

National Exams May 2019

16-Chem-B12, Corrosion and Oxidation

3 hours duration

**NOTES:**

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.
3. Any non-communicating calculator is permitted.
4. Eight (8) questions constitute a complete exam paper.
5. Each question value is indicated in the left column.
6. Clarity and organization of the answer are important.

- /10 1. A cell is composed of a pure copper and pure lead electrode immersed in solutions of their bivalent ions. For a 0.3 molar concentration of  $\text{Cu}^{2+}$ , the lead electrode is oxidized and shows a potential of 0.507 V. What would be the concentration of Pb ion at 25°C?
- /10 2. The value of  $i_{\text{corr}}$  obtained for iron corroding in an aqueous solution (electrolyte) by the Tafel extrapolation technique is  $3.74 \times 10^{-4} \text{ A/m}^2$ . Find the rate of corrosion in (a) mm/year and (b) mdd
- /10 3. Suppose that a buried steel structure is to be cathodically protected using a rectifier capable of delivering 1 volt and 5 amperes through the wiring system. Assume that the soil resistance is 80% of the external resistance. Calculate a) the soil resistance when the anode bed is 4-meter long, and 0.10-meter in diameter and b) the current density.
- /10 4. An engineer at the processing plant suggests substituting 50%  $\text{H}_2\text{SO}_4$  in their operation instead of the 95%  $\text{H}_2\text{SO}_4$  that was always used. Briefly, his reasons are (1) yield will not be substantially changed; (2) production will decrease 20%, but at the present time we have 50% more capacity than we need; (3) lower cost of the dilute acid will achieve a saving of \$10,000/year; and (4) corrosion of the steel reaction tank and piping will be reduced. The idea looks good to us but the manager thought we should check with you on item 4, since you're supposed to know something about corrosion.
- /10 5. We have a vertical cooler lined with 330 brass that some moron claimed was corrosion resistant. The cooler contains HCl vapor and a little air at temperatures up to 150°C. The brass doesn't seem to be pitted or etched but it's cracked at every sharp bend, letting the gas through to the steel shell. It is probably news to you, but HCl eats the hell out of steel. We're going to have to shut down for repairs or relining before the whole cooler comes down. Can we braze the cracks? Do we have to replace it? With what? We need an answer now.
- /10 6. An engineer had a large pump made of Alloy 20 that failed very quickly from corrosion. He now plans to order a Hastelloy B pump, but I think you should look at the situation because these pumps are very expensive. The solution being pumped is 35%  $\text{H}_2\text{SO}_4$  well aerated, at room temperature. If Hastelloy B seems reasonable, let me know soon because we've got to place the order.
- /10 7. A solution of 80% phenol with some amylene, sulfuric, and sulfurous acids at 100-110°C (212-230°F) has cracked a 316 stainless steel digester. What could we line it with?
- /10 8. How would you go about selecting an inhibitor for cast iron municipal water mains? Answer: Forget it. (1) Cast iron corrodes very slowly in water; (2) citizens only tolerate additives in their drinking water for health reasons, and reluctantly even then; (3) the expense of inhibiting all that water would be prohibitive.