



**GWANDA STATE UNIVERSITY**  
**FACULTY OF ENGINEERING AND THE ENVIRONMENT**  
**DEPARTMENT OF METALLURGICAL ENGINEERING**  
**CORROSION ENGINEERING**  
**EMG3207**  
**Part III Examination Paper**  
**APRIL 2024**

This examination paper consists of 3 printed pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Examiner : Mrs Siqiniseló Maphosa**

**INSTRUCTIONS**

- 1. Answer any 4 questions**
- 2. Each question carries 25 marks**
- 3. Use of calculators is permissible**

### Question 1

- a) Compare cathodic and anodic protection, in your comparison include mechanisms, effectiveness and limitations in different environments. [8]
- b) Define and explain including causes, mechanisms and prevention the following forms of corrosion
  - i) Crevice corrosion [6]
  - ii) Corrosion fatigue [6]
- c) Discuss using an example of conditions present on a buried steel pipeline in contact with both soil and water how a differential environment affects corrosion [5]

### Question 2

Make a cross section sketch showing the section through a crevice explaining and showing the movement and accumulation of chemical species within the crevice corrosion cell. Write down the electrochemical reactions occurring and discuss preventative measures that can be used in engineering applications. [25]

### Question 3

- a) Zinc is an amphoteric element which means it can be oxidised or reduced. Draw the Pourbaix diagram of zinc in water. On the diagram identify the various regions and indicate where corrosion occurs, passivity region and the immunity region. Use the diagram to explain how you would prevent zinc from corroding in a galvanic cell setup. [12]
- b) Give and explain the limitations of a Pourbaix diagram [6]
- c) When zinc is placed into sea water with around 3.5% dissolved salt and a pH of around 8.8 it corrodes quite fast but when you place the zinc in a dry place such as on the roof of a building it corrodes slowly. Explain why that is so. [7]

### Question 4

A steel coupon with an anode surface area of  $2000 \text{ cm}^2$  is placed in an electrolyte. The corrosion current is measured to be 2 mA. (Assume valence of 2, Atomic mass Fe= 55.85)

- a) What mass of steel will be lost in 3 hours? [5]
- b) What is the corrosion rate in  $\mu\text{g}/\text{cm}^2/\text{day}$ ? [4]
- c) Discuss the significance of corrosion testing including factors that affect test accuracy and reliability. Describe two laboratory methods used for testing corrosion in metals. [12]

- d) Explain the basic concept of adhesive wear. include discussions on the mechanisms of adhesion, surface roughness, lubrication, material properties, and wear mechanisms in different contact conditions. [4]

### Question 5

- a) Calculate what the theoretical remnant mass of a flat piece of steel with dimensions 500mm by 400mm by 10mm will be if it is left lying in aerated seawater for 35 years when a short-term laboratory test of a similar sized piece of steel produced a steady 100 $\mu$ A of current while it corroded. Faradays law:  $W=Zit/nF$ ,  $Z=56\text{g/mol}$ ,  $F= 96500 \text{ C/mol}$ . SG steel =7.8 [10]
- b) Had the current in the lab test been found to be 200  $\mu$ A, will there still be some steel left after 35 years? (show calculations) [4]
- c) If the laboratory current was measured at 0,5mA what would the corrosion rate in microns per year (mpy) be of the steel exposed to the seawater now be? Convert this rate to the US American units of mills per year [6]
- d) A piece of steel is immersed in an aqueous solution of 3.5% (m/v) NaCl and it starts to corrode. Explain by means of a sketch the corrosion process that occurs on the surface of the steel. Label your sketch and give one example of electrochemical half reactions that take place at the various sites on the immersed steel surface. What can fundamentally be done to influence the corrosion rate [5]