FACULTY: ENGINEERING

FIRST SEMESTER EXAMINATIONS

2016/ 2017 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE CODE: GNE 231

COURSE TITLE: SCIENCE OF MATERIALS – 3 UNITS

DURATION: 3 HOURS

INSTRUCTIONS

1. ATTEMPT ANY **FIVE** QUESTIONS OF YOUR CHOICE
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM
3. YOU ARE NOT ALLOWED TO BORROW CALCULATORS AND ANY OTHER WRITING MATERIALS

1. (a) List four criteria for material selection. **(4 marks)**

(b) Briefly discuss the fundamental classification of most engineering materials and list the factors that form this basis of classification **(4 marks)**

(c) Define the following:

i. Thermoplastic

ii. Thermosetting plastics **(2 marks)**

(d) Give an example of each of the following types of materials:

i. Bio-materials

ii. Organic polymers

iii. Composites

iv. Smart materials

v. Nano structured materials

vi. Quantum dots materials **(6 marks)**

(e) For each of the following compounds, state whether the bonding is essentially metallic, covalent, ionic, van der Waals, or hydrogen:

i). Ni, (ii) ZrO_2, (iii) graphite, (iv) solid Kr, (v) Si, (vi) BN, (vii) SiC, (viii) Fe_2O_3. **(4 marks)**

2. (a) List four fundamental concepts of atomic structure **(2 marks)**

(b) List four assumptions of Bohr atomic models **(4 marks)**

(c) Explain with a schematic the energy level for a hydrogen atom **(3 marks)**

(d) With a schematic diagram explain the differences between Bohr and wave mechanical atomic models **(3 marks)**

(e) Define the following:

i. Isotopes

ii. Isotones

iii. Microstructure

iv. Whiskers

v. Single crystals

vi. Principal quantum number

vii. Fatigue striations

viii. Beachmarks **(8 marks)**

3. (a) Explain with a schematic diagram the typical creep curve of strain versus time at constant stress and constant elevated temperature. **(3 marks)**

(b) Define the following terms: **(6 marks)**

i. Co-ordination number

ii. Atomic radius

iii. Atomic packing factor

(c) Sketch the FCC and BCC unit cells and give one example of a metal that crystallize in each of the structures. **(6 marks)**

(d) With a schematic diagram explain the relationships between (i) force and separation distance (ii) energy and separation distance showing their equilibrium inter-atomic separation distance at which atom enters into bonding. **(5 marks)**

4. (a) Sketch the approximate Pressure-Time equilibrium phase diagram for pure iron **(6 marks)**

(b) Distinguish between the following three types of plain-carbon steel: Eutectoid, hypoeutectoid and hypereutectoid. **(6 marks)**

(c) A 10 mm diameter, 500 mm long stainless steel 309 rod is subjected to a tensile load of 30 kN. what is the engineering stress experienced by the rod? Show that the rod will return to its original length after the tensile load is removed. Then determine resultant elongation of the rod. The stainless steel 309 has yield strength of 290 MPa and modulus of elasticity of 200 GPa. **(8 marks)**

5. (a) With the aid of a stress-strain curve, explain the relationship between high, medium and low carbon steel in terms of their toughness. **(6 marks)**

(b) Evaluate the packing efficiency and density of sodium chloride if the radius of the sodium ion and chlorine ion are 0.98 Å and 1.81 Å respectively. Their atomic masses can be taken as 22.99 amu for sodium and 35.45 amu for chlorine. **(4 marks)**

(c) Explain the numbering system used by the AISI for plain carbon steel. **(5 marks)**

(d) Determine whether each of the electron configurations given below is an inert gas, a halogen, an alkali metal, an alkaline earth metal or a transition metal.

i. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$

ii. $1s^2 2s^2 2p^6 3s^2 3p^6$

iii. $1s^2 2s^2 2p^6 3s^2$

iv. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

v. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ **(5 marks)**

6. (a) A cylindrical specimen of a certain alloy of diameter 1 cm and length of 4 cm is subjected to a tensile test. The maximum load withstood by the specimen is 8 kN. Calculate the:

i. Tensile load at yield

ii. Maximum extension which the specimen can undergo without deforming plastically

iii. Ultimate tensile strength.

(Take the alloy's elastic modulus as 70 GPa and its Yield Strength as 40 MPa). **(6 marks)**

(b) Briefly discuss the process of reducing the thickness or changing the cross-section of a long workpiece by compressive forces **(3 marks)**

(b) Aluminium has FCC structure. Its density is 2700 kg/m^3. Find the unit cell dimensions and atomic diameter. Given atomic weight of Al = 26.98 **(5 marks)**

(c) For a brass alloy, the stress at which plastic deformation begins is 345 MPa and the modulus of elasticity is 103 GPa.

i. What is the maximum load that may be applied to a specimen with cross sectional area of 130 mm^2 without plastic deformation?

ii. If the original specimen length is 76 mm, what is the maximum length to which it may be stretched without causing plastic deformation? **(6 marks)**

7. (a) Explain the transformation associated with each of Eutectic, Eutectoid and Peritectic reactions. **(6 marks)**

(b) Differentiate between the structures of α-Ferrite, Austenite and Cementite during the slow cooling of steel. **(6 marks)**

(c) List the stages in the cup-and-cone fracture formation. **(4 marks)**

(d) A hypoeutectoid plain carbon steel that was slow-cooled from the austenitic region to room temperature contains 9.1 wt % eutectoid ferrite. Assuming no change in structure on cooling from just below the eutectoid temperature to room temperature, what is the carbon content of the steel? **(4 marks)**