

Q1. Select the letter (a, b, or c) that corresponds to the correct answer:

(27 marks)

1. High velocity of corrosive medium through a pipe may have the effect of:
a) removal of metal ions from inner pipe surface thus causing pitting
b) depositing of suspended particles thus causing irregular surface
c) forming passive film that may help protecting the pipe
2. Corrosion rate of metal is higher in aerated aqueous solution compared to deaerated aqueous solution. This is because:
a) oxygen with react rapidly with metal at the anode surface.
b) exchange current density of oxygen is higher than that of hydrogen
c) overpotential of oxygen evolution is higher than that of hydrogen evolution.
3. Thiosulfate, Cl⁻, Br⁻ and I⁻ ions are responsible for much of the:
a) aluminum alloys cracking b) steel pitting c) passive film formation in stainless steel
4. Failure of distillation columns in refineries is an example for:
a) galvanic corrosion b) stress corrosion cracking c) uniform attack corrosion
5. Best control option for underground metal pipes corrosion is:
a) addition of chemical inhibitors b) paint coating c) electrical protection
6. What will happen when joining a plastic pipe to steel main pipe:
a) stress corrosion cracking b) crevice corrosion c) no corrosion
7. Graphitization of grey cast iron is an example of:
a) intergranular attack on iron
b) selective leaching of alloy metal (Fe) c) loss of carbon (graphite)
8. The reaction at metal surface: $3\text{Cu} + 2\text{Na}_3\text{PO}_4 = \text{Cu}_3(\text{PO}_4)_2 + 6\text{Na}$, occurs when:
a) anodic inhibitor is added to corrosive medium b) cathodic inhibitor is added to corrosive medium
c) copper oxidizes (corrodes) due to the corrosive medium of sodium phosphate
9. A bimetallic plate-couple (steel and aluminum) is exposed to seawater. You better paint (coat) all surfaces; but if you are allowed to paint only one metal, what do you choose?
a) steel (anode) b) steel (cathode) c) aluminum (anode)
10. Widely used in transport of acids and corrosive chemicals in metal containers:
a) inhibitive coating b) anodic protection c) cathodic protection
11. If steel rivets are fixed in a copper plate, what will happen after few months of exposure to non-polluted, non-industrial atmosphere:
a) no corrosion will occur.
b) plate will slightly corrode c) rivets will completely corrode
12. Why a bi-metallic couple with an unfavorable area ratio (small anode/ large cathode) corrodes faster than a couple with large anode and small cathode?
a) high anodic current density
b) high cathodic current density c) no protective passive film will be formed.
13. Will not significantly corrode equipment made of steel:
a) H₂SO₄ (conc.) b) H₂SO₄ (dilute) c) rain and snow
14. What is the importance of sodium and ammonium sulfite in electrochemical corrosion?
a) They form corrosive solutions to stainless steel b) they are mixed inhibitors.
c) they react with dissolved oxygen and deaerated the corrosive media
15. The optimum cost for protection of underground pipes is determined by the:

- a) maximum cost of butyl rubber tape coat b) percentage of pipe covered by the coat
c) minimum total cost of both coating and cathodic protection
16. The following is an example for resistance polarization (η_{Res}) in metal corrosion applications:
a) protective coat over metal b) Nernst diffusion layer c) charge transfer at the anode
17. Which expression is *incorrect*?
a) stress corrosion cracking occurs to brass alloy in NH_3 solution
b) Pitting is common to brass in salt (chloride) solutions
c) brass corrodes by selective leaching of Zn if Cu <85%
18. Corrosion of metal in acid results in $H_2(g)$ evolution. Which expression is correct?
a) activation polarization of gas is directly proportional to exchange current density of the gas
b) i_o for H_2 evolution is higher over Fe compared to Zn
c) Zinc is a good catalyst for H_2 evolution

Q2. Write the equations needed and show all calculation steps to find the following parameters:

(5 marks)

- a) A sheet of zinc (48 cm long and 12 cm wide) has lost 7.5 grams to corrosion in 120 days. What is the corrosion rate (r , mg/cm²/day)? (Take zinc metal density = 7.13 g/cm³)
- b) For the case above, what is the penetration rate (r_p , cm/year)?

Q3. On your answer paper, make a Table like the one below to organize your answers:

- A. Give three possible problems in the design of liquid containers that cause corrosion. Indicate the type of corrosion resulted in each case.
- B. Give three possible problems in the use of joints (in metallic equipment and structures) that cause corrosion. Indicate the type of corrosion in each case.

(9 marks)

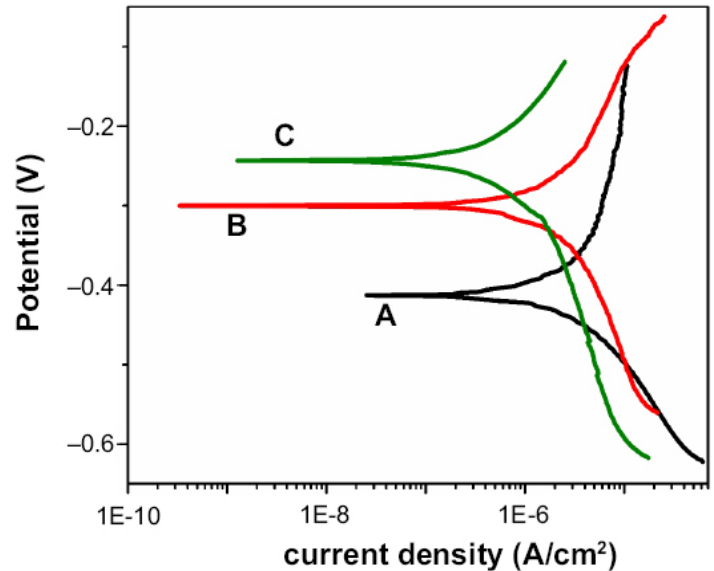
#	A. LIQUID CONTAINERS	
	Problem	Corrosion Type
1		
2		
3		
#	B. JOINTS	
	Problem	Corrosion Type
1		
2		
3		

Q4. Obtain the best estimate of the required values from the graph (next) in the following **three different cases** regarding electrochemical corrosion: **(9 marks)**

Case (I): Assume A, B & C represent different pH values of an acidic medium containing a metal alloy. Give the values of corrosion current density i_{corr} (A/cm^2) and corrosion potential, E_{corr} (V), for the most corrosive conditions.

Case (II): Assume A, B & C represent different temperatures of the corrosive medium containing a metal alloy. What is *percent reduction in corrosion current density* when the solution temperature is reduced from “A” to “B”?

Case (III): Assume A, B & C represent stainless steel alloys with different weight percents of chromium (Cr). What alloy has the highest Cr content AND what alloy has the least resistance for electrochemical corrosion?



Tabulate your answers by filling in the appropriate blank spaces as follows:

ملاحظة: نفس الرسم تم استخدامه لثلاث حالات مختلفة (ثلاث اسئلة منفصلة) بتغيير تسمية الرموز A, B, C

Case (I)	$i_{\text{corr}}, \text{A}/\text{cm}^2 = \dots\dots\dots$	$E_{\text{corr}}, \text{volt} = \dots\dots\dots$
Case (II)	$i_{\text{corr}}, \text{A}/\text{cm}^2 = \dots\dots\dots$	% Reduction = $\dots\dots\dots$
Case (III)	Alloy with highest Cr content $\dots\dots\dots$	Alloy with least resistance for corrosion $\dots\dots\dots$

Wish you all success ...