MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2018/2019 ACADEMIC YEAR
FOURTH YEAR *SECOND* SEMESTER

SCHOOL OF SCIENCE
BACHELOR OF SCIENCE

COURSE CODE: PHY 431E

COURSE TITLE: THERMODYNAMICS OF MATERIALS

DATE: **TIME:**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **TWO** questions
2. Use of sketch diagrams where necessary and brief illustrations are encouraged.
3. Read the instructions on the answer booklet keenly and adhere to them.

*This paper consists of **three** printed pages. Please turn over.*

Instructions to candidates:

a) Answer question **one** (30 marks) and **any other two** (20 marks each)

b) The following are useful constants and formulae

(i) Planck's constant, $h = 6.63\times10^{-34}\ J.s$

(ii) mass of an electron, $M_e = 9.11\times10^{-31}\ kg$

(iii) Boltzmann's constant, $K_B = 1.38\times10^{-23}\ JK^{-1}$

(iv) s.h.c of water $= 4.19 Jg^{-1}K^{-1}$

Question one (30 marks)

a) Explain the importance of heat in diffusion (**4marks**)

b) Using an appropriate graph, explain the solidification process of a composite material. (**4marks**)

c) i. Define the term free energy (**1mark**)

ii. What are the similarities/ differences between Gibbs and Helmholtz free energies (**3marks**)

d) State the factors that affect diffusion in solids (**4marks**)

e) State Fick's laws in words and symbols, state the meaning of each term in the symbol. (**4marks**)

f) What properties makes for a good oxide film (**3marks**)

g) Define sintering (**1mark**)

h) With the aid of a diagram derive Fick's second law, hence or otherwise show that Fick's first law is just a simplified format of the second law when applied to a steady state. (**6marks**)

Question Two (20 marks)

a) What is diffusion (**1mark**)

b) State and give an example of each of the sintering products (**6marks**)

c) State Gibbs phase rule. Using the phase rule calculate the number of degrees of freedom for a binary system. **(3marks)**

d) Explain the physical meaning of the equation $\Delta(\gamma A) = \Delta\gamma A + \gamma\Delta A$, when considering a sintering process **(2marks)**

e) On a well labelled diagram show the graphs of oxidation rates of a metal by their equations. **(4marks)**

f) Briefly explain corrosion classification techniques. **(4marks)**

Question Three (20 marks)

a) (i) What is an Ellingham diagram (**2marks**)

(ii) State three uses of the Ellingham diagram (**3marks**)

b) (i) Consider the following two oxidation reactions:

$2M+O_2 \rightarrow 2MO$

$N+O_2 \rightarrow NO_2$

where M and N are metals. Draw and explain the Ellingham diagram for the variation of ΔG with T for the resultant reaction (**6marks**)

c) i. State the Pilling-Bedworth ratio expression (**1marks**)

ii. What deductions can be made from this expression (**3marks**)

d) i. State the property that determines categorization of sintering. (**1mark**)
ii. State the four categories of sintering (**4marks**)

Question Four (20 marks)

a) A sheet of BCC Fe 1.0 mm thick is exposed to a carburizing gas on one side and a decarburizing gas on the other at 725°C. After reaching steady state, the Fe membrane is quenched to room temperature, and the C concentrations at each side of the membrane are 0.012 and 0.075 wt%. Calculate the diffusion coefficient if the diffusion flux is $1.4x10^{-8}$ kg/m^2-sec. (**6marks**)

b) After a combustion process in a cylinder, the pressure is 1200kPa and the temperature is $350\,^0C$.The gases expand to 140kPa with a reversible and adiabatic process. Calculate the work done by the gases assuming they can be approximated by air with constant specifics heats. (**6marks**)

c) State the factors that determine the limits of solubility. (**8marks**)