ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA

DEPARTMENT OF MECHANICAL ENGINEERING

FIRST SEMESTER EXAMINATION
2019/2020 ACADEMIC SESSION

COURSE: MEE 311 – Physical Metallurgy
CLASS: 300 Level Mechanical Engineering

HOD'S SIGNATURE

INSTRUCTIONS:

(i) Answer Questions **1** & **2** and **ANY** Other **Three** Questions
(ii) Time Allowed: **3 Hours**

The following constants/parameters may be useful:

Boltzmann's constant, k	=	1.38×10^{-23} J/K
Electron charge, q	=	1.602×10^{-19} C
Electron rest mass, m_e	=	9.11×10^{-31}kg
Neutron rest mass, m_N	=	1.68×10^{-27} kg
Planck's constant, h	=	6.62×10^{-34} J/s
Permittivity of vacuum, ε_o	=	8.85×10^{-12} farad/meter
Permeability of vacuum, μ_0	=	$4\pi \times 10^{-7}$ H/m
Velocity of light, c	=	3×10^8 m/s
Avogadro's Number, N	=	6.023×10^{26} $(kg\ mol)^{-1}$
Universal Gas Constant, R	=	8.314×10^3 J/(kg mol . K)

1(a) (i) State the Heisenberg's uncertainty principle. (ii) Why is the principle not significant for large objects? (iii) How significant is it for an electron? (iii) What are leptons and Baryons?

(b). Derive the expression for the Schroedinger equation in three dimensions.

(c). Write an expression for the "quantized condition" for the energy values of the atomic system. Hence or otherwise, determine the frequency of the quantum of radiant energy given off when the electron in an excited hydrogen atom falls from energy state E_2 to E_1. If $\lambda\nu = c$, where c is the velocity of light, calculate the corresponding wavelength of the radiation.

2(a). Define Hardness, as a material-mechanical property.

(b). Describe briefly, with the aid of schematic diagrams and relevant equations, the following hardness test methods: (i) Brinell Hardness Test; (ii) Vickers Hardness Test; (iii) Rockwell Hardness Test and (iv) Shore Scleroscope Hardness Test.

(c). Given that the test data for a certain material has the relationship: $HV = 2.9\sigma_y$, where σ_y = yield stress measured at a strain of 0.08 more than that at which the hardness is measured, and HV is the diamond pyramid hardness of a material in a particular state of strain. If the pertinent material has a stress – strain curve given by

$$\sigma = ae^{0.32}$$

where σ = true stress, e = linear strain, a = constant. Determine from "first principles", an expression for the tensile strength of the material in terms of the measured value of HV for the specimen.

3(a). Explain briefly, with schematic diagrams and relevant examples, the different types of bonds in engineering materials.

(b). Explain briefly, why (i) solid solution alloys show lower electrical conductivities compared to their pure metals; (ii) is annealed cold-drawn copper wire used as electrical conductor rather than as-drawn wire? (iii) is graphite (a non-metal) an electrical conductor?

(c). What are the two major mechanisms that affect or result in good thermal conductivity?

4(a). (i). Define the terms Polymorphism and Allotropy

(ii). Show in a well-labelled diagram/plot the allotropic changes in Iron, with respect to temperature at atmospheric pressure.

(b). Show in a schematic plot, the volume change vs temperature curve for different allotropes of iron (Fe).

(c). What are the factors affecting the transition temperatures in materials?

5(a). Define the terms (i) Enantiotropy and (ii) Monotropy (both as polymorphic changes).

(b). Calculate the % volume change in titanium that has undergone a phase change from BCC to HCP at 880 ^{0}C on cooling, if the lattice parameters are;

$a_{bcc} = 3.32$ Å; $a_{hcp} = 2.956$ Å and $c = 4.683$ Å.

(c). Draw a well labelled graphic plot of the tensile stress-strain curve for elastic (brittle Al_2O_3) and plastic (in addition to elastic) material (low carbon steel).

6(a). Distinguish between (i) Toughness and Brittleness in metals; (ii) Stable and Unstable fractures (iii) Izod and Charpy impact tests.

(b). What are the three major factors present in the impact test that are absent in the tensile test?

(c). What are the advantages and limitations of the Izod Impact Test?

7(a). (i) Define creep and creep stress relaxation. (ii) Describe briefly, the two major types of creep tests.

(b). A series of creep tests at constant stress on an Al-Cu alloy gave the following results for the minimum creep strain rate:

Temperature (^{0}C)	Minimum creep strain rate (h^{-1})
140	0.04
180	0.17
220	0.75
260	3.26
300	6.57

Suggest a suitable analytical form for the relationship between creep rate and temperature and evaluate all the constants in such a relationship. (R; molar gas constant = 8.314 J/mol/k).

(c). (i) Derive the expression for the relationship between stress and Time in stress relaxation.

(ii) A steel bolt is loaded in tension to 10,000 psi and rigidly Attached at both ends. After 3 years of service at (620 ^{0}C), what is the stress in the bolt? (Take $E = 22.5 \times 10^8$ psi, $B = 3 \times 10^{-40}$ %(h) psi and $n' = 8$).