



GWANDA STATE UNIVERSITY
FACULTY OF ENGINEERING AND THE ENVIRONMENT
DEPARTMENT OF METALLURGICAL ENGINEERING
CORROSION AND WEAR
EMR 5203
Part V Examination Paper

This examination paper consists of 4 printed pages

Time Allowed: 3 hours

Total Marks: 100

Examiner : S. Maphosa

INSTRUCTIONS

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

ADDITIONAL MATERIALS

- 1. Data booklet**
- 2. Calculator**

Question 1

- a) Compare cathodic and anodic protection [8]
- b) Define and explain the following forms of corrosion
 - i) Crevice corrosion [6]
 - ii) Corrosion fatigue [6]
- c) Explain how a differential environment affects corrosion [5]

Question 2

- a) What is wear of an engineering solid? How is it different than erosion? [5]
- b) Differentiate between
 - i) Abrasive and adhesive wear [4]
 - ii) Fatigue wear and corrosive wear? [4]
- c) Explain the mechanism of fretting wear that takes place in movement of two solid surfaces. List the causes and remedial action for fretting wear [6]
- d) Explain the concept of passivity with neat sketches and comment about I_{corr} and E_{corr} with their significance.[6]

Question 3

- a) Discuss the properties and applications of any three nickel based alloys used for wear resistance applications.[9]
- b) Calculate the corrosion rate in mm per year of iron which immersed in sea water produces a current of 0.5 A m^{-2} . Density of iron is 7.9 g cm^{-3} [4]
- c) Zinc experiences corrosion in an acid solution. The rates of both oxidation and reduction half-reactions are controlled by activation polarization.
 - i) Compute the rate of oxidation of Zn (in $\text{mol/cm}^2 \cdot \text{s}$) given the following activation polarization data [6]

$$\begin{aligned}E_{(Zn/Zn^{2+})} &= -0.763 \text{ V} \\i_o &= 10^{-7} \text{ A/cm}^2 \\ \beta &= +0.09\end{aligned}$$

$$\begin{aligned}E_{(H^+/H_2)} &= 0.0 \text{ V} \\i_o &= 10^{-10} \text{ A/cm}^2 \\ \beta &= -0.08\end{aligned}$$

For hydrogen reduction

$$E_H = E_{rev.(H^+/H_2)} + \beta_H \log\left(\frac{i}{i_{oH}}\right)$$

And for Zn oxidation

$$E_{Zn} = E_{rev.(Zn/Zn^{+2})} + \beta_{Zn} \log\left(\frac{i}{i_{oZn}}\right)$$

- ii) Compute the value of the corrosion potential given

$$E_{Corr} = E_{H^+/H_2}^o + \beta_H \log\left(\frac{i_{Corr}}{i_{oH}}\right)$$

[6]

Question 4

- a) Describe the principles and procedure of chemical vapour deposition (CVD) method as a technique used to enhance wear resistance in detail. Also list their applications, advantages and disadvantages. [10]
- b) Naval supply replenishment vessels transfer equipment and supplies to military ships in service while allowing for the relative motion of the ships. They employ high horsepower continuous slip air clutches to control the tension of connecting cables between the ships to allow for motion of the seas and relative movement of the vessels.

The drums became unreliable and subject to significant wear.



Figure 1: Continuous slip air clutches

As a metallurgical engineer suggest a solution to prevent or reduce significant wear on the above [6]

c) State and explain THREE factors that influence the wear of steel [9]

Question 5

- a) Iron is corroding in seawater at a current density of $1.69 \times 10^{-4} \text{ A/cm}^2$. Determine the corrosion rate in (a) mdd (milligrams per decimeter² day) (b) ipy (inches per year) (density for Iron = 7.86) [10]
- b) An electronic device substrate is to be coated with 10 micron thick ceramic coating. Suggest a suitable technique for this application and discuss the process briefly. [15]