Department of Mechanical Engineering – Clemson University

PhD Qualifying Examination

MATERIALS

IMPORTANT:

You are to answer all four (4) given problems.

Each problem will be weighted equally for grading purposes.

The examination is closed book.

Duration of the Exam: Two (2) Hours

Write and Draw Legibly or No Credit

Student Identifying Number _____

1. The stress-strain behavior of a metal alloy is described by $\sigma = 500*(1+\varepsilon)$:

(a) Is the material strain hardening? Why or why not?

(b) Why does a strain hardening material behave as it does? That is, what is (are) the physical mechanism(s) of strain hardening behavior?

(c) If the material fractures at 100% strain, what is the average flow stress of a fractured specimen?

(d) Estimate toughness for the material defined in (a) and (c). Pay specific attention to units

2. The (heat-treatment) hardening process for metals is important to give good wear resistance and long life.

(a) Explain the difference between through hardening and case hardening of high-carbon steels. In what situations is each process favorable? Describe a specific process used for each.

(b) Choose and describe a hardness testing method for metals.

(c) What is the purpose of quenching in the hardening process for high-carbon steel? What microstructural changes take place and what material properties are imparted?

(d) What is the purpose of tempering in the hardening process for high-carbon steel? What microstructural changes take place and what material properties are imparted?

3. (a) Explain the difference between the thermoplastics, thermoset, and elastomers, and provide an example polymer for each.

(b) When plastics undergo long-term loading, they exhibit two important properties; Creep and Stress Relaxation; explain these phenomena and propose a test to measure each.

(c) Draw a graph which shows the deformation resistance vs. temperature for:

- **a100% Crystalline polymer,**
- **a 50% Crystalline polymer, and**
- **an amorphous polymer,**

while indicating, on the graph, the glass transition and melting temperatures

4. Draw an A-B binary phase diagram containing one eutectic transformation and two (limited-solubility) terminal solutions, α and β. Make sure that the drawing is large enough so that it could be fully labeled.

(a) Label the axes and the melting points $T_{m,A}$ and $T_{m,B}$;

(b) Label all phase fields and identify the phases;

(c) Label the eutectic temperature and the eutectic composition;

(d) Label the point at which the solubility of B in A is maximal;

(e) Indicate the composition range for the A-B alloys which are suitable for casting; and

(f) Indicate the composition range for the B-based A-B alloys which are suitable for cold working;