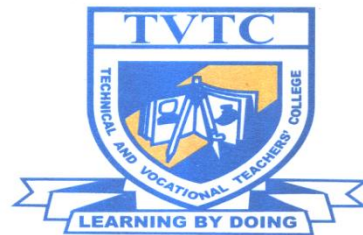




**THE COPPERBELT UNIVERSITY**

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. Global warming [3marks]
  - ii. Indoor air pollutants [3marks]
  - iii. Acid rains [3marks]
  - iv. Ozone layer [3marks]
- 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. [4marks]
- c) Suggest two ways of increasing the rate at which copper is deposited at the cathode. [4marks]

## QUESTION TWO

- a) Briefly differentiate corrosion and rusting. [2marks]
- b) Discuss two causes of corrosion and give an example. [6marks]
- c) Discuss two effects of corrosion on engineering materials and give examples [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) Define the following terms
  - i. An electrolyte [2mark]
  - ii. The cathode [2mark]
  - iii. The salt bridge [2mark]
- b) Consider a cell made of copper(+0.34V) and silver(+0.80V) and;
  - i. Draw a well labeled diagram illustrating the cell. [4marks]
  - ii. Use half reaction equations to demonstrate what is happening at the anode and cathode. [4marks]
  - iii. Deduce the overall redox equation for the cell [3marks]
  - iv. Calculate the emf of the cell. [3marks]

### QUESTION FIVE

- a) List any five applications of electrolysis [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 the meaning of Gibbs free energy [6marks]
- b) Consider the reaction below and answer the following questions.
 
$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$$
 , given that  $\Delta H^\circ = 92220kJ, \Delta S^\circ = 198.75J / K$ 
  - i. Determine if this reaction is spontaneous at 298K [8marks]
  - ii. Use the value of Gibb's energy in (i) to calculate the equilibrium at 25°C. [6marks]

### 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)  $\text{Cu}^{2+}_{(s)} + 2e^- \rightarrow \text{Cu}_{(s)}$

$$2\text{moles} \rightarrow 64\text{g}$$

$$X \rightarrow 2\text{g}$$

$$X = (2 \times 2) / 64$$

$$X = 0.0625\text{moles}$$

$$\text{time} = C / I$$

$$\text{time} = 6031.25 / 0.13$$

$$\text{time} = 46394.23\text{sec}$$

- c) Increase the current, concentration of copper ions and finding the right temperature.

## QUESTION TWO

- a) The main difference though between corrosion and rust is that corrosion occurs as a result of chemical influence and it affects a lot of materials whereas rusting is only accelerated by certain chemicals and usually affects iron substances. [2marks]

- b) Many metals corrode merely by being exposed to moisture in the air. Moisture supplies water & air supplies oxygen. This is common among steel structures. [3marks]

Stress corrosion can be the result of the crevice loads due to stress concentration, or can be caused by the type of assembly or residual stresses from fabrication (e.g. cold working); the residual stresses can be relieved by annealing or other surface treatments.

[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) In urban areas, exposure to indoor air pollution has increased due to a variety of reasons, including. Volatile organic compounds (**VOCs**) originate mainly from solvents and chemicals. The main indoor sources are perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents & wood preservatives. The main health effect is irritation of the eyes, nose and headache.

**Tobacco smoke** generates a wide range of harmful chemicals and is known to cause cancer. It is well known that passive smoking causes a lot of problems to the passive smoker.

**Charcoal:** Rural areas face the greatest risk from indoor pollution, because about 3.5 billion people continue to rely on traditional fuels such as firewood, charcoal, and cow dung for cooking and heating. Such fuels produce large amounts of smoke and other air pollutants in the confined space of the home.

**Paints:** Interior wall paints are recognized as a significant source of VOCs in the indoor environment. The main indoor air quality concern from paints is the release of total volatile organic chemicals (TVOCs), many of which are irritants or odorants, and can present other toxic exposure concerns. Actual chemicals released by paints depend on their chemical formulation.

- b) Metals such as arsenic, Lead, Cadmium, Nickel, Mercury, Chromium, and Cobalt are termed as heavy metals because of their high atomic mass numbers. These metals are toxic even at low concentrations.

### QUESTION FOUR

- a) Definition of the terms;

- i. An electrolyte is a substance that when in molten form can conduct electricity and be decomposed by it.
- ii. The cathode is the electrode at which reduction occurs.
- iii. The salt bridge is a material that allows electrons to flow without extensive mixing of the solutions in the half cells.

b) Electrochemical cell

- i. Draw a well labeled diagram showing the anode, cathode, salt bridge, direction of the electron/ion flow and the voltmeter.
- ii. Half equations

At the anode oxidation takes place:  $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^{-}$

At the cathode, reduction takes place:  $Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}$

- iii. Add the two half equations:  $Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$
- iv. Emf of the cell:

$$E_{cell} = E_{rhs} - E_{lhs}$$

$$E_{cell} = 0.8 - 0.34$$

$$E_{cell} = 0.46V$$

## QUESTION FIVE

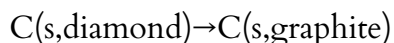
a) Application of electrolysis

- i. **Manufacture of compounds:**  
Compounds like NaOH, KOH,  $Na_2CO_3$ ,  $KClO_3$ , white lead,  $KMnO_4$ , etc., are manufactured by electrolysis.
- ii. **Electroplating:**  
The process of coating an inferior metal with a superior metal by electrolysis is known as electroplating.
- iii. **Manufacturing of Non-Metals**  
Non-metals like hydrogen, fluorine, chlorine are obtained by electrolysis.
- iv. **Electro-refining of metals:**

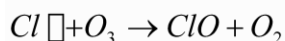
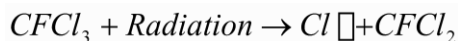
This is the process of refining the metal. i.e. removing impurity from metal by the use of electrolysis method. The metals like copper, silver, gold, aluminum, tin, etc., are refined by electrolysis.

v. In the determination of *equivalent mass*.

- b) 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:



- c) The Main Ozone-Depleting Substances (ODS) are: Chlorofluorocarbons (CFCs). They are used as coolants in refrigerators, freezers and air conditioners in buildings and cars manufactured before 1995. When these CFCs enter the air, they rise up into the atmosphere to meet up with and destroy ozone molecules.



- d) Inorganic compounds may consist of heavy metals and toxic elements (e.g., lead, mercury, chromium, arsenic, etc.) in pure form or combined with other elements. These compounds exist primarily in the solid phase, but can also exist at ambient temperatures in the gas phase if finely divided or have a high vapor pressure (e.g., mercury, hydrogen sulfide) or the liquid phase if water soluble. In general the undesirable (e.g., toxic or hazardous) nature of these compounds stems from the element(s) they contain rather than their structure.

## 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 [**6marks**]

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

$$\Delta G = -9240 - 298(0.19875)$$

b)  $\Delta G = 9180.77 \text{ kJ/mol}$

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

ii. Using the relationship,

$$\Delta G = -RT \ln K$$

$$9180.77 = 8.314 \times 298 \ln K$$

$$\ln K = 9180.77 / 2477.572$$

$$\ln K = -3.7055$$

$$K = 0.0246$$