MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: ENGINEERING MATERIALS

CODE: CHEP 102

SESSIONAL EXAMINATIONS

JUNE 2023

DURATION: 3 HOURS

EXAMINER: MR M. MAPOSA

INSTRUCTIONS

1. Answer **Any four** Questions
2. All questions carry equal number of marks
3. Start a new question on a fresh page
4. Total marks 100

Additional material(s): *Periodic Table*

QUESTION 1

a) Using examples of your choice, briefly describe the following structural failure methods. Your description should highlight the cause of each failure, how failure leads to collapse of structure and the methods used to prevent each type of failure.

    i)   Fatigue failure

    ii)   Creep failure

    iii)   Hydrogen embrittlement   [9]

b) An alloy is 40 % Zinc and 60 % Copper. Given that the densities of zinc and copper are 7.13 g/cm^3 and 8.96 g/cm^3 respectively. Calculate the density of the alloy.   [5]

c) Explain any four benefits of using alloys instead of pure metals   [4]

d) A sheet of carbon steel one meter wide by three meter long has lost 50 g to corrosion over the past six months. Convert that mass loss to a penetration rate of the steel in mm units.

What would be the total corrosion current associated with such a corrosion rate? (carbon steel density = 7.8 g/cm^3)   [7]

QUESTION 2

a) Give the economic and environmental effects of corrosion [6]

b) Describe fully the meaning of the following terms as applied in the study of corrosion

    i)   Hot temperature corrosion

    ii)   Passivation

    iii)   Immunity [6]

c) A completely soluble binary system of nickel and copper is represented by a phase diagram in fig 1.
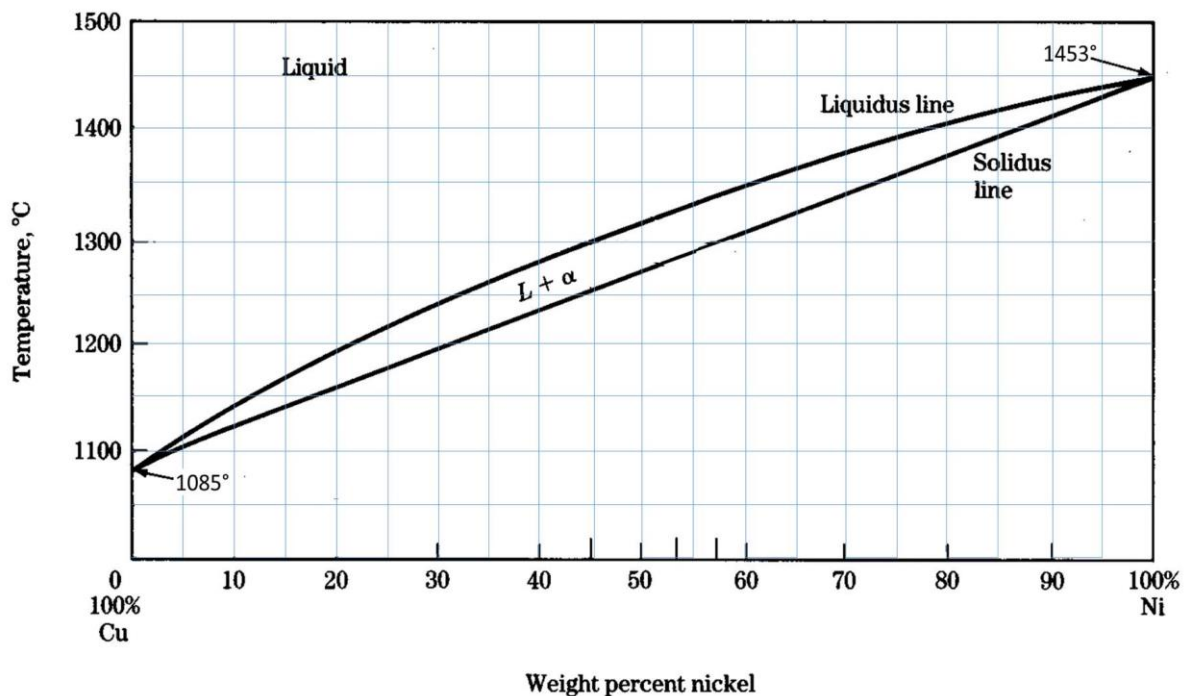
Fig 1 Nickel – copper phase diagram

[EN380 Naval Materials Science and Engineering Course Notes]

    i)   Explain the significance of the liquidus and solidus lines

    ii)   How many phases are shown in the diagram?

    iii)   Deduce the weight percentage of each of copper and nickel in solid and liquid state when the mixture contained 73 % Cu and 27 % Ni at 1200 °C.

iv)   Calculate the weight percentage of the alloy which is in solid state and in liquid state at 1200 °C   [8]

d) With the aid of diagrams distinguish between interstitial and substitutional alloys   [3]

e) Give any two advantages of using alloys instead of pure metals   [2]

QUESTION 3

a) Describe the strengths and limitations of the Pourbaix diagram predicting the likelihood of corrosion of a structural material   [6]

b) Laboratory tests carried out on two alloys produced the following results

Material	Density of Material in g/cm³	Weight loss in gmd	Pitting Factor
A	7.8	20	1
B	8.8	15	1

Calculate maximum penetration in millimetres for each material at the end of six months   [8]

c) The wall of a steel tank containing aerated water is corroding at a rate of 30.5 mdd (miligrams per square decimeter per day). Given that the thickness of the tank wall is 2 mm

   i)   Determine the depth of corrosion on the tank surface in mm per day

   ii)   How long will it take in days for the wall thickness of the tank to decrease by 0.50 mm?

   iii) Approximate the life span of the steel tank if the minimum working thickness of the tank is 0.8 mm   [11]

QUESTION 4

(a) Explain fully the following terms

   i)   Elastic deformation

   ii)   Plastic deformation

   iii)   Yield strength   [6]

(b) How do the following methods reduce material failure rate?

   i)   Painting steel structures

   ii)   Alloying metals

   iii)   Heat treatment

   iv)   Cold treatment   [6]

(c) A mild steel cylindrical tank 2 m high and 1 m in diameter contains aerated water to the 1,20 m level and shows a loss in weight due to corrosion of 200 g after six weeks.

   i)   Calculate the corrosion current

   ii)   Find the total corroding surface area of the tank

   iii)   Calculate the current density involved in the corrosion of the tank. Assume uniform corrosion on the tank's inner surface and that the steel corrodes in the same manner as pure iron.   [8]

(d) A sample of zinc corrodes uniformly with a current density of 4.27×10^{-7} A/cm^2 in an aqueous solution. What will be the corrosion rate of the zinc in milligrams per decimeter per day? The reaction for the oxidation of zinc is $Zn \rightarrow Zn^{2+} + 2e^{-}$.   [5]

QUESTION 5

a) Describe cathodic protection as a method of corrosion prevention, stating its advantages and disadvantages [8]

b) Draw a clearly labelled diagram to show how cathodic protection can be used on an underground steel pipe. [5]

c) Sketch and explain a stress-strain graph to show how stress beyond yield strength will eventually lead to failure. [5]

d) A thick steel sheet of area 350 cm^2 is exposed to air near the ocean. After a one-year period it was found to experience a weight loss of 300 g due to corrosion. To what rate of corrosion, in both mpy and mm/yr, does this correspond? [4]

e) Iron corrodes in seawater at a rate of 2.5 gmd. How many grams of rust will be formed through corrosion over a period of 2 years, assuming that all corrosion of iron will deposit iron (iii) oxide? [3]

END OF EXAMINATION