CONFIDENTIAL

UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	MATERIAL SCIENCE
COURSE CODE	:	BWC 30503
PROGRAMME	:	3 BWC
EXAMINATION DATE	:	DECEMBER 2014/ JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	A) ANSWER **FOUR (4)** QUESTIONS IN SECTION A B) ANSWER **ONE (1)** QUESTION IN SECTION B

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

CONFIDENTIAL

SECTION A

Q1 (a) (i) What is the difference between a crystal structure and a crystal system?

(2 marks)

(ii) Show that the atomic packing factor for BCC is 0.68.

(4 marks)

(iii) Calculate the radius of a vanadium atom, given that V has a BCC crystal structure, a density of 5.96 g/cm^3, and an atomic weight of 50.9 g/mol.

(5 marks)

(b) (i) In brief, explain the types of defects in crystalline materials.

(4 marks)

(ii) Differentiate between the edge and screw dislocations in terms of Burger's vector.

(5 marks)

Q2 (a) (i) Briefly explain the difference between self diffusion and inter diffusion

(4 marks)

(ii) Compare interstitial and vacancy atomic mechanisms for diffusion.

(4 marks)

(b) Explain why interstitial atoms such as C in Fe, can diffuse more rapidly, compared to vacancies.

(5 marks)

(c) A sheet of steel 2.5 mm thick has nitrogen atmospheres on both sides at 900 ^{0}C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is 1.2×10^{-10} m^2/s, and the diffusion flux is found to be 1.0×10^{-7} kg/m^2s. Also, it is known that the concentration of nitrogen in steel at high-pressure surface is 2 kg/m^3.

(i) How far into the sheet from this high-pressure side will the concentration be 0.5 kg/m^3?

(5 marks)

(ii) What assumptions do you use in dealing with this problem.

(2 marks)

Q3 (a) Of those metals listed in **Table Q3(a)**,

(i) Which will experience the greatest percent reduction in area?

(4 marks)

(ii) Which is the strongest?

(4 marks)

Justify your answers.

Table Q3(a) Tensile Stress-Strain Data for Several Hypothetical Metals

Material	*Yield Strength (MPa)*	*Tensile Strength (MPa)*	*Strain at Fracture*	*Fracture Strength (MPa)*	*Elastic Modulus (GPa)*
A	310	340	0.23	265	210
B	100	120	0.40	105	150
C	415	550	0.15	500	310
D	700	850	0.14	720	210
E	Fractures before yielding			650	350

(b) Consider a cylindrical specimen of an alloy steel that is pulled in tension, as stress-strain behaviour shown in **Figure Q3(b)**.

(i) Determine the modulus of elasticity

(2 marks)

(ii) Estimate the yield strength at a strain offset of 0.002.

(2 marks)

(iii) Calculate the maximum load that can be sustained by a cylindrical specimen having an original diameter of 8.5 mm.

(4 marks)

(iv) Obtain the change in length of a specimen originally at 80 mm long that is subjected to a tensile stress of 1500 Mpa.

(4 marks)

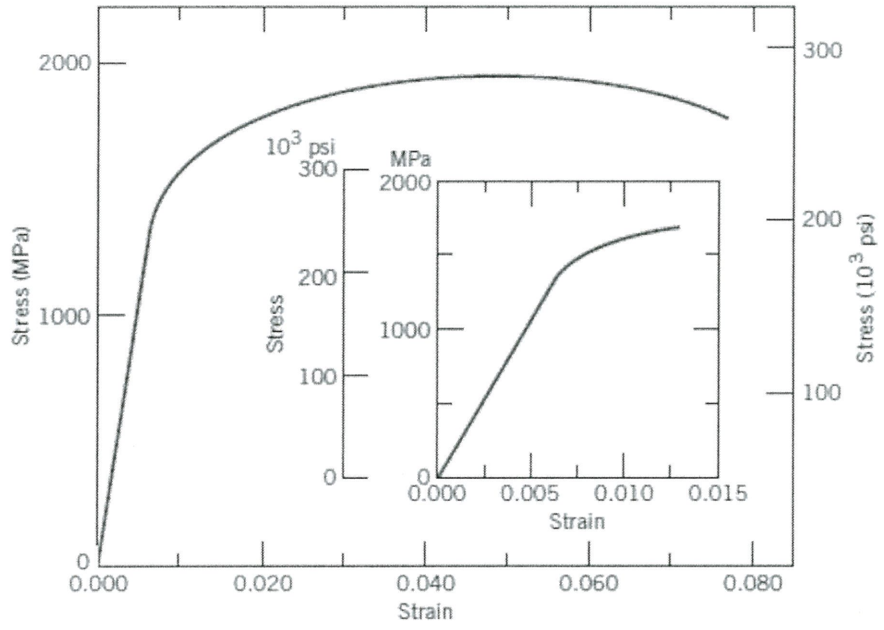

Figure Q3(b) The stress-strain behaviour for an alloy steel.

Q4 Two metals, X (melting point = 1300 ^{0}C) and Y (melting point = 1000 ^{0}C) are partially miscible. They form two solid solutions α and β. Under equilibrium conditions, maximum solubility values are given in **Table Q4**:

Table Q4

Temperature (^{0}C)	0	200	400	600	800	900	950
Maximum solubility of Y in X (wt. %)	3	10	20	32	50	40	35
Maximum solubility of X in Y (wt. %)	2	2	3	5	10	5	3

A eutectic reaction occurs when the alloy contains 20 wt.% of X and producing both α and β phases.

(a) (i) Based on the given information, construct an appropriate equilibrium phase diagram.

(7 marks)

(ii) Label each phase.

(5 marks)

(b) An alloy containing 60 wt.% of X is slowly cooled under equilibrium cooling conditions to room temperature from a temperature just above the melting point of X. Discuss the phase transformation which will take place and calculate the percentage of α at 200 ^{0}C.

(5 marks)

(c) Outline the heat treatment you would recommend for the above alloy to obtain a very fine dispersion of β phase

(3 marks)

SECTION B

Q5 (a) What are the different stages of age hardening treatment for alluminium alloys?

(5 marks)

(b) What is hardenability? Why is it not so high in plain carbon steel?

(5 marks)

(c) Discuss the heat transfer characteristics during normalising and its effect on mechanical properties.

(5 marks)

(d) Discuss the tampering process.

(5 marks)

Q6 Glass, aluminum, and various plastic materials are utilized for containers. Make a list of the advantages and disadvantages of using each of these three material types; include such factors as cost, recyclability and energy consumption for container production.

(20 marks)

- END OF QUESTION -