UNIVERSITY OF GHANA

BSc. MATERIALS SCIENCE AND ENGINEERING

FIRST SEMESTER EXAMINATION: 2018/2019

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MTEN 303: INTRODUCTION TO MATERIALS PROCESSING (3 Credits)

INSTRUCTIONS: ANSWER ALL QUESTIONS **TIME ALLOWED:** 3 HOURS

1. (a) Explain briefly the differences between jet milling, vibratory milling, and agitated ball milling.

(i) Which technique would you use if you wanted to obtain a particle size of (less than) < 1 μm and why?

(ii) Which technique would you use and why if maintaining the purity of your powder was your primary concern?

(b) Keramica-UG is a new company that wants to manufacture alumina furnace tubes and they hire you as a consultant. You are asked to propose a process for the fabrication of such tubes. Give a general description of the process you would propose. Explain the roles of the different steps involved.

(c) With the aid of a plot, compare wet and dry milling. Enumerate factors that affect the milling rate in ball milling.

[20 marks]

2. (a)

(i) Explain briefly the types of shaping operations in manufacturing.

(ii) With the aid of a diagram, explain sintering.

(iii) Distinguish between Isostatic and uniaxial pressing.

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(b) (i) Draw LaMer diagram for precipitation process.

(ii) Plot the free energy versus nucleus radius diagram for nucleation process including the resultant curve and surface and volume contributions.

(iii) From question 2(b) (ii) and assuming that crystals are spherical particles with radius, r. Derive an expression for the critical size beyond which the crystal is stable during homogeneous nucleation.

(c) Using appropriate flow diagram or chemical equations, explain Sol-Gel processing.

[20 marks]

3.

(a) Describe briefly an experiment to determine the fluidity of molten metal.

(b) A large steel sand casting shows the characteristic signs of penetration defect - a surface consisting of a mixture of sand and metal.

(i) What steps can be taken to correct the defect?

(ii) What other possible defects might result from taking each of these steps?

(c) The total solidification times of three casting shapes are to be compared: (α) a sphere with diameter = 10 cm, (β) a cylinder with diameter and length both = 10 cm, and (γ) a cube with each side = 10 cm. The same casting alloy is used in the three cases.

(i) Determine the relative solidification times for each geometry.

(ii) Based on the results of part (i), which geometric element would make the best riser?

(iii) If $C_m = 3.5$ min/cm^2 in Chvorinov's rule, compute the total solidification time for each casting.

(d) Describe hydrothermal synthesis and enumerate at least 2 advantages of using this technique.

[20 marks]

4. (a)

(i) Explain briefly the following: glass-transition temperature and crystallinity in polymers.

(ii) What is crazing in polymer processing? Explain its relevance in crack initiation and propagation.

(b)

(i) List the main differences between thermosetting and thermoplastics.

(ii) Explain how cross-linking improves the strength of polymers.

(iii) With aid of sketches, describe the four arrangements 'mers' in polymer networking.

(c) Mention two polymer processing methods and describe one of these.

[20 marks]

5. (a) Explain why castings may have a slightly different shape than the pattern used to make the mould. Cite an example with drawings.

(b) Draw diagrams to show the following casting defects and give the possible causes; cold shut, misruns, and inclusions.

(c) Would you recommend pre-heating moulds in permanent-mould casting? Justify your answer.

(d) In the design of sprues, the shape of the sprue can be determined by using two important equations. Assuming that the pressure at the top (1) of the sprue is equal to the pressure at the bottom (2) and that there are no frictional losses, at any point in the sprue.

(i) Write down these two equations.

(ii) Prove that the relationship between the height, (h) and cross-sectional area, (A) is by a parabolic relationship: $\frac{A_1}{A_2} = \sqrt{h_2/h_1}$

[20 marks]