UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *MECHANICAL ENGINEERING*
SUBJECT	:	SCIENCE OF MATERIALS 2B
CODE	:	MTK2B21
DATE	:	NOVEMBER 2016 EXAM
DURATION	:	3 HOURS
TOTAL MARKS	:	100

EXAMINER	:	PROF RF LAUBSCHER
MODERATOR	:	ME N JANSE VAN RENSBURG
NUMBER OF PAGES	:	4 PAGES AND 1 ANNEXURES

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN.
REQUIREMENTS	:	PLEASE COMPLETE THE EXAM IN THE ASSESSMENT SCRIPT PROVIDED

INSTRUCTIONS TO CANDIDATES:

PLEASE ANSWER ALL QUESTIONS.

QUESTION 1

Illustrate the global materials cycle for a glass bottle diagrammatically?

(5)

QUESTION 2

Briefly describe the following:

Materials engineering
Edge dislocation
Stainless steel
Matthiessen's rule
Anisotropic
Vulcanization
HAZ

(21)

QUESTION 3

Calculate the atomic packing factor for a body centred and a face centred cubic unit cell?

(5)

QUESTION 4

A tensile test on a cylindrical test specimen with radius of 8.1 mm results in data as shown in table 1. Determine the following?

a. Plot engineering stress versus engineering strain
b. Determine the modulus of elasticity
c. Determine the yield stress (0.2%)
d. Determine the tensile strength of the alloy
e. Determine the ductility of the alloy
f. Determine the modulus of resilience
g. Determine the toughness

(14)

Table 1

Load (kN)	Length (mm)
0	50
7.85	50.025
15.7	50.05
19.6	50.5
27.5	52.5
31.4	55.0
45.0	57.5
50.0	58.5
48.0	59.5

QUESTION 5

What is the difference between engineering stress and strain and true stress and strain? Derive expressions for true stress and strain so that $\sigma_{true} = f(\sigma_{eng}, \varepsilon_{eng})$ and $\varepsilon_{true} = f(\varepsilon_{eng})$.

(10)

QUESTION 6

A certain component is to be carburized to obtain 0.55 wt % C at a depth of 2.0 mm. After carburizing (for 1.2 hours) the heat treater finds that he only achieved 0.35 wt % C at a depth of 2.0 mm. His furnace only operates at a 900 °C and maintains a constant atmosphere of 1.2 wt % C. The steel used has an initial carbon content of 0.2 wt %. How should he change his process, within the given parameters, to be successful?

(10)

Given:

$$\frac{C_x - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

Tabulation of Error Function Values

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

QUESTION 7

What is the relevance of linear defects as regards to the strength of metallic materials? Discuss (hint: introduce the three different hardening techniques).

(10)

QUESTION 8

Describe the process of glass tempering under the following headings: aim, mechanism and process?

(5)

QUESTION 9

Briefly describe the different manufacturing techniques utilized to manufacture metallic products.

(10)

QUESTION 10

Sketch the basic units (mers) of the following polymers.

(a) polyethylene
(b) polyvinyl chloride
(c) polytetrafluoroethylene
(d) polypropylene
(e) polystyrene

(5)

QUESTION 11

Briefly introduce and discuss extrinsic semi-conduction?

(5)

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QUESTION 1

What important aspects should be considered when making a material selection during design? **(5)**

QUESTION 2

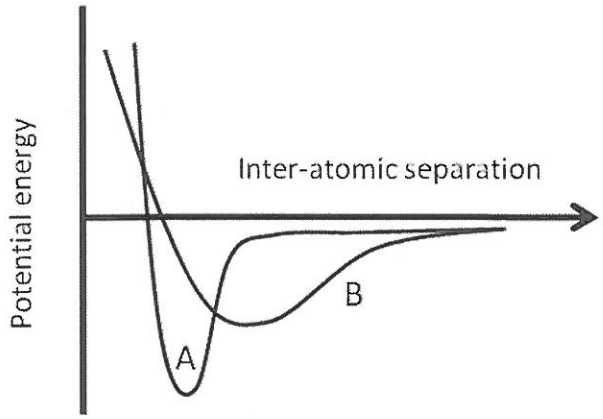
Briefly describe the following:

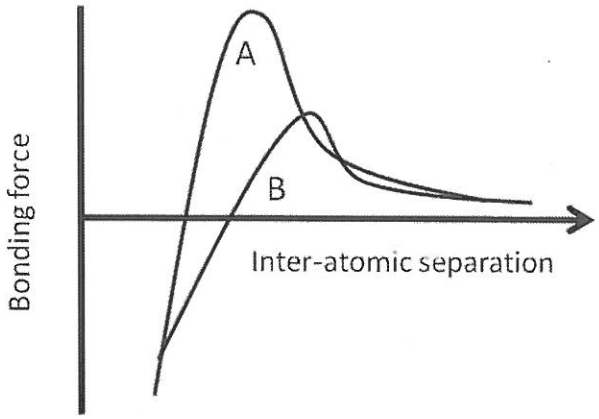
60 HRA
Amorphous material
Dispersed phase
Matthiessen's rule
Resistivity
Mohs scale
Investment casting

(21)

QUESTION 3

Compare the appropriate materials properties of material A and B with one another?





(6)

QUESTION 4

A tensile test on a cylindrical test specimen with diameter of 12 mm results in data as shown in table 1. Determine the following?

a. Plot engineering stress versus engineering strain
b. Determine the modulus of elasticity
c. Determine the yield stress (0.2% offset)
d. Determine the tensile strength of the alloy
e. Determine the ductility of the alloy
f. Determine the modulus of resilience
g. Determine the toughness **(14)**

Table 1

Load (kN)	Length (mm)
0	50
7.85	50.033
15.7	50.066
19.6	50.658
27.5	53.289
31.4	56.579
45.0	59.868
50.0	61.184
48.0	62.5

QUESTION 5

Determine the linear density and linear packing fraction for FCC aluminum for$[0\bar{1}0]$, $[\bar{1}10]$ and $[\bar{1}11]$. R = 0.143 nm.

(12)

QUESTION 6

The diffusion coefficient for copper in aluminium at 450 and 550 K is 5.5×10^{-14} and 6×10^{-13} m^2/s, respectively. Determine the approximate time at 450 K that will produce the same result (in terms of concentration at a specific point) as a 7 hour heat treatment at 550K.

(6)

Given:

$$\frac{C_x - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

Tabulation of Error Function Values

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
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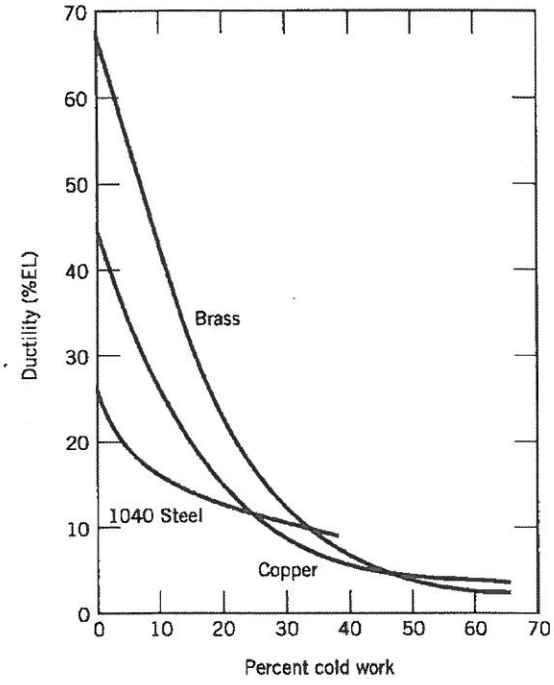
QUESTION 7

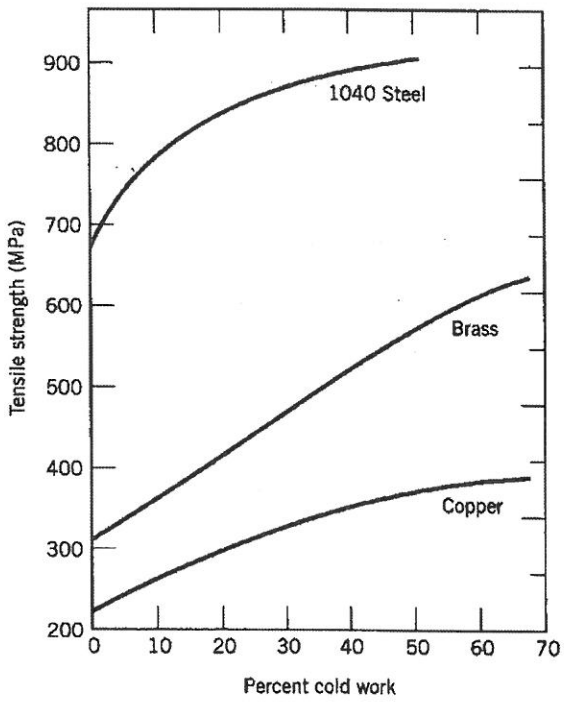
Briefly describe the hardness test?
Why is the hardness test more frequently done than any other mechanical test?

(5)

QUESTION 8

A cylindrical brass rod originally 10 mm in diameter is to be cold worked by drawing. A minimum tensile strength of 450 MPa and a ductility of at least 15 % are desired. The final diameter must be 7.5 mm. Explain how this may be accomplished?





$$\%CW = \left(\frac{A_0 - A_d}{A_0}\right) \times 100$$

(10)

QUESTION 9

You are to manufacture the following products. Choose a suitable alloy for each? Motivate you choice: Hunting knife, hacksaw blade (metal saw blade) and a medical implant.

(6)

QUESTION 10

Briefly describe the process of work hardening? How can this process be reversed? Why does steel work harden at room temperature and lead and tin not?

(10)

QUESTION 11

Briefly introduce the working of a p-n rectifying junction. Make use of sketches to explain.

(5)

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