Q.1 A titanium-6Al-4V (Grade 5) alloy (density = 4500kg/m^3) was assessed under erosion-corrosion conditions. The surface area of the sample was 50cm^2. The total volume loss of the material was 0.9mm^3 after 1 hour. The volume loss measured after cathodic protection was applied was 0.55mm^3. Use the potentiodynamic polarisation curves (provided in Figure Q1), chemical composition and atomic mass (provided in Table Q1) to evaluate the pure corrosion damage in static and erosion-corrosion conditions. Calculate the damage associated with corrosion-enhanced erosion and erosion-enhanced corrosion.

The anodic dissolution reaction for titanium is: $Ti \rightarrow Ti^{2+} + 2e^-$

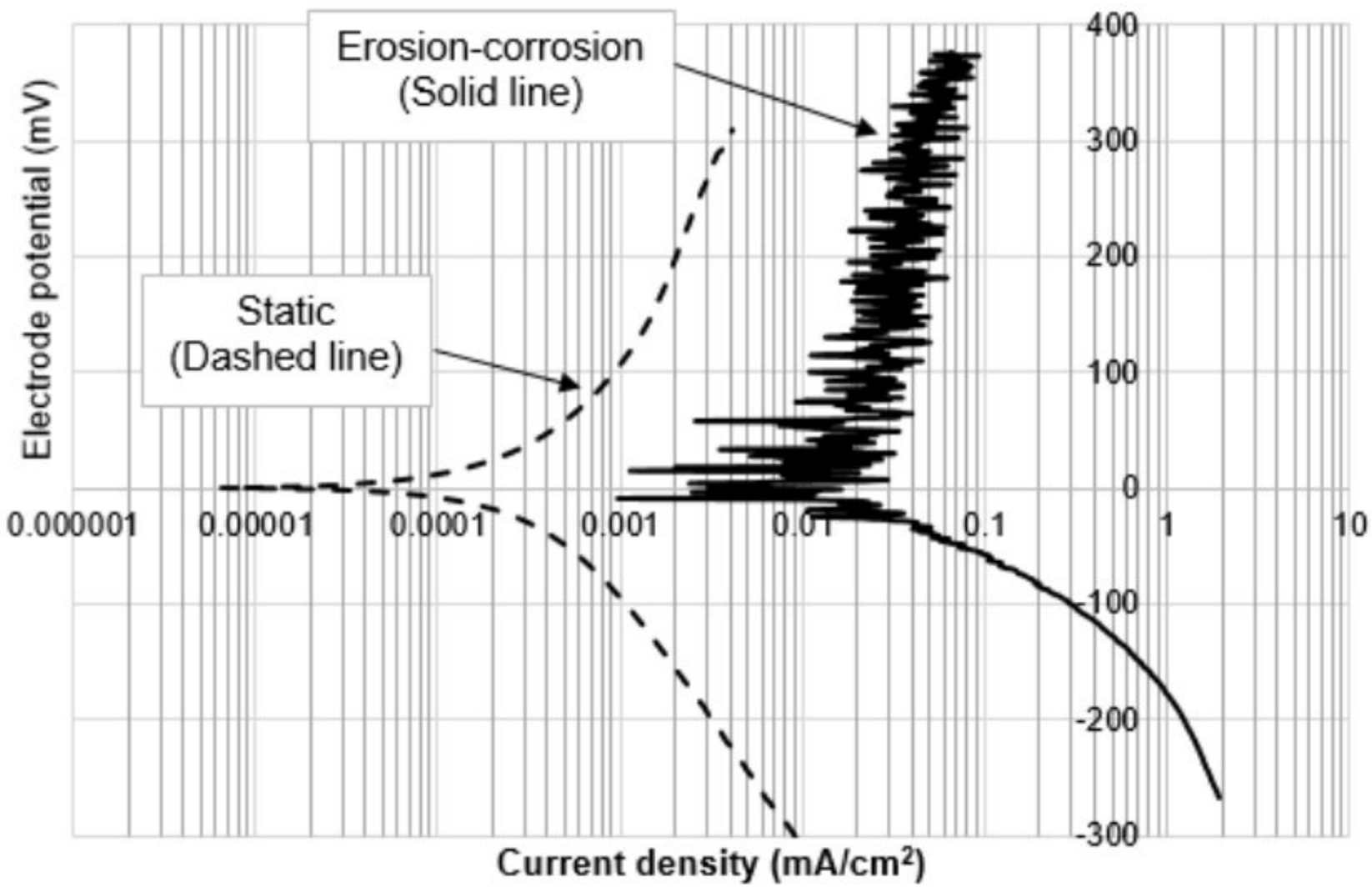

Figure Q1.

Table Q1. Chemical composition and atomic mass for Ti-6Al-4V

Element	Al	V	C	O	Fe	Ti
%wt.	6	4	0.1	0.2	0.3	Bal.
Atomic mass (g/mol)	27	51	12	16	56	48

(25 marks)

Q.2 A fluid handling equipment made from a copper-nickel alloy operating in the offshore industry is experiencing premature failures. The equipment has to handle a 3.5%NaCl aqueous solution with dissolved oxygen and operates at 6-10m/s. Suggest four methods which could be used increase the lifetime of the component. Explain the rationale for each suggestion.

(25 marks)

Q.3 **(a)** Describe the different types of mechanisms which can occur during abrasive wear.

(5 marks)

(b) A cylindrical bronze pin of 1mm radius rests on a rotating steel disk at a mean radius of 25mm. The normal load on the pin is 10N. The rotation speed of the disk is 300rpm and the test lasts for 10 hours. The mass losses of the pin and disk are 50mg and 3mg, respectively. Using the material data given below, calculate the wear coefficients and wear depths for the bronze pin and steel disk. (Hardness of bronze = 0.8GPa, density of bronze = 8.5Mg/m^3; hardness of steel = 2.5Gpa, density of steel = 7.8Mg/m^3).

(20 marks)

Q.4 **(a)** Figure Q4a. is a Pourbaix diagram for copper. Explain what the different regions in the diagram represent.

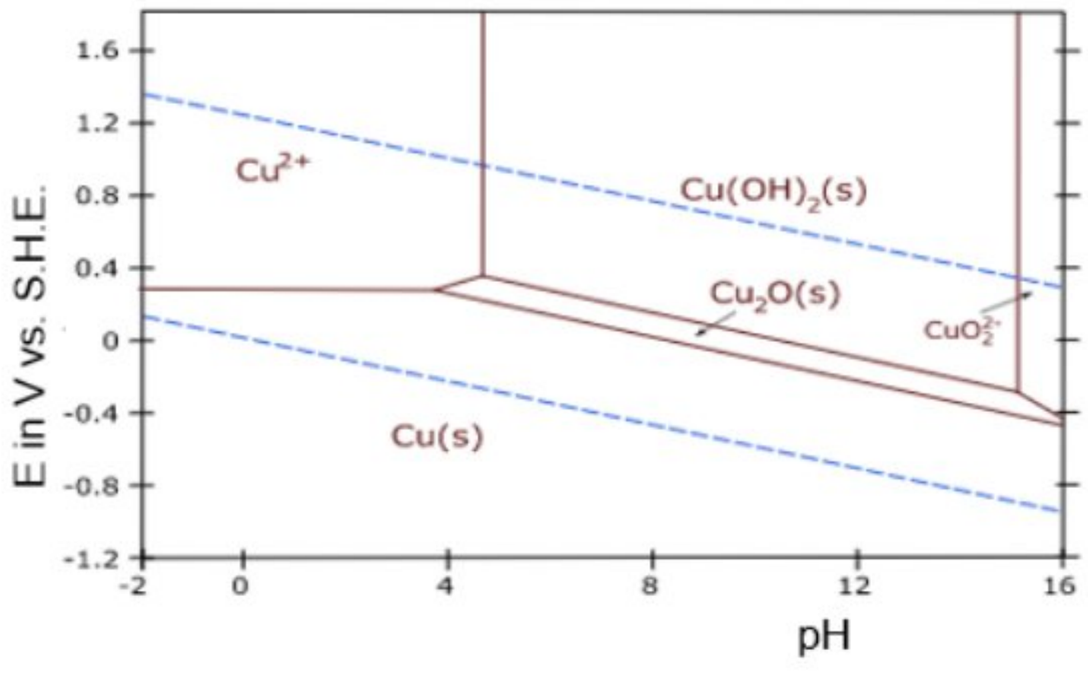

Figure Q4a.

(5 marks)

(b) Explain what is occurring in the potentiodynamic polarisations scans shown in Figure Q4b. The tests were conducted in an aerated aqueous solution at ambient temperature.

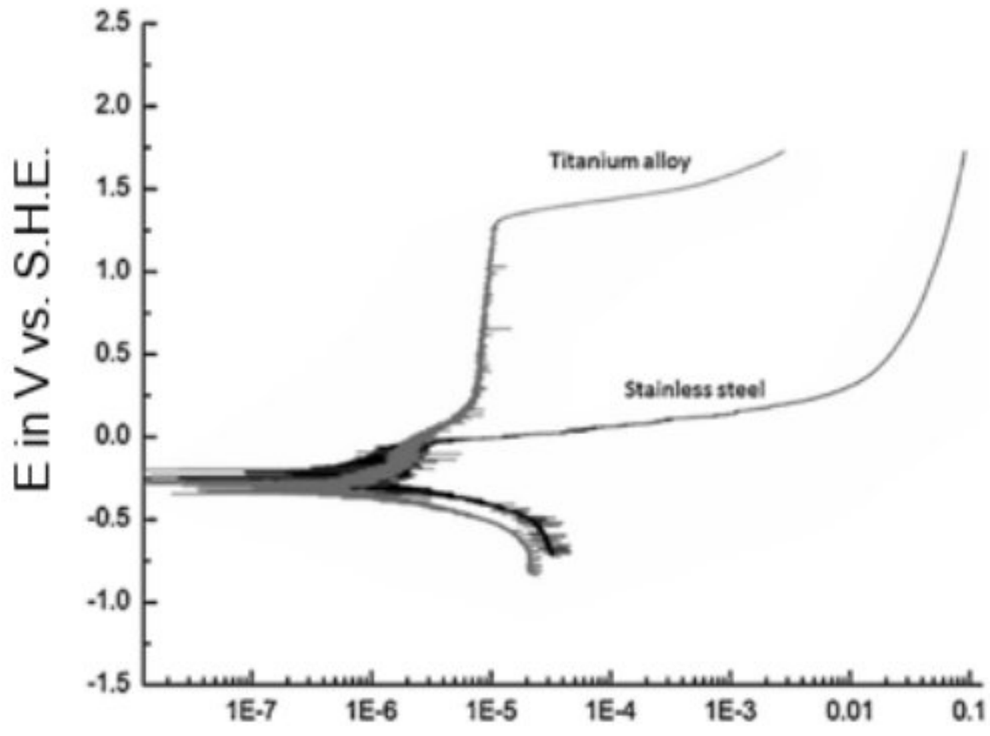

Figure Q4b.

(15 marks)

(c) Calculate the PREN values for the following alloys given in Table Q4. using the NACE (MR 0175/ISO 15156-3) PREN equation. What would happen to the passive oxide film of these stainless steels if the temperature was increased?

Composition (wt.%)	C	N	Mn	P	S	Mo	Cr	Ni	Fe
Alloy 1	0.03	0.1	1.5	0.035	0.01	4.8	27	6.5	Bal.
Alloy 2	0.2	0.05	2	0.045	0.03	0.5	22	12	Bal.
Alloy 3	0.12	-	1	0.04	0.03	-	16	0.75	Bal.

Table Q4. Chemical composition for alloys

(5 marks)