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.

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, $h = 6.63 \times 10^{-34} J.s$
   (ii) mass of an electron, $M_e = 9.11 \times 10^{-31} kg$
   (iii) Boltzmann's constant, $K_B = 1.38 \times 10^{-23} JK^{-1}$
   (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**)
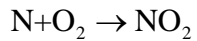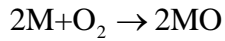f) Briefly explain corrosion classification techniques.   (**4marks**)

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 1.4×10^{-8} kg/m²-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)**