Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	MATERIAL ENGINEERING TECHNOLOGY
COURSE CODE	:	BNQ 20503/ BNQ 30503
PROGRAMME CODE	:	BNN
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) (i) Define the term '*tensile strength*' and '*ductility*' in mechanical properties of metals.

(4 marks)

(ii) Explain **TWO (2)** reasons why hardness tests are preferable compared to other mechanical tests.

(4 marks)

(b) A cylindrical rod 100 mm long and having a diameter of 10.0 mm is to be deformed using a tensile load of 27, 500 N. It must not experience either plastic deformation or a diameter reduction of more than 7.5×10^{-3} mm. Given the materials listed in **Table Q1 (b)**, decide which of the materials are suitable for the above situation. Justify your choice(s).

Table Q1 (b): Materials and Its Properties

Material	Modulus of Elasticity (GPa)	Yield Strength (MPa)	Poisson's Ratio
Aluminium Alloy	70	200	0.33
Brass Alloy	101	300	0.34
Steel Alloy	207	400	0.30
Titanium Alloy	107	650	0.34

(7 marks)

(c) **Table Q1 (c)** shows the engineering stresses that produce plastic engineering strains prior to necking for a brass alloy. On the basis of this information, determine the engineering stress necessary to produce an engineering strain of 0.25.

Table Q1 (c): Engineering stress and Engineering strain in a brass alloy

Engineering stress (MPa)	Engineering Strain
235	0.194
250	0.296

(10 marks)

Q2 (a) (i) Explain why upon solidification, an alloy of eutectic composition forms a microstructure consisting of alternating layers of the two solid phases.

(2 marks)

(ii) Identify **THREE (3)** variables that determine the microstructure of an alloy.

(3 marks)

(b) **Figure Q2 (b)** shows a portion of the Copper-Zinc phase diagram. For a 36 wt. % Zn – 32 wt. % Cu alloy;

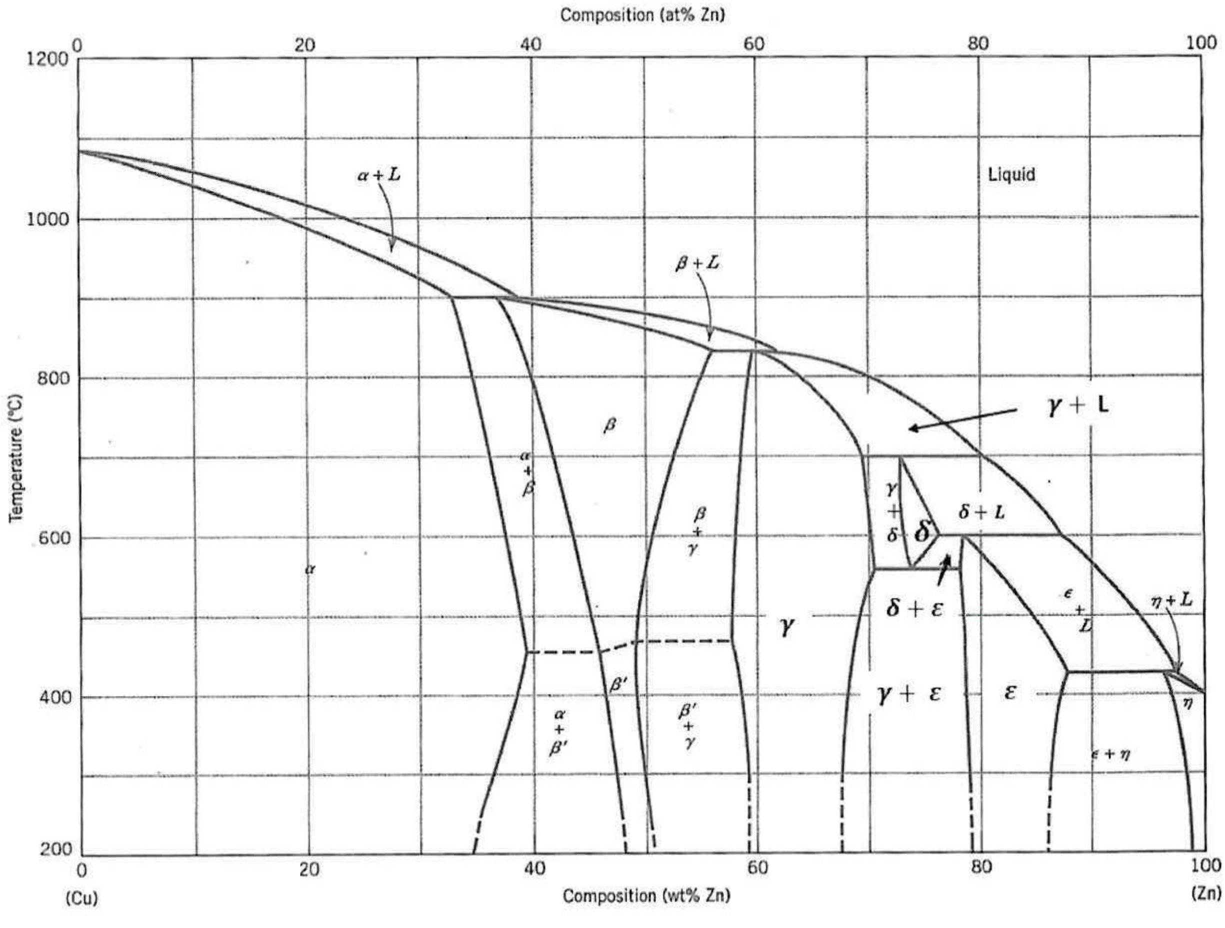

Figure Q2 (b): Copper-Zinc Phase Diagram

(i) sketch the microstructure that would be observed for condition of very slow cooling at the conditions of 1000 °C, 760 °C, 600 °C, and 400 °C.

(4 marks)

(ii) deduce and label each composition presented in the microstructure drawn in question **Q2(b)(i).**

(3 marks)

(c) **Figure Q2 (c)** shows a portion of the magnesium-lead phase diagram. A magnesium-lead alloy of mass 5.5 kg consists of a solid α phase that has a composition that is just slightly below the solubility limit at 200 °C.

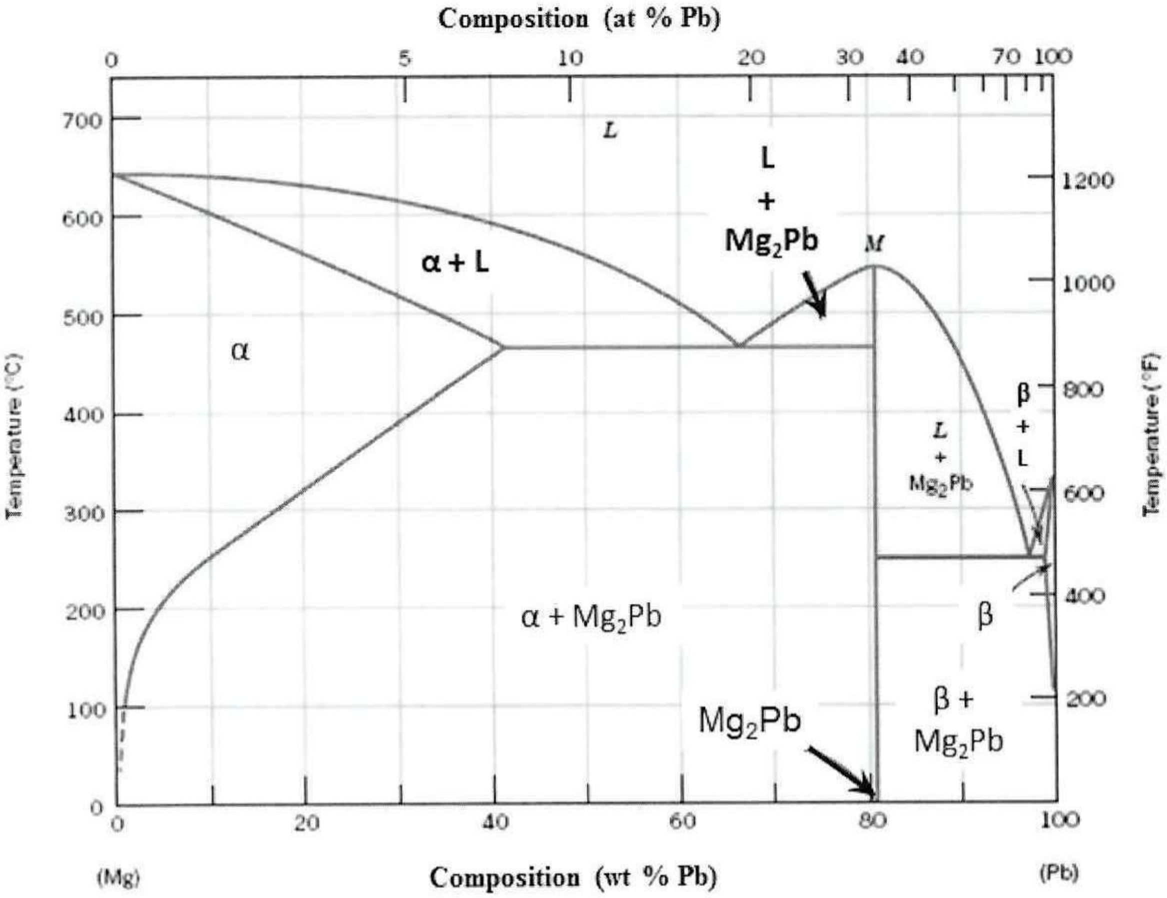

Figure Q2 (c): Magnesium-lead phase diagram

(i) Calculate the mass of lead in the alloy.

(3 marks)

(ii) If the allow is heated to 350 °C, determine the quantity of lead that maybe dissolved in α phase without exceeding the solubility limit of this phase.

(4 marks)

(d) For alloys of two hypothetical metals A and B, there exist an α, A rich phase and β, B rich phase. From the mass fractions of both phases for two different alloys provided in **Table Q2 (d)** (which are at the same temperature), determine the composition of the phase boundary (or solubility limit) for both α and β phases at this temperature.

Table Q2 (d): Hypothetical metals of A and B

Alloy composition	Fraction α phase	Fraction β phase
60 wt % A - 40 wt% B	0.57	0.43
30 wt % A - 70 wt% B	0.14	0.86

(6 marks)

Q3 (a) Describe **FOUR (4)** types of copolymers and draw each related structure.

(10 marks)

(b) Differentiate the characteristics between Thermoplastic Polymer and Thermoset Polymer with an example each.

(10 marks)

(c) (i) Demonstrate in **ONE (1)** diagram with label both Frenkel & Shottky defects

(3 marks)

(ii) Recall **TWO (2)** reasons that ceramic materials are more brittle than metals.

(2 marks)

Q4 (a) (i) Describe your understanding about creep phenomena.

(4 marks)

(ii) Illustrate the creep rupture test graph complete with its label.

(6 marks)

(iii) Materials constantly exposed to elevated temperature and static mechanical stress are often affected by creep phenomena. Identify **THREE (3)** factors with its known effects (e.g. higher/lower is better) that affect creep properties for alloy of high temperature use.

(6 marks)

(iv) Steady-state creep data for aluminium at 260 ^oC is given in **Table Q4 (a)** as follows:

Table Q4 (a): Data for Aluminium steady-state creep

$\dot{\varepsilon}_s\ (h^{-1})$	σ (MPa)
2.0 x 10^{-4}	3
3.65	25

Determine the steady-state creep rate at a stress of 10 MPa and 260 ^oC.

(6 marks)

(b) **Figure Q4 (b)** shows the Larson-Miller data for S-590 alloy. Predict the time to rupture for a component subjected to T = 800 ^oC and σ = 140 MPa.

(3 marks)

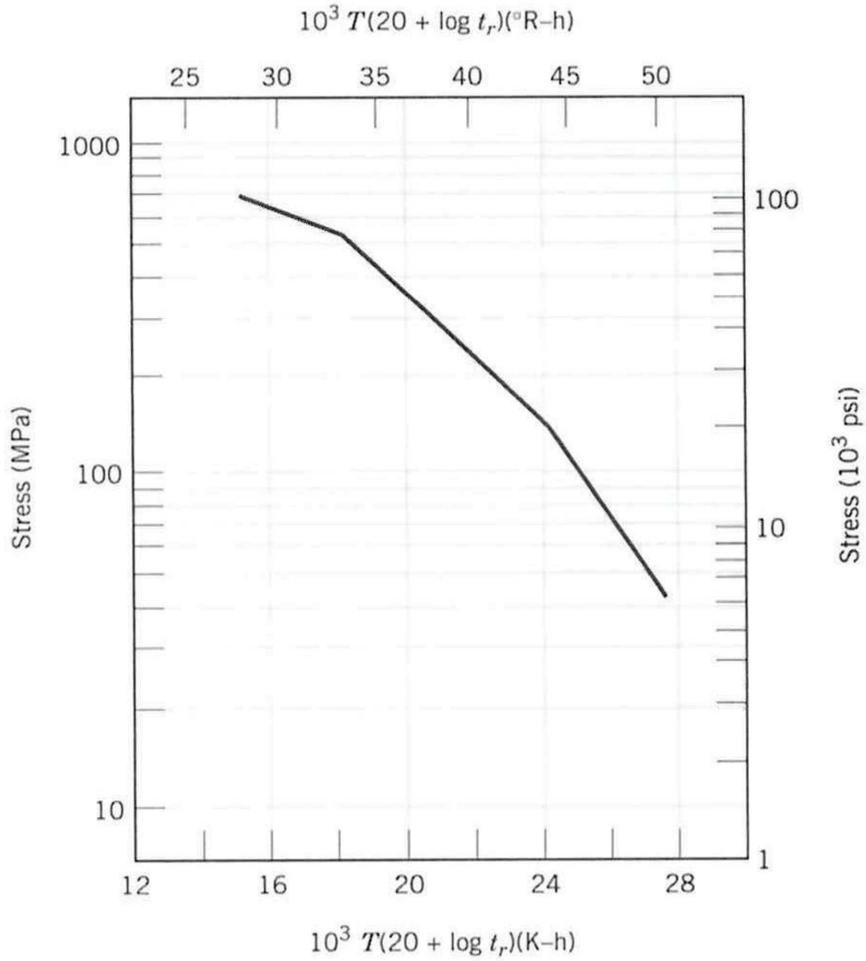

Figure Q4 (b): Larson-Millar data for S-590 Alloy

Q5 (a) (i) Define the term '*activation polarization*' in prediction of corrosion rates.

(2 marks)

(ii) Referring to **Q5 (a) (i)**, explain the reason why the term '*activation*' is applied in this type of polarization

(2 marks)

(iii) Describe the phenomenon of '*passivity*' with **TWO (2)** examples of types of alloy that passivate.

(4 marks)

(b) 'An electrochemical reaction is a process in which electrons flow between a solid electrode and substance, such as an electrolyte. This flow triggers an electric current through the electrodes causing the reaction to liberate or absorb heat. Under different conditions, other types of reactions create an electric current flow. For example, two electrodes in contact with each other results in a reduction and oxidation (redox) reaction' (corrosionpedia.com).

(i) $$Cu^{2+} + Fe \rightarrow Cu + Fe^{2+}$$ **Equation Q5 (b)**

Based on **Equation Q5 (b),** differentiate between oxidation and reduction electrochemical reactions in term of:

(a) its definition;

(b) equation of half-cell reaction that occurs in each process of oxidation and reduction; and

(c) whether the reactions (oxidation or reduction) occurs at anode or cathode side of the cell.

(6 marks)

(ii) For the following pairs of alloys that are coupled in seawater, predict the possibility of corrosion; if corrosion is probable, indicate which metal/alloy will corrode. Refer **Figure Q5 (b)** for assistance.

(a) Aluminium and magnesium
(b) Brass (Cu-Sn alloy) and Monel (70 wt% Ni-30 wt% Cu)
(c) Titanium and 304 stainless steel
(d) Copper and lead

(8 marks)

(iii) Draw a cathodic protection system complete with label for an underground tank.

(3 marks)

Increasingly inert (cathodic) ↑

Platinum
Gold
Graphite
Titanium
Silver
[316 Stainless steel (passive)
304 Stainless steel (passive)]
[Inconel (80Ni-13Cr-7Fe) (passive)
Nickel (passive)]
[Monel (70Ni-30Cu)
Copper-nickel alloys
Bronzes (Cu-Sn alloys)
Copper
Brasses (Cu-Zn alloys)]
[Inconel (active)
Nickel (active)]
Tin
Lead
[316 Stainless steel (active)
304 Stainless steel (active)]
[Cast iron
Iron and steel]
Aluminum alloys
Cadmium
Commercially pure aluminum
Zinc
Magnesium and magnesium alloys

Increasingly active (anodic) ↓

Source: M. G. Fontana, *Corrosion Engineering*, 3rd edition. Copyright 1986 by McGraw-Hill Book Company. Reprinted with permission.

Figure Q5 (b): Galvanic Series

-END OF QUESTIONS-