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#### MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

**FACULTY OF ENGINEERING, APPLIED SCIENCES AND TECHNOLOGY**

**DEPARTMENT: MINING AND MINERAL PROCESSING ENGINEERING**

**MODULE: PHYSICAL METALLURGY 1**

**CODE: ENGM221**

**SESSIONAL EXAMINATIONS**

**JUNE 2023**

**DURATION: 3 HOURS**

**EXAMINER: Miss F.E. CHARANGWA**

## INSTRUCTIONS

1. *Answer any four (4) questions*
2. *Start a new question on a fresh page*
3. *Total attainable marks 100*

***Additional material(s):*** *Calculator*

**Question One**

1. Briefly explain the main differences between ionic, covalent and metallic bonding; giving examples and the help of diagrams on each. **[6Marks]**
2. What type of bonding will be expected for each of the following materials; Bronze, Brass, Rubber, Barium sulphide (BaS) and Aluminium phosphide (AIP)? **[5Marks]**
3. Calculate the radius of a vanadium (V) atom, given that V has a BCC crystal structure, a density of 5.96 g/cm3 and an atomic weight of 50.9g/mol. **[4Marks]**
4. What are the major differences between an edge and screw dislocation, giving a detailed description of each? Which of them can cross slip?  **[10Marks]**

**Question Two**

* 1. Answer the following:
		1. What is fatigue and creep? **[2Marks]**
		2. Explain two different forms of fatigue? **[3Marks]**
	2. Explain:
		1. Fatigue limit. [**2Marks**]
		2. Low Stress fatigue fracture.  **[2Marks]**
		3. Brittle fracture. [**2Marks**]
	3. Distinguish the following:
		1. Engineering stress and true stress **[2Marks]**
		2. Ductility and malleability **[2Marks]**
		3. Point defects and line defects of a crystal **[2Marks]**
		4. Schottky and Frenkel defect **[2Marks]**
		5. Positive and negative dislocation **[2Marks]**
	4. Explain creep failure and ways of improving creep resistance in materials. [**4Marks**]

**Question three**

1. Briefly discuss the 3stages to fatigue failure. **[6Marks]**
2. Explain any two techniques for minimizing fatigue **[6Marks]**
3. Explain why small angle grain boundaries are not as effective in interfering with the slip process as are the high-angle grain boundaries **[4Marks]**
4. State and explain 3 strengthening mechanisms. In your description also include how dislocations are involved in each of the mechanism of strengthening. **[9Marks]**

**Question four**

1. Describe the concept of diffusion and briefly explain steady state diffusion. **[5Marks]**
2. Briefly discuss the **2** factors that affect the rate of diffusion. **[6Marks]**
3. Compare interstitial and vacancy atomic mechanisms for diffusion **[5Marks]**
4. A sheet of iron is exposed to a carburizing gas atmosphere on one side and a decarburizing (carbon-deficient) atmosphere on the other side at 675°C. If a condition of steady state is reached, calculate the diffusion flux of carbon through the plate if the concentrations of carbon at positions of 5 and 10mm beneath the carburizing surface are 1.2 and 0.8 kg/m3, respectively. Assume a diffusion coefficient of 3.5 × 10-11 m2/s at this temperature. **[5Marks]**
5. The stead state diffusion is found in the purification of hydrogen gas. Compute the number of kg of hydrogen that passes per hour through a 6mm sheet of palladium having an area of 0.25m2 at 600$℃$. Assume a diffusion coefficient of $1.7×10^{-8 }m^{2}/s$, that the concentration at the high and low pressure sides of the plate are 2.0 and0.4kg of hydrogen per cubic meter of palladium, and that steady-state conditions are reached. **[4Marks]**

**Question five**

Sketch the temperature – time diagram during the heating cycle of a 0.8% C steel. Use standard Fe-Fe3C phase diagram. Explain the characteristic of the 6 main phases involved in the phase diagram. **[25Marks]**

**Question six**

Metals basically undergo three stages with grain structure changes during thermomechanical processing. With the aid of clearly labelled sketches write short notes on the following:

1. Recovery **[5Marks]**
2. Grain growth **[5Marks]**
3. Recrystallization. **[5Marks]**
4. What are the advantages and disadvantages of a fine-grained microstructure? **[6Marks]**
5. Give 4 objectives of heat treatment processes. **[4Marks]**

**\*\*\*THE END\*\*\***