1995 December 13

CHE 5824 CORROSION PROCESSES

Final Exam

- Three hours, closed book.
- Attempt all questions.
- Hand calculators may be used for computation - NOT for storage of information pertinent to this course and exam.
- Marks will be lost if sketches and diagrams are poorly presented.

Data

Atomic weights
Fe = 55.9, O = 16.0, H = 1.0

QUESTION 1

Referring to the attached Pourbaix diagram for cobalt, respond to the following:

(i) explain lines (a) and (b), and derive the equations to describe them;

(ii) describe the behaviour of cobalt newly immersed in nominally pure acid at pH 0;

(iii) give the narrowest range of potentials that you can define to encompass that of a corroding specimen of cobalt immersed in an aqueous solution of its ions at a concentration of 10^{-4} g-ion/L and a pH of 2;

(iv) describe what happens if the pH of the solution in (iii) above is made neutral;

(v) describe the corrosion behaviour of cobalt in aqueous solution at pH 11 and pH 14.

(12 marks)

Question 2

Using sketched curves such as would be obtained from Butler-Volmer expressions for typical coupled anodic and cathodic reactions, show qualitatively how you would construct an Evans diagram of E vs. log i to illustrate the corrosion of iron in aerated sea water.

If the cathodic reaction in the above example is mass-transfer controlled, use the Evans diagram to illustrate the effect of increasing agitation on the corrosion potential and the corrosion rate.

(10 marks)

Question 3

Sketch a simple cell equipped with a three-electrode circuit that could be constructed to determine the polarization behaviour of a passivating metal such as stainless steel in aerated sea water. What would the anodic and cathodic arms of a typical polarization curve look like? Indicate the Flade potential, the active and passive corrosion regions and the transpassive region on the former, and show how mass transfer control would alter the shape of the latter.

(9 marks)

Question 4

What is a common cause of IGA (inter-granular attack) of stainless steel, and how can it be avoided?

Explain how the sensitization of stabilized stainless steels can be avoided by appropriate heat treatment.

(9 marks)

Question 5

Compare and contrast the mechanisms of crevice corrosion and pitting.

(9 marks)

Question 6

Indicate, with sketches, how you would protect from corrosion:

(i) a buried natural gas pipeline of carbon steel passing through ~1000 km of varied terrain in a temperate climate with moderate rainfall;

(ii) the carbon-steel water-box areas and Al-bronze tube sheets of a sea-water-cooled condenser tubed with titanium.

(8 marks)

Question 7

Describe the different mechanisms of action and major applications of the following treatments for carbon steel:

(i) chromium plating;

(ii) galvanizing;

(iii) tin plating;

(iv) cadmium plating.

(8 marks)

Question 8

A carbon steel corrosion coupon is machined as a disc, 1.5 cm diameter, from sheet material 1.2 mm thick. A 1.1 mm hole is drilled through the disc at a distance of 4 mm from the centre for mounting purposes.

The coupon is weighed, then suspended by a nylon thread in an aqueous process stream for 1500 h, after which it is weighed again.

A descaling treatment consisting of exposure to inhibited organic acids for 15 minutes is applied, after which the coupon is weighed again. A 1 cm-square "blank" coupon, made from the same sheet material, loses 0.0027 g during the descaling.

If the weights of the corrosion coupon are as follows:

before exposure 1.6534 g

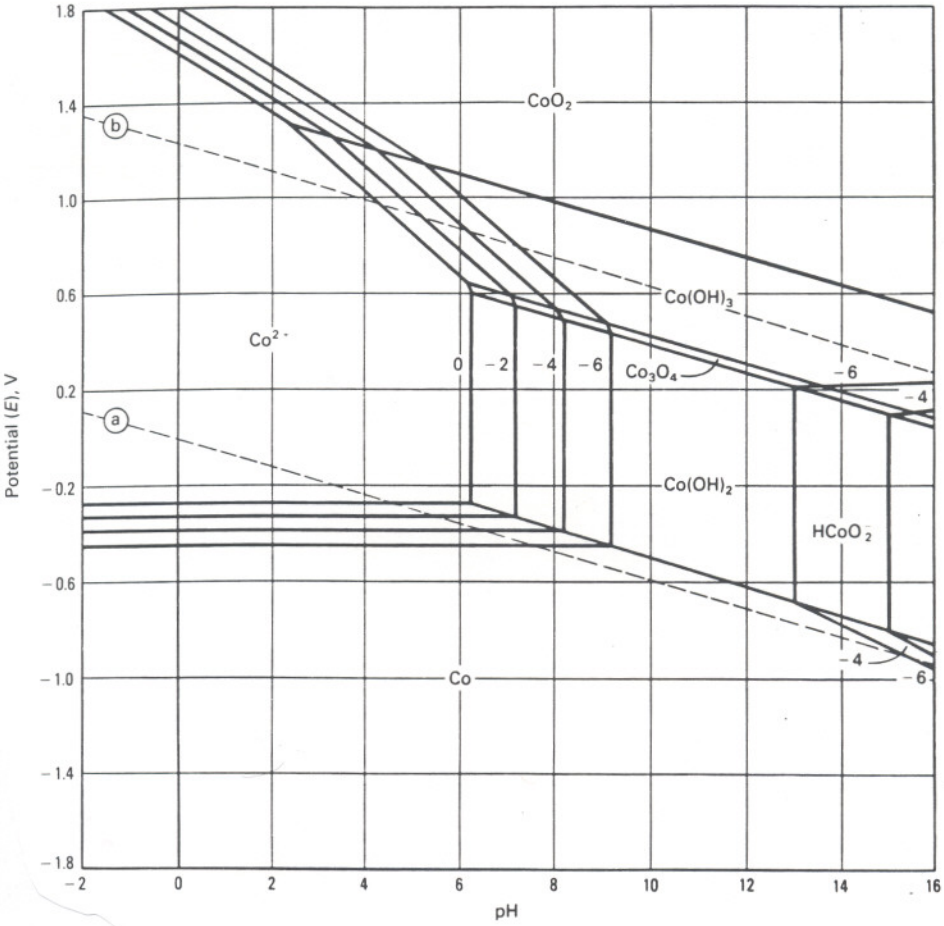
after exposure 1.6417 g

after descaling 1.6279 g

compute the total corrosion in $mg.dm^{-2}$ and μm penetration, and the average corrosion rate in mdd and $\mu m.a^{-1}$.

If the scale has the average composition $(Fe_2O_3)_3\ (FeOOH)_2$, what can you say about the amount of material lost or gained during the exposure?

(10 marks)



E-pH diagram for cobalt