



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, $h = 6.63 \times 10^{-34} \text{ J.s}$

(ii) mass of an electron, $M_e = 9.11 \times 10^{-31} \text{ kg}$

(iii) Boltzmann's constant, $K_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$

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

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)**

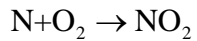
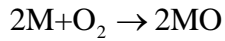
f) Briefly explain corrosion classification techniques. **(4marks)**

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:



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°C. 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 specific heats. **(6marks)**
- c) State the factors that determine the limits of solubility. **(8marks)**