UNIVERSITY OF JOHANNESBURG

PROGRAM : BACCALAUREUS TECHNOLOGIAE
ENGINEERING METALLURGY

SUBJECT : **MECHANICAL METALLURGY IV**

CODE : **TMP42-2**

DATE : WINTER SSA EXAMINATION 2015
14 JULY 2015

DURATION : 08:00 - 11:00

WEIGHT : 40 : 60

TOTAL MARKS : 100

EXAMINER : DR S BHERO

MODERATOR : MR JM PROZZI 5138

NUMBER OF PAGES : 3 PAGES

INSTRUCTIONS : ANSWER ALL QUESTIONS

REQUIREMENTS : CALCULATOR

QUESTION 1 (40 marks)

1.1 Distinguish the following and explain the characteristics of each.

1.1.1 Beach marks and chevron marks (4)

1.1.2 Natural aging and artificial aging (4)

1.1.3 Strain aging and age hardening (4)

1.1.4 Grain growth and Ostwald ripening (4)

1.1.5 Luder bands and Twin bands (4)

1.2 Which of the flowing pairs is larger and why?

1.2.1 True stress versus engineering stress (4)

1.2.2 True strain versus engineering strain (4)

1.3 Explain how creep strength is increased by the following:

1.3.1 Coarse grains (3)

1.3.2 Columnar grains (3)

1.3.3 Single grain (3)

1.3.4 Mechanical alloying (3)

Question 2 (30 marks)

2.1 Define Peierls-Nabarro stress in a perfect crystal and in a real crystal. (2)

2.2 Use sketches to illustrate small and large dislocation width and explain reasons for the respective Peierls-Nabarro stresses in the two configurations. (4)

2.3 The term strain aging suggests that a process takes process over time.

2.3.1 Explain the yield point phenomenon when a tensile test piece is loaded beyond yield point, off loaded and then retested immediately afterwards. (3)

2.3.2 What microstructural changes would occur in the test piece if a retest is conducted after two weeks? (3)

2.3.3 Suggest ways of shortening the aging time. (2)

2.4 Define Cottrell atmospheres and using a sketch show how Cottrell atmospheres arise. (4)

2.5 Define strength of a crystal in relation to the Peierls-Nabarro force. (3)

2.6 Explain a number of ways by which e the Peierls-Nabarro force can be raised. (3)

2.7 The strength of the material alone does not satisfy certain applications. Explain economies achieved by:

2.7.1 The strength to weight ratio? (3)

2.7.2 The strength to density ratio? (3)

Question 3 (30 marks)

3.1 Ductile-to-brittle transition of steels is raised by C, and lowered by Mn and fine grain size of microstructure. Given that the ductile-to-brittle transition of a standard grade of 0.25%C and 0.60% Mn steel is at -5°C. Sketch the position of the ductile-to-brittle transition of:

3.1.1 Coarse-grained 0.25% C and 0.85% Mn steel relative to that of the standard grade. (3)

3.1.2 Coarse-grained 0.60% C and 0.60% Mn steel relative to that of the standard grade. (3)

3.1.3 Coarse-grained 0.05% C and 1.20% Mn steel relative to that of the standard grade. (3)

3.1.4 Fine-grained 0.05% C and 1.20% Mn steel relative to that of the standard grade. (3)

3.1.5 Which of the above steel grade is the best and which one is the worst for use and why? (3)

3.2 The elastic modulus is more important for designers than the UTS. Cantilever beams of steel, titanium and aluminium of equal dimensions are subjected to equal loads at the free end.

3.2.1 The UTS shows the strength below which the material will not fail. Why then is UTS not an ideal property for designers? (3)

3.2.2 If the steel beam deflects 5cm, use a sketch to show the deflections on the three beams given that the Elastic moduli for steel, titanium and aluminium are 210, 105 and 70 MPa respectively. (3)

3.3 Resilience is the total energy absorbed in the elastic range.

3.3.1 Explain the relationship between resilience and formability of a material. (3)

3.3.2 Resilience $U_r = \int \sigma d\varepsilon$ between the origin and the yield point, derive an expression of resilience U_r in terms of yield stress σ and young's modulus E. (3)

3.3.3 Sketch a graph to show the resilience of low carbon steel, high carbon steel and Al. (3)

Total = 100