NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF CIVIL, MINING AND PROCESS ENGINEERING

QUALIFICATION: BACHELOR OF ENGINEERING IN METALLURGY	
QUALIFICATION CODE: 08BMET	LEVEL: 8
COURSE CODE: CEN810S	COURSE NAME: Corrosion Engineering 414
SESSION: June 2023	PAPER: 2
DURATION: 2 HOURS	MARKS: 70

SECOND OPPORTUNITY PAPER	
EXAMINER(S)	Prof D Groot
MODERATOR:	Prof J van der Merwe, University of the Witwatersrand

INSTRUCTIONS

1. Answer all questions.
2. Read all the questions carefully before answering.
3. Marks for each question are indicated at the end of each question.
4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.
2. Scientific calculator, non-programmable

THIS PAPER CONSISTS OF 4 PAGES (Including this front page)

Question 1

Passivation plays an important role in corrosion of metals and alloys.

(a) Describe the behaviour of an "active-passive" metal when a fresh surface is exposed to a corrosive environment. Draw a schematic Evans diagram to illustrate your discussion, labelling the various regions on the diagram. Indicate important potentials and current densities. [10]

(b) Give an example of such a metal or alloy. [1]

Question 2

The formation of mill scale during certain processing of e.g. steel profiles is considered a form of corrosion.

(a) Compare this type of corrosion to the other broad class of corrosion mechanisms, and discuss how this type may be modeled. [7]

(b) Discuss the effect of metal oxide volume on the protective ability of an oxide layer on a metal. [8]

Question 3

Intergranular corrosion (IGC) is a localised corrosion that occurs at or near the grain boundaries in a metal or alloy.

(a) State at least three general factors that can cause this type of corrosion. [3]

(b) State what the main preventative measures against IGC are that you can take during the metal alloying stage. [2]

Question 4

Consider an unpainted mild steel item exposed to the atmosphere. After some time, examination of the piece shows general corrosion. *Hint: keep in mind the practical experiment you did.*

Explain, in terms of the basic aqueous corrosion cell, how this type of corrosion has occurred. [9]

Question 5

A brass (copper-based alloy) fitting used in a marine application is joined by soldering with lead-tin solder. This application is used even in fresh water plumbing systems.

(a) Do you expect corrosion to occur? Explain your answer. [3]

(b) Explain the advantages and disadvantages of this type of joining. [2]

Question 6

Cathodic protection may be achieved by the use of an impressed current from an electrical source, or by the use of sacrificial anodes. Discuss the merits and demerits of sacrificial anodes approach. [6]

Question 7

Consider a pipeline made of high strength steel, carrying a flow of seawater to a desalination plant. One part is encased in concrete, running into the sea. The rest is buried in moist soil, running to the plant. At the plant it is connected via bolted flanges to an electrical pump. The pump housing is a casting in naval brass.

(a) Is stress corrosion cracking likely, in your opinion? Explain your answer. [3]

(b) What (other) type(s) of corrosion may be expected in this situation? What could be done to manage the problem(s)? [9]

Question 8

Consider a concentration cell made up of two Zn electrodes. One is immersed in a deaerated $ZnSO_4$ solution at 0.2 mol/l, and the other in a deaerated $ZnSO_4$ solution at 0.6 mol/l.

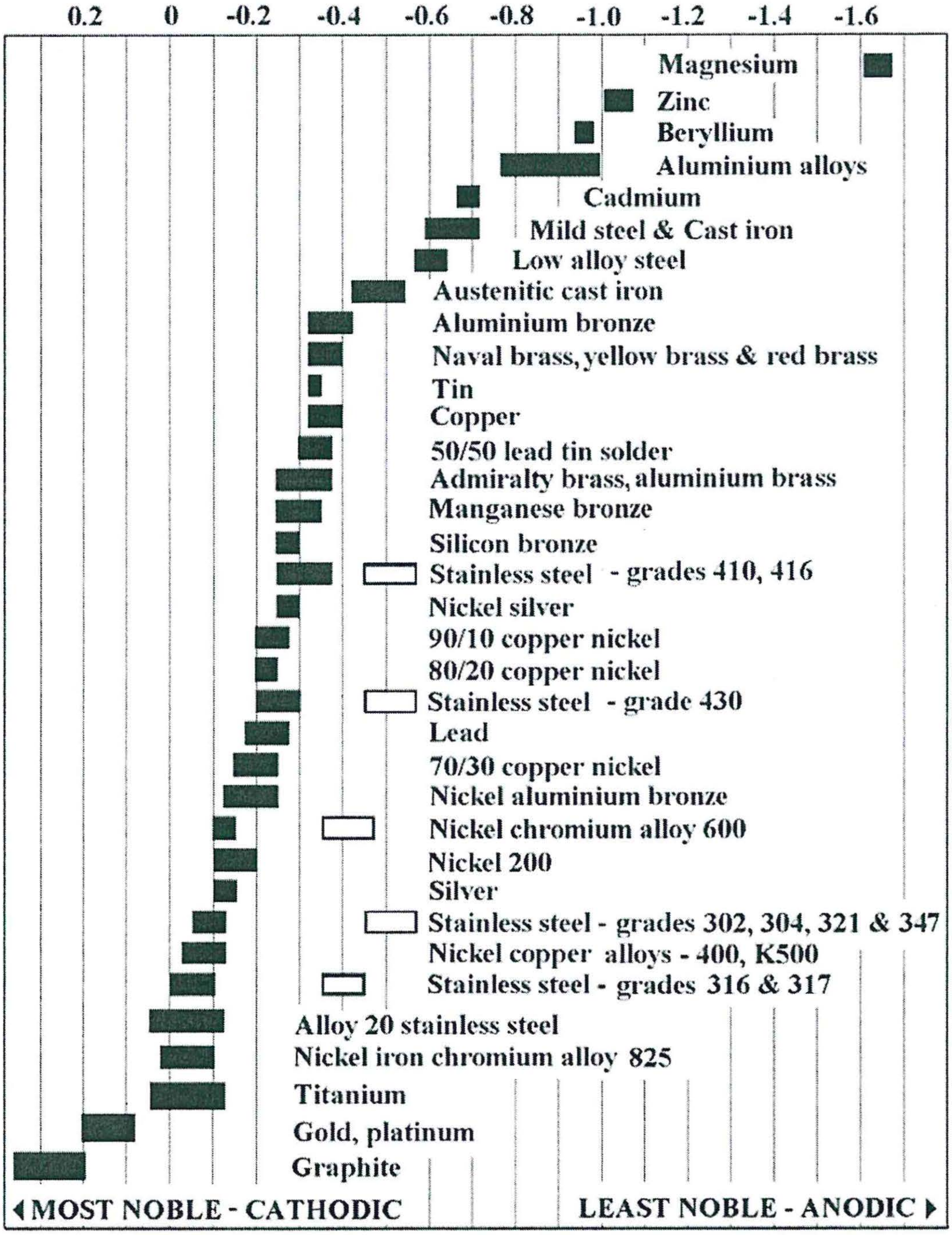
(a) Calculate the cell potential. [3]
(b) State which electrode is the anode and explain why. [2]
(c) State your assumptions. [2]

Given information

$i = i_0 [\exp(\alpha\eta zF/RT) - \exp((1-\alpha)\eta zF/RT)$ $E = E^0 - (0.059/n) \log([\text{product}] / [\text{reagent}])$
$\eta = b \log(i/i_0)$ $\eta = a_a + b_a \log I$ F = 96 485 Coulomb/mol $\Delta G = -nFE$
$a_a = -2.303 (RT/(\alpha nF)) \log i_0$ $b_a = 2.303 (RT/(\alpha nF))$
E^0 for Cu^{+2}/Cu = 0.337 V; H^+/H_2 = 0.000 V; Fe^{+2}/Fe = -0.440 V; Zn^{+2}/Zn = -0.763 V; Ag^+/Ag = 0.799 V

Electrode	Solution	j_0 (A/cm^2)	b_c (mV/dec)	b_a (mV/dec)
For reaction	$2H^+ + 2e \rightarrow H_2$			
Pt	1 M HCl	10^{-2}	30	
	0.1 M NaOH	0.7×10^{-3}	110	
Au	1 M HCl	10^{-5}	50	
Ag	0.1 M HCl	0.15	100	100
Fe	0.26 M H_2SO_4	2×10^{-5}	110	
Cu	0.1 M HCl	2×10^{-6}	120	
Zn	0.5 M H_2SO_4	2×10^{-10}	120	
Pb	1 M HCl	2×10^{-12}	120	
For reaction	$Cl_2 + 2e \rightarrow 2Cl^-$			
Pt	1 M HCl	5×10^{-3}	110	130

Galvanic series in seawater



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