NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINEERING
Part One Examination January 2011

TCE 1101 Material and Containment

Duration of Examination: 3 Hours

Instructions to Candidates

1. Answer question **ONE** and any other **THREE** questions
2. Each question carries 25 marks
3. Show all steps clearly in any calculation
4. Start the answers for each question on a fresh page

Question 1

(a)Show through a schematic representation the broad classes under which engineering materials fall giving specific examples under each class. **(4 marks)**

(b) Outline the standard procedure for testing the tensile strength of a material. Support your explanation with relevant diagrams. **(4 marks)**

(c) Define strain and explain the two variations of strain. **(2 marks)**

(d) Define ductility and arrange the following metals in order of increasing ductility. Au, Cu, Zn, Pt, Al. **(3marks)**

(e) Outline in detail the difference between proof stress and proof factor of safety.**(8 marks)**

(f) Explain the processes of crushing and grinding clearly showing the differences between the two and why the processes are important in metal extraction. **(4marks)**

Question 2

a) State and briefly explain the properties to consider when conducting material selection. **(5 marks)**

b) State the four main forms in which iron ore is found giving the molecular formula of each form. **(5 marks)**

c) Give a detailed analysis of the blast furnace justifying its shape and giving all the equations that take place in the different zones that exist in the furnace. **(15 marks)**

Question 3

a) State the two classes of nucleation found in metal solidification. (**2 marks)**

b) Show that the critical radius (r_*) in homogeneous nucleation is given by

$$r_* = 2\gamma T_m/\Delta H_s\, \Delta T$$

show all steps of the derivation clearly. **(10 marks)**

c) How do the values of r_* and r relate to each other with regards to stability? (**3 marks)**

d) Steel making can be carried out in the Linz Dunawitz furnace. Draw a detailed diagram of this furnace explaining the process and give the corresponding steel making reactions.
(10 marks)

Question 4

a) AISI classifies steels into four categories. State the four categories and briefly explain one category of your choice? **(5 marks)**

b) Draw and analyse the Fe-C phase diagram. Label and indicate all the equilibrium lines and all the invariant points explaining the reactions or the phases that are interacting in each case. Show all the stable phases in each zone. **(10 marks)**

c) Give a detailed analysis of point defects explaining the three main types of point defects and how they occur. **(10 marks)**

Question 5

a) Calculate the critical radius of the homogeneous nucleus that occurs when pure liquid copper solidifies. Assume that $\Delta T = 0.2T_{mp}$. The freezing temperature of copper is 1083°C, latent heat of solidification = $1826T/cm^3$, interfacial energy = 177×10^{-7} J/cm^2 and ΔT_{max} =236°C
(10 marks)

b) State the Fick's 2nd law and give its areas of application. **(4 marks)**

c) Briefly explain what an alloy and an alloy system are. **(2 marks)**

d) Draw the four cooling curves for a binary alloy and explain each curve. **(9 marks)**