UNIVERSITY OF GHANA

FACULTY OF ENGINEERING SCIENCES

BSc. (ENG) FIRST SEMESTER EXAMINATIONS: 2012/2013

MTEN 303 INTRODUCTION TO MATERIALS PROCESSING (2 Credits)

TIME ALLOWED: 2 Hours 30 Mins.

Answer ALL Questions : (This paper is divided into 3 sections; Metals, Polymers and Ceramics)

SECTION A: Metals

Question 1

a) One of the hazards during pouring is that, buoyancy of the molten metal will displace the core. Write an expression that supports this statement.

b) A 92% aluminum-8% copper alloy casting is made in a sand mold using a sand core that weighs 20 kg. Determine the buoyancy force in Newtons tending to lift the core during pouring. (1kg = 9.81N)

c) State the continuity law as applied to the flow of molten metal in casting?

d) A mold sprue is 20 cm long, and the cross-sectional area at its base is 2.5 cm^2. The sprue feeds a horizontal runner leading into a mold cavity whose volume is 1560 cm^3

Determine;

(i) Velocity of the molten metal at the base of the sprue,

(ii) Volume rate of flow, and

(iii) Time to fill the mold.

7

Question 2

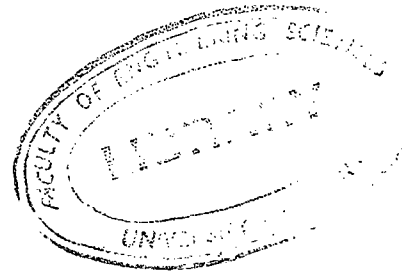
a) What is the difference between permanent mold casting and semi-permanent mold casting?

b) Identify the two sources of contraction in a metal casting after pouring.

c) A sand core used to form the internal surfaces of steel casting experiences a buoyancy force of 23 kg. The volume of the mold cavity forming the outside surface of the casting is 5000 cm^3. What is the weight of the final casting? (**Hint**: Ignore considerations of shrinkage).

d) The housing for a certain machinery product is made of two components, both aluminum castings. The larger component has the shape of a dish sink, and the second component is a flat cover that is attached to the first component to create an enclosed space for the machinery parts. Sand casting is used to produce the two castings, both of which are plagued by defects in the form of misruns and cold shuts. The foreman complains that the parts are too thin, and that is the reason for the defects. However, it is known that the same components are cast successfully in other foundries. What other explanation can be given for the defects?

20 Marks



SECTION B: Polymers

Question 1

a) How do the properties of thermosetting polymers differ from those of thermoplastics?

b) Cross-linking (curing) of thermosetting plastics is accomplished by one of three ways. Name these three ways.

c) What is the difference between glass transition temperature (T_g) and melting temperature (T_m) of a polymer?

d) As a young Engineer, briefly describe any two methods that you will use in the processing of a thermoplastic polymer.

e) Copolymers can possess four different arrangements of their constituent 'mers'. Name and briefly describe the four arrangements.

Question 2

a) What are the two methods by which polymerization occur? Briefly describe these two methods.

(b) Compute the repeat unit molecular weights for the following;

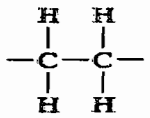
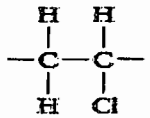
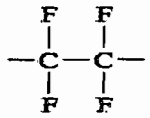
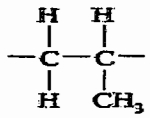
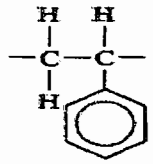
(i) Poly(vinyl chloride) (PVC)

(ii) Polyethylene (PE)

(iii) Polypropylene (PP)

(**Table 1** is the list of repeat unit chains with their respective number of carbons, hydrogens and other functional moieties in the repeat units: Atomic units for Carbon =12.0 g/mol, Hydrogen= 1.0 g/mol and Cl= 35.5 g/mol)

Table 1. Repeat Unit Chains for some selected Polymers

Polymer	*Repeat Unit*
Polyethylene (PE)	
Poly(vinyl chloride) (PVC)	
Polytetrafluoroethylene (PTFE)	
Polypropylene (PP)	
Polystyrene (PS)	

(d) Table 2 below, provide the list of molecular weight data for a polypropylene material. Compute;

(i) The number-average molecular weight

(ii) The weight-average molecular weight, and

(iii) The degree of polymerization.

Table 2. Molecular weight data for polypropylene

Molecular weight range (g/mol)	x_i	w_i
8,000-16,000	0.05	0.02
16,000-24,000	0.16	0.10
24,000-32,000	0.24	0.20
32,000-4,000	0.28	0.30
40,000-48,000	0.20	0.27
48,000-56,000	0.07	0.11

25 Marks

Section C: Ceramics

Question 1

a) What does the study of ceramics entail?

b) The following are X-ray fluorescence data on three ceramic raw materials; (A, B & C). On the basis of this data, identify these three raw materials and give three inferences from each data to justify your answers.

X-ray fluorescence data

Raw Materials	LOI	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O
Sample **A**	30.90	0.77	60.8	5.80	1.67	0.02	0.03	Trace	0.02
Sample **B**	0.20	98.27	0.67	0.14	Trace	0.04	0.03	0.13	0.08
Sample **C**	13.02	46.06	38.40	0.68	1.09	0.08	0.07	0.09	0.09

Question 2

a) (i) State Newton's law of viscous flow.

(ii) For a laminar flow of liquid in a pipeline, derive an expression for coefficient of viscous flow.

(iii) Draw the graphs for the types of flow you know of and explain why they meet the stress axis at different points.

Question 3

(a) In determining the Apparent Porosity and Bulk Density of a roof tile, a Materials Engineer applied the Archimedes' principle and obtained the following results:

Weight of a test piece of the dry roof tile suspended in air = 58.8 g

Weight of soaked test piece of the roof tile in water = 33.0 g

Weight of soaked test piece of roof tile in air = 63.0 g

Calculate;

(i) The Bulk Density of the roof tile

(ii) The Apparent Porosity of the roof tile

If the specific gravity of the particles that make up the roof tiles is 3.0.

(iii) Calculate the True Porosity of the roof tile.

(iv) What inference could you draw from the Apparent and True Porosity values?

25 Marks