



**THE COPPERBELT UNIVERSITY**

In association with



**TECHNICAL AND VOCATIONAL TEACHERS' COLLEGE**

**BACHELOR OF SCIENCE IN DESIGN AND TECHNOLOGY TEACHER EDUCATION**

**DECEMBER, 2019**

**SUBJECT: SECOND YEAR CHEMISTRY (CH210)**

**TIME ALLOWED: 3 HOURS**

**TOTAL: 100**

**INSTRUCTIONS TO CANDIDATES:**

1. **DO NOT** turn the paper until you are told to do so.
2. There are SIX (6) questions in this paper. Answer any FIVE (5) questions.
3. Each question carries 20 marks
4. Cell phones and programmable calculators are not allowed in the examination room.

**QUESTION ONE**

- a) Define the following terms.
- i. A salt bridge [2marks]
  - ii. An electrolyte [2marks]
  - iii. The standard electrode potential. [2marks]
  - iv. Anions. [2marks]
  - v. Salt bridge. [2marks]
- b) During electrolysis of a Copper (II) Sulphate solution, a current of 0.13A is passed through the solution and 2grams of Copper are collected. Determine how long this process took. [6marks]
- c) Suggest two ways of increasing the rate at which copper is deposited at the cathode. [4marks]

## QUESTION TWO

- a) Define corrosion. [2marks]
- b) Discuss two causes of corrosion and give an example. [6marks]
- c) Discuss two effects of corrosion on engineering materials and give an example [6marks]
- d) Suggest three ways of controlling corrosion. [6marks]

## QUESTION THREE

- a) Write brief notes on how the following contribute to indoor pollution.
- i. Volatile Organic Compounds. [4marks]
  - ii. Tobacco smoke. [4marks]
  - iii. Charcoal. [4marks]
  - iv. Paints. [4marks]
- b) List two heavy metals and briefly explain how each one affects the environment or human life. [4marks]

## QUESTION FOUR

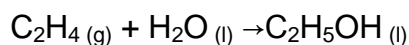
- a) For the cell made of copper(+0.34V) and silver(+0.80V)
- Write a balanced overall equation. **[5marks]**
  - Calculate the value of the equilibrium constant ( $K_C$ ), given that the standard electrode potential for silver and copper +0.80V and +0.34V respectively. **[5marks]**
- b) The Daniel cell is one of the most important cells in engineering. Given that the concentration of copper is  $0.5\text{mol/dm}^3$ , and the cell emf is 1.082V, calculate the concentration of the zinc ions. **[6marks]**
- c) Briefly explain why a dry cell will discharge after being used for some time. **[4marks]**

### QUESTION FIVE

- a) Outline the differences between an electrolytic cell and an electrochemical cell? **[5marks]**
- b) With a very good example, explain what a spontaneous reaction is. **[5marks]**
- c) Chlorofluorocarbons (CFCs) are an example of Ozone Depleting Substances. Briefly explain how CFCs deplete the ozone layer. **[5marks]**
- d) Write brief notes on toxic inorganic chemicals and give two examples. **[5marks]**

### QUESTION SIX

- a) Explain what you understand by Gibb's free energy of a reaction. **[4marks]**
- b) Determine if a reaction with change in enthalpy -120KJ and change in Entropy -160J/K is feasible at 270K. **[8marks]**
- c) The equation for the hydration of ethane to form ethanol is



Given the standard enthalpies of ethane, water and ethanol are +52KJ, -286KJ and -278KJ respectively. Calculate the standard enthalpy of the reaction, and state if the reaction is endothermic or exothermic. **[8marks]**

## SOLUTIONS

### QUESTION ONE

- a) A salt bridge is an inverted U-tube that contains an electrolyte and connects the two half-cells in a galvanic cell. **[2marks]**

An electrolyte is a chemical compound that conducts electricity when it is in a molten state. **[2marks]**

The standard electrode potential is the measure of individual potential of a reversible electrode at standard state, which is with solutes at an effective concentration of  $1 \text{ mol dm}^{-3}$ , and gases at a pressure of 1 atm, with temperature kept at  $25^\circ\text{C}$ . **[2marks]**

A cation is an ion or group of ions possessing a positive charge and having the natural ability to move toward the negative electrode in electrolysis. **[2marks]**

- b)  $C = it = 0.1 \times 10 \times 3600 = 3600 \text{ Coloumbs}$ .

$$4e^- \rightarrow 24dm^3$$

$$4 \times 96500 \rightarrow 24dm^3$$

$$3600 \rightarrow X,$$

$$X = \frac{3600 \times 24}{4 \times 96500} = 0.224dm^3 \quad \textbf{[6marks]}$$

- c) Manufacturing of sodium hydroxide by the electrolysis of sodium chloride  
Purification of copper, using a lump of impure copper as the anode. **[3marks]**  
Electroplating e.g. chromium plating. **[3marks]**

### QUESTION TWO

- a) Corrosion is the gradual degradation of materials as they interact with the environment. **[2marks]**
- b) Many metals corrode merely by being exposed to moisture in the air. Moisture supplies water & air supplies oxygen. **[3marks]**

Stress corrosion cracking (SCC) is a progressive fracturing that occurs in metals as a result of the combined influence of tensile stress and a corrosive environment. **[3marks]**

- c) Corrosion degrades the useful properties of materials such as strength, appearance & permeability to liquids & gases.[3marks]  
Corrosion inflates the maintenance costs of infrastructure. [3marks]
- d) Painting, galvanizing and alloying[ 6marks]

### QUESTION THREE

- a) Global warming is the increase in the earth's average temperature as a result of increased presence of greenhouse gases. Normally, when heat enters the atmosphere, it comes as short-wave radiation; a type of radiation that passes smoothly through our atmosphere. As this radiation heats the earth's surface, it escapes the earth in the form of long-wave radiation; a type of radiation that is much more difficult to pass through the atmosphere. Greenhouse gases released into the atmosphere cause this long-wave radiation to increase. Thus, heat is trapped inside of our planet and creates a general warming effect.[4marks]

The ozone layer is a layer in the stratosphere that shields the earth from ultraviolet rays from the sun. the ozone layer is made up of atoms of ozone and is very important because the rays, if allowed to penetrate, may be very harmful to the earth.[4marks]

Acid rain is rain or any other form of precipitation that is unusually acidic. Meaning that it possesses high levels of hydrogen ions (low pH). Acid rain is caused by emissions of sulfur dioxide and nitrogen oxide which react with the water molecules in the atmosphere to produce acids such as sulphuric & nitric acids. The acid rain can cause paint to peel, corrosion of steel structures such as bridges, and can harm the soil structure. [4marks]

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere. If the atmosphere contains radioactively active gases (i.e., greenhouse gases) they will radiate energy in all directions and increase the average temperature. Human activities, primarily the burning of fossil fuels and

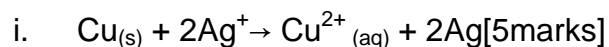
clearing of forests, have intensified the natural greenhouse effect, causing global warming. **[4marks]**

- b)** Mercury is a heavy metal belonging to the transition element series of the periodic table. Mercury is a widespread environmental toxicant and pollutant which induces severe alterations in the body tissues and causes a wide range of adverse health effects. **[2marks]**

Lead is a naturally occurring bluish-gray metal present in small amounts in the earth's crust. Although lead occurs naturally in the environment, activities such as fossil fuels burning, mining, and manufacturing contribute to the release of high concentrations. The nervous system is the most vulnerable target of lead poisoning. Headache, poor attention span, irritability, loss of memory and dullness are the early symptoms of the effects of lead exposure on the central nervous system. **[2marks]**

#### QUESTION FOUR

- a) For this cell,



$$E_{cell}^{\theta} = \frac{0.059}{n} \log K_c$$

$$0.8 - 0.34 = \frac{0.059}{2} \log K_c,$$

ii.  $K_c = 3.92 \times 10^{15}$  **[5marks]**

$$E_{cell} = E_{cell}^{\theta} - \frac{0.059}{n} \log \left[ \frac{Zn}{Cu} \right]$$

$$1.082 = 1.1 - \frac{0.059}{2} \log \left[ \frac{Zn}{0.5} \right]$$

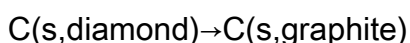
$$0.0610169 = \log \left[ \frac{Zn}{0.5} \right]$$

b)  $[Zn] = 2.04 \text{ mol} / \text{dm}^3$  [6marks]

- c) The dry cell will discharge when there is no longer potential difference between the half cells. This is because equilibrium has been reached and the cell may be recharged by passing a direct current through it. [4marks]

### QUESTION FIVE

- a) An electrolytic cell is a type of cell where an electric current is passed through an electrolyte and the electrolyte gets decomposed, an electrochemical cell uses chemical energy to generate a voltage. [5marks]
- b) Sacrificial protection is a corrosion protection method in which a more electrochemically active metal is electrically attached to a less active metal. The highly active metal donates electrons to replace those which may have been lost during oxidation of the protected metal. This reverts the protected metal back to its original form, and thereby prevents it from corroding. A typical sacrificial protection is where a more reactive metal is used as a sacrificial anode by attaching it to steel pipes or pump bodies. The iron becomes a cathode which does not corrode, while the anode corrodes to provide the desired sacrificial protection. The sacrificial metal must however be replaced periodically as it is consumed, otherwise, the protected metal starts corroding. [10marks]
- c) In chemistry, a spontaneous process is one that occurs without the addition of external energy. A spontaneous process may take place quickly or slowly, because spontaneity is not related to kinetics or reaction rate. A classic example is the process of carbon in the form of a diamond turning into graphite, which can be written as the following reaction:



This reaction takes so long that it is not detectable on the timescale of (ordinary) humans, hence the saying, "diamonds are forever." If we could wait long enough, we should be able to see carbon in the diamond form turn into the more stable but less shiny, graphite form. **[5marks]**

## QUESTION SIX

- a) When a process occurs at constant temperature and pressure, we can rearrange the second law of thermodynamics and define a new quantity known as Gibbs free energy:

Gibbs free energy =  $G = H - TS$

When  $G > 0$ , the reaction is non-spontaneous

When  $G < 0$ , the reaction is spontaneous

When  $G = 0$ , the reaction is at equilibrium **[4marks]**

$$\Delta G = \Delta H - T\Delta S$$

- b)  $\Delta G = -120 - (-270 * 0.160) = -76.8 \text{ kJ / mol}$

The reaction is feasible at 270K since the value of G is negative. **[8marks]**

- c)  $H_R = H_P - H_{\text{Reactant}} = -278 - (52 - 286) = -44 \text{ kJ}$ , The reaction is exothermic **[8marks]**