L-1/T-2/IPE **Date: 16/09/2025**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2023-2024

Sub: **MME 195** (Engineering Materials-I)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) A steel pin initially has a diameter of 10.2 mm. It is stretched in tension beyond its yield point so that its diameter reduces plastically to 9.98 mm during loading. The pin is then inserted into a precision-machined hole while under load, and the tensile force is removed afterward. The yield strength of the steel is 420.84 MPa, and the modulus of elasticity is 210 GPa. To ensure that no residual stress remains in the pin after unloading, what should be the diameter of the hole? (Hint: There will be no residual stress if the size of the hole is exactly equal to the pin's final diameter. **(12)**

   (b) Grain size reduction is a prominent strengthening mechanism in metals. If a plain carbon steel sample is strengthened through grain refinement, predict and explain how this would affect its ductile-to-brittle transition behaviour and creep performance. **(16)**

   (c) Explain the concept of non-linear elastic behaviour in materials. Analyze its importance by identifying a practical scenario or application where such behaviour is required. **(7)**

2. (a) In steelmaking, both sulphur and phosphorus must be removed, though their removal conditions differ. Analyze how both elements are effectively removed in modern EAF steelmaking practice and evaluate the advantages of the EAF process in achieving high quality steel. **(15)**

   (b) Iron ore contains not only iron oxide but also various rocky gangue materials that do not melt at furnace temperatures and may cause clogging. Explain how this issue is addressed in the blast furnace process. **(10)**

   (c) In continuous casting, sticking of the solidifying metal to the mould walls is a critical issue that can compromise surface quality and process efficiency. Discuss the methods commonly used in CCM operations to prevent mould wall sticking. Also, differentiate between the primary and secondary cooling processes in CCM **(10)**

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3. (a) What do you understand by non-destructive testing? Explain how the concept of fracture mechanics is applied in material selection and component design, and how NDT supports this process. **(18)**

   (b) A relativity large plate of a glass is subjected to a tensile stress of 50 MPa. If the specific surface energy and modulus of elasticity for this glass are 0.4 J/m^2 and 65 GPa, respectively, determine the maximum length of a surface flaw that is possible without fracture. **(12)**

   (c) Discuss how case hardening enhances the fatigue properties of a material. **(5)**

4. (a) Using appropriate microstructures, examine the structure-property relationships that contribute to the superior strength and toughness of nodular cast iron over grey cast iron. Also, describe the process used to produce nodular cast iron. **(15)**

   (b) Identify the shortcomings of nickel steel and chromium steel, and evaluate how nickel-chromium steel addresses these limitations. **(14)**

   (c) Describe the strategies employed to mitigate pitting corrosion. **(6)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) With necessary schematics, compare the close packing sequence of the atoms in Al (FCC) and Mg (HCP) crystal structures. Also draw the unit cells of FCC and HCP crystal structures, identifying the close packed planes of these unit cells. **(9+8=17)**

   (b) Assume a steel contains 50wt% ferrite and 50wt% pearlite at 727°C. Determine the composition of the steel and calculate the amount of procutectoid ferrite, and eutectoid ferrite. **(18)**

6. (a) A binary alloy having 28.1% Cu and balance Ag solidifies at 779°C and the solid consists of two phases α and β. Phase α being rich in copper has 92% Cu whereas phase β has 91.2% Ag at 779°C. At room temperature, these phases are pure Cu and pure Ag, respectively. Construct the phase diagram in a graph paper labeling all phase fields. Melting points of pure Cu and pure Ag are 1083°C and 960°C, respectively. **(17)**

   (b) A molten Cu-Ag alloy having 5% Ag is allowed to cool slowly till room temperature. With necessary schematics, elucidate the microstructural development of the alloy from its melting point to room temperature. **(13)**

   (c) Does this Cu-Ag system have any alloy that undergo an invariant reaction? If yes, identify the invariant reaction and select the range of those alloys undergoing that reaction. **(5)**

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7. (a) Show that the atomic packing factor of both FCC and HCP are the same. Comment on the difference of their mechanical properties despite having the same packing factor. **(15+3=18)**

   (b) For a eutectoid steel, illustrate the microstructural development along with the changes that occurred though the eutectoid reaction while it is slowly cooled from the austenite region. **(17)**

8. (a) A steel sample containing 0.4 wt% C is heated to 950°C, held there for 2 hours, followed by water cooling. Explain what microstrucutal and crystallographic changes occur in the steel sample during water cooling. After water cooling, if the steel sample is reheated to 600°C and held for 2 hours, what changes would you expect in its microstructure and mechanical properties. **(17)**

   (b) In carburizing process, heat treatment after carburizing the sample is necessary to get the desired hardness whereas in nitriding process, no such post treatment is needed-why? **(10)**

   (c) Suppose, you are provided with a medium carbon steel wire that has been heavily drawn. Justify a suitable heat treatment schedule to restore its ductility. **(8)**