Donald P. Shiley School of Engineering
EGR 221 Materials Science
Assignment 12, Fall 2015

1a) If two parts, a big thick part and small thin part, both made from eutectoid composition steel are quickly cooled from being austenite, will they likely have the same microstructure? Explain.

ANS: A larger part will take longer to cool down – therefore, it will have a slower quench rate. This may result in differing microstructures (quickly cooled produces martensite, less quick can result in pearlite).

1b) Why may martensite crack upon quick cooling?

ANS: martensite is brittle and will fracture (crack) if even relatively small strain is induced. With quenching from austenite, thermal gradients will form (hot inside, cooler outside of the part) and hence thermal expansion/contraction will result in thermal strain – potentially causing quench cracks.

For the next few questions, you may use online resource, textbook, etc., and/or the following: http://faculty.up.edu/lulay/egr221/EngineeringMaterials.pdf

2) Answer the following:

a) Briefly explain the four digits used by AISI to designate steel alloys. What is the difference between AISI 1020, 1040, and 4340 steels?

ANS: the first two digits are a code telling the alloy composition. "10xx" is plain carbon, and "43xx" indicates additional alloying elements besides carbon. The second two digits indicates the carbon content. "xx20" indicates 0.20wt%C and "xx40" indicates 0.40wt%C.

b) What is unique about gray cast iron that makes it useful in many heavy machinery applications?

ANS: gray cast irons have very good wear characteristics and fatigue characteristics.

c) What is stainless steel? What are the alloying elements that make it "stainless" and what are its applications?

ANS: stainless steels are steel alloys that contain at least 10.5wt% chromium. Have excellent corrosion resistance in an oxidizing environment (such as water) – but poor in a reducing environment (such as salt water). Specific alloys have excellent corrosion resistance in specific environments.

3) Answer the following: REF: http://faculty.up.edu/lulay/egr221/EngineeringMaterials.pdf

a) What are tool steels? Give one example and very briefly describe its applications.

ANS: they are steel alloys that are very hard and tough. They are used in making of tools (tools typically being something used to form or cut other metals). Dies used to form aircraft rivets is one example of an application of a tool steel.

b) What are maraging steels? How does their composition differ from other steels? What are their unique properties?

ANS: they are high strength steels that gain their strength from non-carbon elements. They have high strength, very high fracture toughness (resistance to crack growth) and are very weldable – these combinations of properties is unique.

c) What are refractory metals?

ANS: refractory metals are alloys that can be used at extremely high temperatures (1650°C)

4) Answer the following:

a) When and by whom was aluminum first extracted in pure form?

ANS: A pure form of the metal was first successfully extracted from ore in 1825 by Danish chemist Hans-Christian. Techniques to produce aluminum in ways modestly cost-effective emerged in 1889. http://www.aluminum.org/aluminum-advantage/history-aluminum

b) For aluminum alloys, what do the following temper designations mean: T6, T3, F

ANS: T6 – Solution heat treated and artificially aged, T3 - Solution heat treated, cold worked, naturally aged, F - As fabricated

c) What is meant by "wrought" aluminum alloys? *ANS: wrought means formable.*

d) Aluminum is a fairly active element so why is it corrosion resistant in ambient atmosphere? (the textbook might be a good resource for this – or google).

ANS: aluminum is very reactive and forms a protective oxide layer when exposed to the atmosphere. This renders it to be corrosion resistant in many environments (but not all).

5) Describe each of the following. What is the molecular structure that distinguishes them from each other (hint, you should include descriptions such as "networked," "cross linked," and/or "linear"). **Sketches are a good idea!** Give one example of each from every-day life.

a) thermosetting polymer *ANS: these start out as fluid-like short polymer chains, then are cured by UV light, heat, or chemical reaction. The "curing" means the short polymer chains are cross-linked or networked to form a large complex molecule. They will not melt upon heating (but do suffer chemical breakdown). Examples: epoxy (2-part glue, etc.), tooth fillings.*

b) thermoplastic polymer *ANS: these are long polymer chains that are either linear or branched. Thermoplastics melt when heated. Examples: butter, most plastic toys.*

c) Elastomers *ANS: long "kinky" polymer chains that straighten when pulled. They have a nonlinear stress-strain curve, but when unloaded return to their original size and shape. Rubber bands are elastomers.*

6) Define the following:

a) Copolymer. *ANS: polymers made from more than one type of mer (or monomer).*

b) polymerization *ANS: the chemical process of combining many monomers into a long polymer chain.*

c) degree of polymerization *ANS: the longer the polymer chain (i.e. the higher the molecular weight), the higher the degree of polymerization.*

d) saturated and unsaturated bonds *ANS: saturated means that all the carbon bonds are single bonds. Unsaturated means some of the carbon bonds are double bonds.*

7) The purpose of this question is to expose students to some very unique materials. As engineers, you never know when one of these may provide the much needed solution to a problem you are working on. I hope you read beyond just enough to answer the questions…but that's up to you. To find the answers to all of these questions, follow the links at the bottom of the course web page.

ANS: the main educational purpose of this set of problems was for the students to investigate a few interesting materials. Then answers are less important than the process of inquiry.

a) How much stronger are carbon nano-tubes than conventional carbon fiber composites?
b) Name one ceramic that has negative thermal expansion.
c) What are correlated magnets?
d) Name one application of hydrophobic materials.
e) What is a piezoelectric material and what is one application for which they are used?

8) What is the atomic number of each of the following and briefly describe their origin in the universe:

a) Hydrogen – *ANS: The Big Bang (along with helium)*
b) Carbon – *ANS: Created through fusion process inside stars. So some star had to die a long time ago in order to shed its carbon into the interstellar medium, which eventually has found its way into all living creatures.*
c) Gold – *ANS: gold is not made inside stars. The formation of gold by fusion requires energy and therefore, cannot be self-sustaining. All elements heavier than iron (Fe) were formed in supernova explosions (that's how really big stars (bigger than the sun) end their lives --- really, really big boom – more energy produced during a supernova explosion than the total energy produced by all of the other stars in the galaxy combined!).*