MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: ENGINEERING MATERIALS
CODE: CHEP 102

SESSIONAL EXAMINATIONS
SEPTEMBER 2021

DURATION: 3 HOURS

EXAMINER: MR M. MAPOSA

INSTRUCTIONS

1. Answer **all** questions in section A

2. Answer three questions in section B

3. Each question carries 25 marks

4. Total marks 100

ADDITIONAL MATERIAL
Periodic table

SECTION A

*Answer **all** questions in this section*

QUESTION 1

(a) List any two consequences of corrosion [2 marks]

(b) Describe the following terms as applied to corrosion chemistry

   i)   Passivation

   ii)   Polarization

   iii)   Pitting

   iv)   Inhibitor

   v)   Galvanic cell [5 marks]

(c) Distinguish fully between

   i)   dry corrosion and wet corrosion

   ii)   stress and strain

   iii)   interstitial alloys and substitutional alloys [6 marks]

(d) Give any two advantages and one disadvantage of

   i)   Cold working

   ii)   Heat treatment in metallurgy [4 marks]

(e) Sketch a stress-strain graph to show how temperature affect creep rate [3 marks]

(f) A sheet of carbon steel one meter wide by three meter long has lost 40 g to corrosion over the past six months. Convert that mass loss to a penetration rate of the steel in mm units. What would be the total corrosion current associated with such a corrosion rate? (carbon steel density $= 7.8$ g/cm^3) [5 marks]

SECTION B

Answer any three questions in this section

QUESTION 2

a) Using examples of your choice, briefly describe the following structural failure methods

   i)   Fatigue failure

   ii)   Creep failure

   iii)   Hydrogen embrittlement

   iv)   Corrosion fatigue

   v)   Stress corrosion cracking   [20 marks]

b) A certain alloy used to make coins comprises of copper and zinc. The alloy has a density of 8.31 g/cm^3. Given that the densities of copper and zinc are 8.97 g/cm^3 and 7.14 g/cm^3 respectively, calculate the percentage composition of the alloy.   [5 marks]

QUESTION 3

a. State the **three** categories of corrosion giving one example for each

                                                                      [6 marks]

b. With the aid of a well labelled Pourbaix diagram show the potential- pH domains under which iron is under various forms of corrosion, passivation and immunity.

                                                                      [5 marks]

c. Describe two strengths and three limitations of the use of Pourbiax diagram in the study of corrosion and corrosion prevention   [5 marks]

 d. Laboratory tests carried out on three alloys produced results shown in Table 1

Table 1			
Material	Density of Material (g/cm^3)	Weight loss (gmd)	Pitting Factor
A	2.5	30	1
B	8.0	50	2
C	6.5	4.5	2

Calculate maximum penetration in millimeter for each material at the end of two years   [9 marks]

QUESTION 4

(a) Write brief notes on each of the following processes

i)   annealing

ii)   tempering

iii)   hardening

iv)   normalising   [8 marks]

(b) Describe any **three** ways in which phase diagrams are useful in the study, production and use of alloys   [6 marks]

(c) With the aid of well labelled sketch diagrams distinguish between fatigue curve and creep curve highlighting the circumstances leading to failure in each case   [6 marks]

(d) Water entering a steel pipeline at the rate of 45 liters per minute contains 5.80 ml O_2 per liter (at 25 ^{0}C ad 1 atm). Water leaving the pipe contains 0,16 ml O_2 per liter. Assuming that all corrosion is concentrated at a heated section of area 32 m^2 forming iron (lll) oxide: Fe_2O_3, what is the corrosion rate in gmd and in mmy?   [5 marks]

QUESTION 5

(a) What are the major differences between activation and concentration polarisation? [3 marks]

(b) Give the three-step mechanism for activation polarisation [3 marks]

(c) Under what conditions is

    i)   Concentration polarisation rate determining [3 marks]

    ii)   Activation polarisation rate determining [3 marks]

(d) A piece of corroded steel plate was found in a submerged ocean vessel. It was estimated that the original surface area of the plate was 12 m^2 and that approximately 2.7 kg had been corroded away during submersion. Assuming that a corrosion penetration rate of 200 mpy for this alloy, estimate the time of submersion in years. Density of steel is 7.9 g/cm^3 [5 marks]

(e) Explain how the following methods protect materials from excessive corrosion

    i)   Use of inhibitors

    ii)   Cathodic protection

    iii)   Anodic protection

    iv)   Alloying [8 marks]

END OF EXAM