MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2023/2024 ACADEMIC YEAR
FOURTH YEAR *SECOND* SEMESTER

SCHOOL OF PURE, APPLIED AND HEALTH SCIENCES
BACHELOR OF SCIENCE (PHYSICS)

COURSE CODE: PHY 4247-1

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.*

You may use the following constants in your calculations

Electronic rest mass m_e	=	9.10×10^{-31} kg
Planck's constant, h	=	6.63×10^{-34} J.s
Electronic charge e	=	1.60×10^{-19} C
Boltzmann constant k_B	=	1.381×10^{-23} JK^{-1}
Speed of light in vacuum c	=	3.0×10^{8}ms^{-1}
S.h.c water	=	4.19 Jg^{-1}K^{-1}

QUESTION ONE: [20 marks]

a) i. What is an Ellingham diagram (1mark)

ii. State the uses of the Ellingham diagram (2marks)

b) Explain the importance of heat in diffusion (3marks)

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

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

e) You are to decide if two pure metals will form substitutional solid solutions, state the factors that will inform your decision. (4marks)

f) i. Explain the term sintering (2marks)

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

QUESTION TWO: [15 marks]

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

b) On a well labelled diagram and with equations show the graphs of oxidation rates of a metal. (4marks)

c) Explain corrosion classification techniques. (4marks)

d) State Gibbs phase rule. Use the phase rule to calculate the number of degrees of freedom for a binary system. (3marks)

QUESTION THREE: [15 marks]

a) Consider the following two oxidation reactions:

$$2M+O_2 \Rightarrow 2MO$$
$$N+O_2 \Rightarrow NO_2$$

where M and N are metals. On a well labelled Ellingham diagram explain the variation of ΔG with T for the resultant reaction. (6marks)

b) i. State the Pilling-Bedworth ratio. (1mark)

ii. What scenarios arise when the Pilling-Bedworth ratio is: <1, >1 and >2-3. (3marks)

c) i. State the property that determines categorization of sintering. (1mark)

ii. State the four categories of sintering (4marks)

QUESTION FOUR: [15 marks]

a) 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)

b) State four features that distinguishes metals as unique class of engineering materials. (4marks)

c) You are mix two different metals, their composition will exist as both liquid and solid phases, according to the two-phase region in the diagram. By letting W_α and W_β be the fractional amounts by weight of solid and liquid, respectively, show that $W_\alpha = \frac{C_o - C_l}{C_s - C_l}$, where symbols have their usual meaning (5marks)