MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 221: ENGINEERING MATERIALS

DATE: 20/4/2023 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS:

- ✓ You should have the following for this exam
  - Answer Booklet
  - Non-programmable scientific calculator
- ✓ The examination consists of **FIVE QUESTIONS.**
- ✓ **Start each question you attempt on a fresh page**
- ✓ **Question 1 is COMPULSORY and Carries 30 Marks**
- ✓ **ANSWER QUESTION 1 and ANY other TWO QUESTIONS**
- ✓ Maximum marks for each part of a question are as indicated.
- ✓ Use of mobile phones in the exam room is **strictly prohibited**.
- ✓ If need be, supplementary materials shall be provided

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Discuss the several interrelated processes that are employed to produce steel at an integrated iron and steel plant. (6 marks)

b) Write about the three forms of iron outlining the associated carbon content of each form. (3 marks)

c) The Fig Q1B shows the process setup for the extraction of iron from its ore.

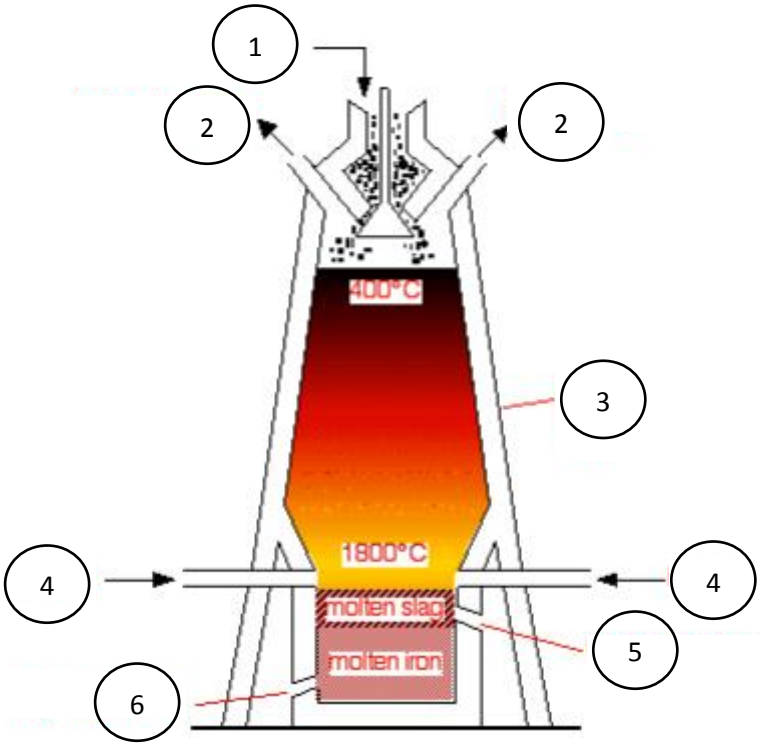

Fig Q1B

i) Describe the equipment used and identify the features numbered 1 through 6 (6 marks)

ii) Explain function(s) of each of the following and also indicate the chemical reactions in which they participate: (3 marks)

a) Coke

b) Limestone

c) Air

d) In the process shown in Fig Q1B above, coke of composition 94% C is used. Of the coke charged, 3.5% C is absorbed by iron and 90.5% C burns to CO only. Given that no CO_2 is produced by combustion of coke and assuming that the atomic masses of iron, Oxygen and carbon are 56, 16 and 12 respectively, calculate:

i) Volume of CO required to produce 1000kg iron. (2 marks)

ii) Weight of coke required to produce 1000kg iron. (2 marks)

iii) Volume of air to burn the coke amount determined in (ii) (3 marks)

iv) Volume and % composition of gases formed in combustion. (2 marks)

v) Volume and % composition of gases resulting in combustion and reduction. (3 marks)

QUESTION TWO (20 MARKS)

a) From a heat treatment perspective, discuss the various classes of steels available in the market and their use(s). (6 marks)

b) How would you describe the 302 or 304 grades of steels? (4 marks)

c) Explain the appropriateness of a combination of polymers and titanium alloys as materials for hip and joint replacement in human bodies. (10 marks)

QUESTION THREE (20 MARKS)

a) Discuss the designations and characteristics of wrought alluminium alloys available in the market. (6 marks)

b) From the perspective of physical properties, discuss the performance of alluminium as a structural material. (8 marks)

c) In redesigning an automobile for a new model year, 25 kg of conventional steel parts are replaced by aluminum alloys of the same dimensions. Approximating the alloy densities by those for pure Fe (ρ_{Fe} = 7.87 Mg/m^3) and Al, (ρ_{Al}= 2.70 Mg/m^3), calculate the resulting mass savings for the new model. (6 marks)

QUESTION FOUR (20 MARKS)

a) Cite major factors that determine the fabrication technique(s) used to form polymeric materials. (4 marks)

b) Using appropriate illustrations, compare and contrast compression, injection, and transfer molding techniques used to manufacture plastic components. (12 marks)

c) Which of the following polyethylene thin films would have the better mechanical characteristics: (1) those formed by blowing, or (2) those formed by extrusion and then rolled? Why? (4 marks)

QUESTION FIVE (20 MARKS)

a) Define a ceramic material and outline some of the properties common in ceramic materials. (3 marks)

b) Discuss the nature of the major commercial silicate glasses. (12 marks)

c) Based on the values given in Table Q5 below and using Pauling's equation, compare the percent covalent character of the following compounds: hafnium carbide, titanium carbide, tantalum carbide, boron carbide, and silicon carbide. (5 marks)

Table Q5

Compound	Electronegativities	
	X_A	X_B
HfC	1.2	2.5
TiC	1.3	2.5
TaC	1.4	2.5
BC	2.0	2.5
SiC	1.8	2.5