negative ions (called *anions*) are attracted towards the anode.
Positive ions (called *cations*) are attracted towards the cathode.

When electricity is passed through an electrolyte, chemical reactions take place at the electrodes, and the electrolyte is broken down. This process is known as electrolysis.

Electrolysis is the process in which a substance conducts electricity and is decomposed by it.

Many substances can be broken down or decomposed by heating. You may remember that limestone (calcium carbonate) can be changed into quicklime (calcium oxide) in this way:

calcium carbonate → calcium oxide + carbon dioxide ↑

$$CaCO_3 \rightarrow CaO + CO_2 \uparrow$$

Electrolysis is also a way of breaking down substances. It uses electrical energy instead of heat energy. Consider some of the ways in which electrolysis can be used.

1. Electrolysis of molten lead bromide

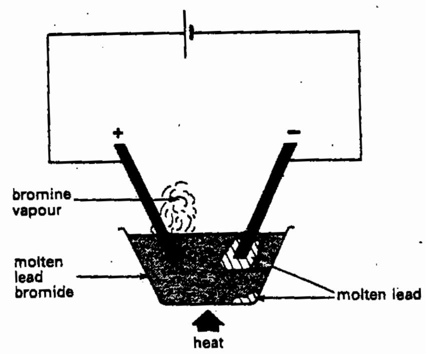

Fig 19.4

When electricity is passed through molten lead bromide, it is broken down to form lead metal and bromine vapour:

lead bromide → lead + bromine ↑

$$PbBr_2 \rightarrow Pb + Br_2 \uparrow$$

The lead is formed at the cathode and the bromine is formed at the anode.

We can consider the reactions at the anode and at the cathode separately.

At the anode

Negative bromide ions are attracted towards the

positive anode. At the anode they lose electrons and form bromine molecules:

bromide ions → bromine molecules ↑ + electrons

$$2Br^- \rightarrow Br_2 \uparrow + 2e$$

At the cathode

Positive lead ions are attracted towards the negative cathode. At the cathode they gain electrons and form lead atoms:

lead ions + electrons → lead atoms

$$Pb^{2+} + 2e \rightarrow Pb$$

2. Electrolysis of copper (II) sulphate solution

The way in which copper (II) sulphate solution conducts electricity depends on the electrode material.

(i) *With platinum electrodes*

Copper metal is formed at the cathode and oxygen gas is formed at the anode.

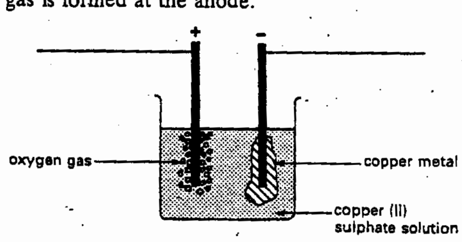

Fig 19.5

The solution contains copper (II) ions (Cu^{2+}) and sulphate ions (SO_4^{2-}) from the ionic copper (II) sulphate. It also contains some hydrogen ions (H^+) and hydroxide ions (OH^-) because water is slightly ionised.

At the anode

Hydroxide ions lose electrons forming water molecules and oxygen molecules:

hydroxide ions → water molecules + oxygen molecules ↑ + electrons

$$4OH^- \rightarrow 2H_2O + O_2 \uparrow + 4e$$

The sulphate ions are unchanged

At the cathode

Copper (II) ions gain electrons to form copper atoms.

copper (II) ions + electrons → copper atoms

$$Cu^{2+} + 2e \rightarrow Cu$$

(ii) *With copper electrodes*

Copper is still formed on the cathode, but the reaction at the anode is different. Instead of oxygen gas being formed, the anode dissolves.

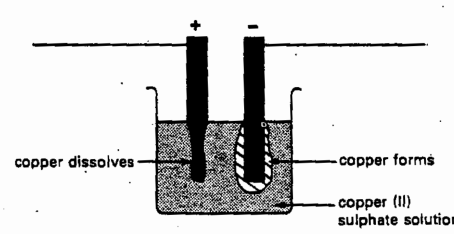

Fig 19.6

At the anode

Copper atoms from the anode lose electrons to form copper (II) ions. These ions pass into the solution.

copper atoms → copper (II) ions + electrons

$$Cu \rightarrow Cu^{2+} + 2e$$

The overall change is that copper is moved from the anode to the cathode. This makes the process suitable for copper plating. For copper plating, the object to be plated is made the cathode and a piece of pure copper is used as the anode.

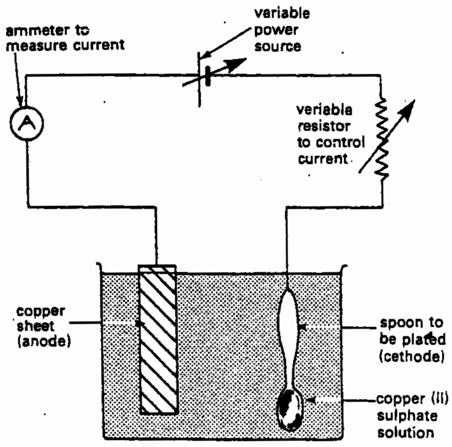

Fig 19.7 Copper plating a spoon

For successful copper plating the current, temperature and concentration of the electrolyte must be carefully controlled. The anode is sometimes arranged as a cylinder around the object to be plated. This gives a more even plating.

3. Electrolysis of dilute sulphuric acid

Pure water is a very poor conductor of electricity because it is mainly covalent. In pure water less than one molecule in one million is split into ions:

water ⇌ hydrogen ions + hydroxide ions

$H_2O \rightleftharpoons H^+ + OH^-$

If a little sulphuric acid is added to water it becomes a good conductor of electricity. The electrolysis of water containing a little sulphuric acid (dilute sulphuric acid) can be shown in the laboratory using the apparatus shown in Fig 19.8.

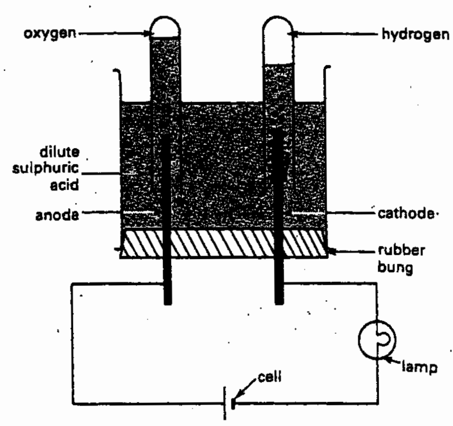

Fig 19.8 Electrolysis of acidified water

The electrolyte contains hydrogen ions (H^+) and sulphate ions (SO_4^{2-}) from the sulphuric acid. It also contains hydrogen ions (H^+) and hydroxide ions (OH^-) from the slightly ionised water.

At the anode

The hydroxide ions lose electrons forming water molecules and oxygen molecules:

hydroxide ions → water molecules + oxygen molecules ↑ + electrons

$4OH^- \rightarrow 2H_2O + O_2\uparrow + 4e$

The sulphate ions are unchanged.

At the cathode

Hydrogen ions gain electrons to form hydrogen molecules:

hydrogen ions + electrons → hydrogen molecules ↑

$2H^+ + 2e \rightarrow H_2\uparrow$

The overall change is that water is split up into its elements.

water → hydrogen ↑ + oxygen ↑

$2H_2O \rightarrow 2H_2\uparrow + O_2\uparrow$

This is a very convenient way of producing hydrogen gas. However, it is not used on a large scale in most parts of the World because of the high cost of electricity.

19.4 Making use of electrolysis

Electrolysis is of benefit to man in a number of ways:

1. It has allowed him to produce large quantities of the more reactive metals such as aluminium. Before the discovery of electricity aluminium was a very rare and precious metal. Many aluminium compounds existed, but it was difficult to extract aluminium from them. Nowadays, vast quantities of aluminium are made by the electrolysis of molten aluminium oxide (see page 100). It is used in so many ways that hardly a day goes by without us using the metal in some way or other. Think how many ways you have used aluminium today.

2. Electrolysis allows us to easily purify some metals. Copper can be purified in this way.

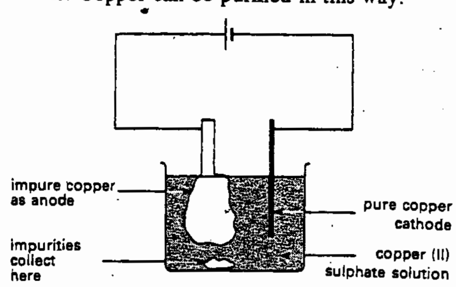

Fig 19.9 Purifying copper

When the current flows copper is dissolved from the impure anode and transferred to the pure cathode. The impurities are left behind.

3. The discovery of electrolysis allowed the modern electroplating industry to develop. Metals like steel are often plated. Car bumpers are chromium plated because it makes them look more attractive and it prevents the steel underneath from rusting. By tin plating steel cans, a container seeming to be made of pure unreactive tin is produced. A can made of pure tin would be very much more expensive and certainly not as strong.

Table 2 shows some substances manufactured by electrolysis.

Name of substance	Electrolyte	Other substances formed at the same time
aluminium	molten alumina in cryolite	oxygen
sodium hydroxide	sodium chloride solution	hydrogen and chlorine
magnesium	molten Carnallite	chlorine
sodium	molten sodium chloride	chlorine
hydrogen	sodium hydroxide solution	oxygen

Table 2