UNIVERSITY OF JOHANNESBURG

PROGRAM	: National Diploma *Metallurgical Engineering*
SUBJECT	: **MECHANICAL METALLURGY**
CODE	: **TMP 31-1**
DATE	: SUMMER EXAMINATION 2016 22 NOVEMBER 2016
DURATION	: (SESSION 2) 12:30 - 15:30
WEIGHTING	: 60%
TOTAL MARKS	: 120

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MODERATOR	: Jose Prozzi
NUMBER OF PAGES	: 5

INSTRUCTIONS : Calculators are permitted

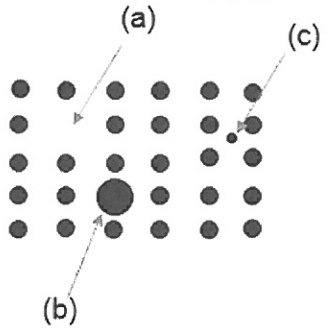
Section A **45 marks**

Answer all questions in this section

Question 1

1.1 Define mechanical metallurgy. [2]

1.2 In the figure below, name the defects labelled (a), (b), and (c). [3]



1.3 Suggest a word or phrase for the following descriptions. [6]

a) A property that does not vary with direction of orientation.
b) Deformation that is fully recovered when the stress causing it is removed.
c) Planes along which maximum and minimum normal stresses act.
d) A dislocation with low mobility.
e) The temperature above which the strength of a metal increases with increasing grain size.
f) Failure under the combined effects of a corrosive environment and a static tensile stress.

Question 2

Study the table below carefully.

	Statement (i)	**Statement (ii)**
A	True	False
B	False	False
C	False	True
D	True	True

Using A, B, C or D from the table above, indicate the True/False combinations valid for the following pairs of descriptions. [14]

a) **Statement (i):** Stress concentration around a thin crack is higher than around a large spherical pore.
Statement (ii): Stress concentration is more detrimental to brittle metals.

b) **Statement (i):** The phenomenon of cross slip is restricted to screw dislocations.
Statement (ii): At high temperatures, screw dislocations can move out of the slip plane by climb.

c) **Statement (i):** Transgranular fracture propagates along the grain boundaries.
Statement (ii): Cup-like depressions are typical of ductile fracture.

d) **Statement (i):** BCC metals have the largest number of slip systems, and are therefore very ductile.
Statement (ii): Lomer-Cotrell barriers contribute to the strain hardening of HCP metals.

e) **Statement (i):** Below the endurance limit, a material is presumed to have infinite life.
Statement (ii): Carburizing and nitriding tend to reduce the endurance limit of metals.

f) **Statement (i):** Materials with wide staking faults have poor resistance to creep.
Statement (ii): At elevated temperatures, deformation may occur along new slip systems.

g) **Statement (i):** Nickel, like iron and zinc experiences brittle fracture at low temperatures.
Statement (ii): Phosphorus increases the ductility transition temperature of steel.

Question 3

3.1 A solid rectangular bar measuring: 35 mm x 20mm x 1500 mm in length, is subjected to an axial tensile force of 54 kN along its length. Calculate the stress in the bar. [2]

3.2 Define true strain, and calculate the missing values in the table below. [7]

True strain	0.01	0.10	0.20	**(a)**	1.0	4.0
Engineering strain	0.01	0.11	0.22	0.65	1.72	**(b)**

3.3 Explain how stacking fault energy influences the strain hardening of FCC metals. [6]

3.4 State Griffith's theory for brittle fracture. [5]

Section B **75 marks**

Answer only 5 questions in this section. Where more than 5 questions are attempted, only the first 5 will be considered.

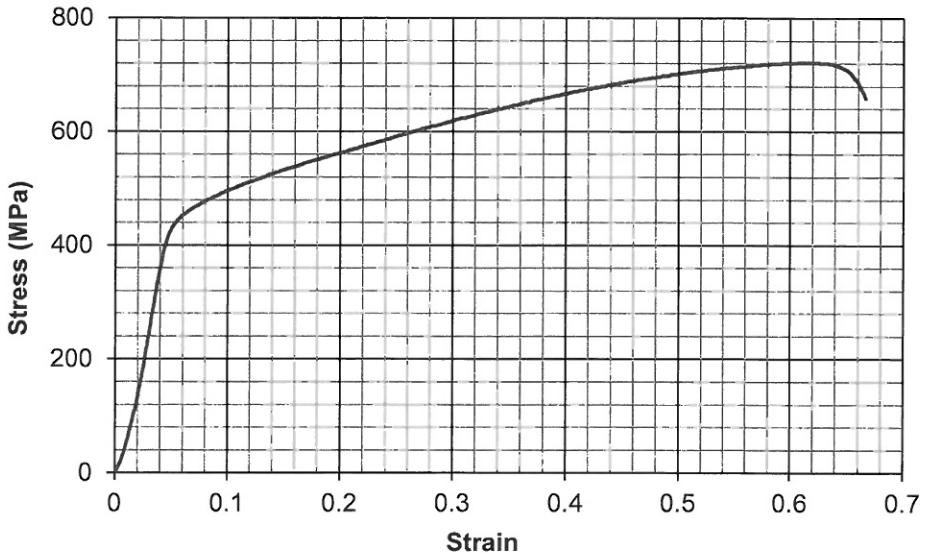
All questions carry 15 marks each.

Question 4

4.1 When is a metal classified as ductile? [1]

4.2 Compare the Von Mises and Tresca criteria for yielding of ductile materials. [4]

4.3 When a metal was loaded in simple tension, the graph below was obtained.



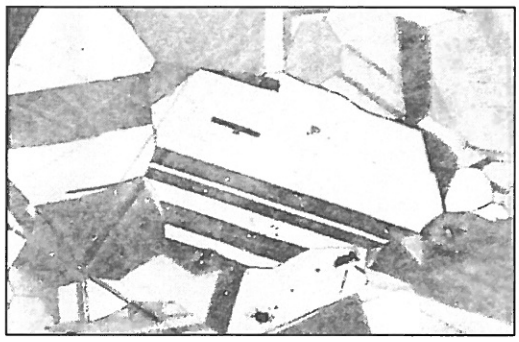
Use the Von Mises criterion to determine whether the metal will yield under the following stress state: [10]

$\sigma_x = 30MPa$ $\sigma_y = -75MPa$ $\tau_{xy} = 15MPa$

Question 5

5.1 What is a structure insensitive property? Give an example. [2]

5.2 Name two surface defects in the figure below, and describe how they are formed. [5]



5.3 How does each of these defects influence the strength and ductility of metals. [8]

Question 6

6.1 What is precipitation hardening? [1]

6.2 Describe how precipitation hardening differs from dispersion hardening. [6]

6.3 Using Al-Cu systems as an example, explain the effect of aging on the strength of precipitation hardened alloys. [8]

Question 7

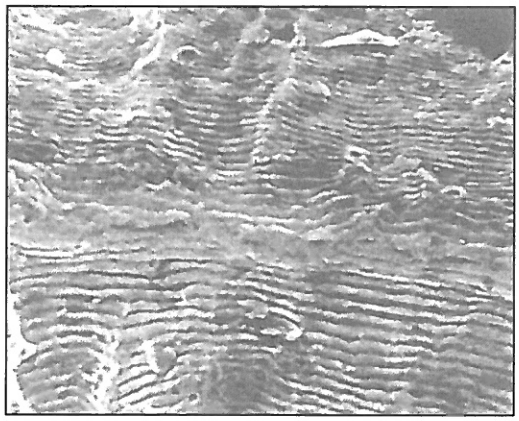
7.1 Define fracture toughness and state how it is affected by temperature. [3]

7.2 Describe the plane strain toughness test, and indicate how you would get a valid K_{IC} value. [6]

7.3 A steel plate 60 mm thick and 0.5 m wide has a 25 mm long internal crack. The plate is loaded in tension. Given that K_{IC} of the steel is 28.3 MPa$\sqrt{m}$, determine the maximum stress the plate can withstand without fracture. [6]

Question 8

8.1 What stress condition caused the fracture surface in the figure below? [1]



8.2 Describe the stages leading to the fracture in the figure. [9]

8.3 Is it advisable to use the striations on the fracture surface to approximate life to failure? Give two reasons for your answer. [5]

Question 9

9.1 Differentiate creep and stress rupture. [2]

9.2 Briefly describe two mechanisms of creep deformation. [4]

9.3 Discuss ways of increasing creep resistance of alloys, and suggest their limitations. [9]

Question 10

10.1 List the types of metals most susceptible to hydrogen embrittlement. [3]

10.2 Describe how hydrogen embrittlement occurs and explain why it is best detected by slow bend tests rather than impact tests. [6]

10.3 Discuss the Charpy test and cite its advantages and disadvantages. [6]

TOTAL MARKS: 120