



**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF CHEMICAL ENGINEERING**

**Materials and Containment 1A**

**TCE1102**

**Final Examination Paper**

**December 2024**

This examination paper consists of 5 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Examiner's Name: Dr Liberty Lungisani Mguni**

**INSTRUCTIONS**

1. Answer **All** questions
2. Each question carries 25 marks
3. The use of calculators is permissible

**MARK ALLOCATION**

<b>QUESTION</b>	<b>MARKS</b>
1.	25
1.	25
3.	25
4.	25
<b>TOTAL ATTAINABLE</b>	<b>100</b>

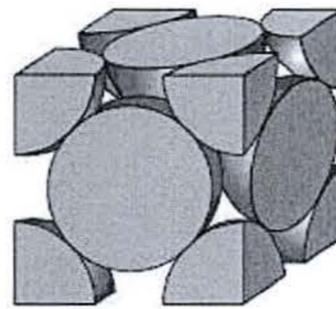
*Answer all questions*

**QUESTION 1**

- a) Distinguish between an amorphous and crystalline material and use examples. [6]
- b) State six types of defects or dislocations. [6]
- c) Assisted by a stress-strain diagram, differentiate between a brittle and ductile material. [6]
- d) Compare and contrast these systems: Binary Isomorphous And Binary Eutectic. [7]

**QUESTION 2**

- a) Why do atoms assemble into ordered structures (crystals)? [5]
- b) State the atomic arrangement given below. Show how the unit cell edge length  $a$  and the atomic radius  $R$  are related to the arrangement. [8]



- b) Determine the atomic packing factor for the arrangement. [5]
- c) Iron has a BCC crystal structure, an atomic radius of 0.124 nm, and an atomic weight of 55.85 g/mol. Compute the theoretical density. [7]

**QUESTION 3**

- a) Discuss the following terms: yield strength, tensile strength, and hardness of materials. [8]
- b) The following data (Table 1) were collected from a 20-mm diameter ductile cast iron test specimen ( $l_0 = 40.00$  mm). After fracture, the total length was 47.42 mm, and the diameter was 18.35 mm. Plot the data and calculate:
  - i) The modulus of elasticity. [5]
  - ii) The yield strength at a strain offset of 0.2%. [4]
  - iii) Determine the tensile strength of the material. [3]
  - iv) The true stress at fracture. [5]

Table 1: The load behavior of cast iron (William Callister and David G Rethwisch, 2010)

Load (N)	$\Delta l$ (mm)	
0	0	
25,000	0.0185	
50,000	0.0370	
75,000	0.0555	
90,000	0.20	
105,000	0.60	
120,000	1.56	
131,000	4.00	(maximum
125,000	7.52	(fracture)

#### QUESTION 4

- a) State three variables that determine the microstructure of an alloy? [6]
- b) For a 99.6 wt% Fe-0.40 wt% C steel at a temperature just below the eutectoid, determine the following:
- i) The compositions of  $Fe_3C$  and ferrite ( $\alpha$ ). [2]
- ii) The amount of cementite (in grams) that forms in 100 g of steel. [4]
- iii) The amounts of pearlite and proeutectoid ferrite ( $\alpha$ ) in the 100 g. [5]
- iv) Describe what happens as we cool along the 98.5 Fe-1.5 wt% C (along green line 3 points given) and how you would calculate composition at each point. [8]

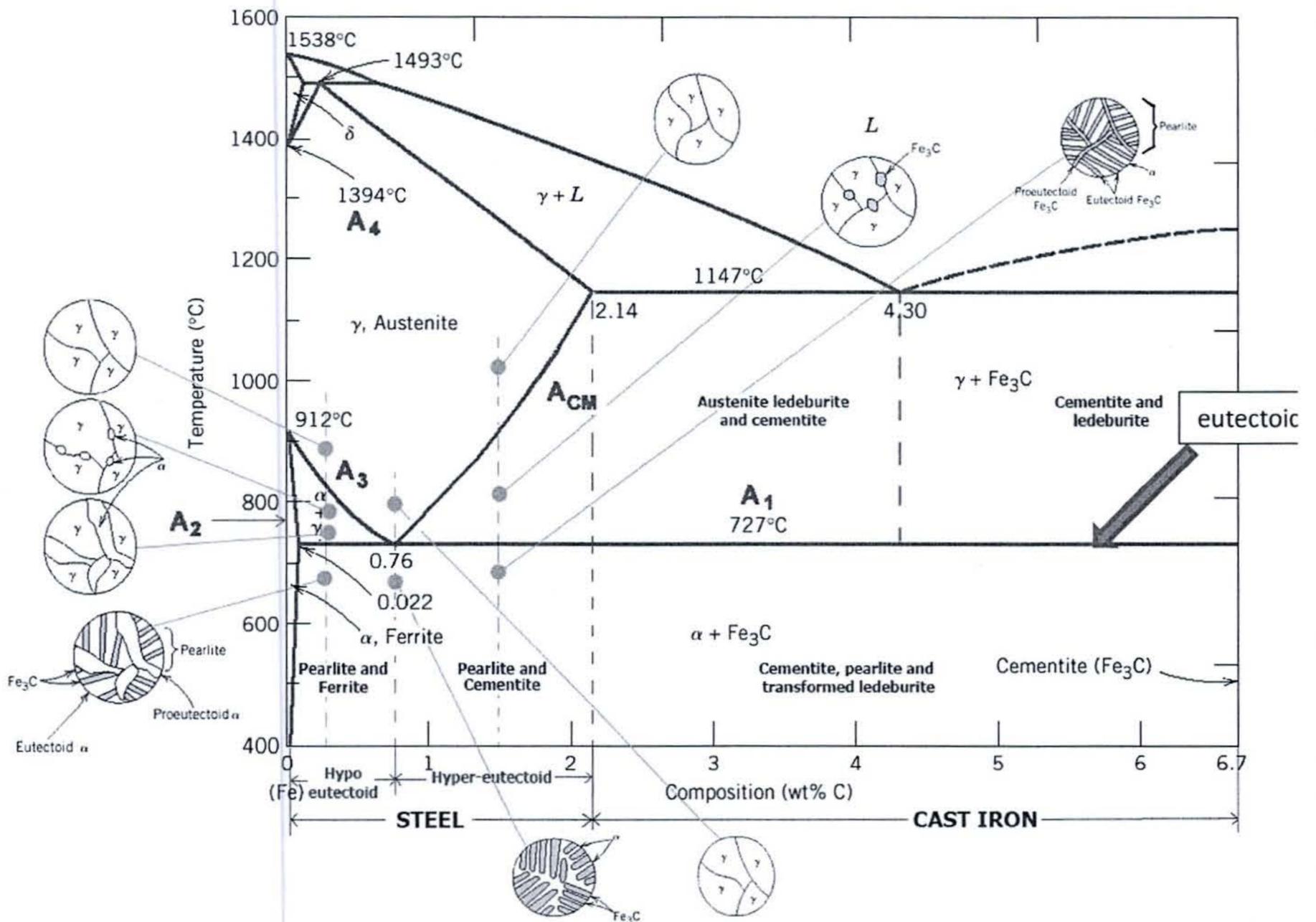


Figure 2: The lead-tin phase diagram. [Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 3, T. B. Massalski (Editor-in-Chief), 1990]