Midterm 1 (v. 2.2) Key (Ave 88, High 100 (3), Low 72)
BE-410, Spring '09, Dr. C. S. Tritt

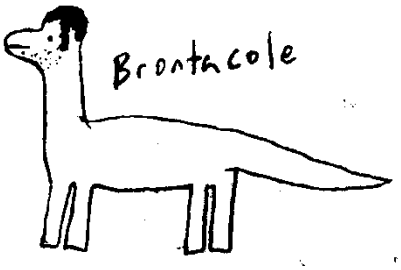
This is a closed book, closed notes, 1 hour test. Write your answers on the blank paper provided. Please consider your answers for a few moments before you starting writing to may them more coherent. Please try to make your answers succinct. A short, clear answer is much better than a verbose, vague one. Partial credit will be given and some questions may have multiple answers that are drastically different. Each of the following 10 questions is worth the same amount.

1. In the context of biomaterial applications, briefly explain what the term failure means.

Failure occurs when a material or device ceases to perform its desired function. While fracture is probably the most obvious type of material failure, excessive deformation and even discoloration can result in failure in particular circumstances.

2. A metal tube in a medical device cracks after 18 months of frequent use and during otherwise normal device operation. During use the tube is subject to a 3.0 Hz pulsatile pressure wave form. What is the mostly likely cause or mechanism of this failure? Briefly explain the reasoning that led to your answer.

The most likely cause of this failure is fatigue. Fatigue failure is characterized by occurring under normal load after prolonged use and particularly in situations involving cyclic loading. All these criteria exist in this example. While creep or stress relaxation also occurs after prolonged use, it generally involves excessive deformation rather than fracture and most metals are not subject to creep. Saying creep was −6.



3. Briefly explain what the piezoelectric effect is and name **or** describe a biomedical application of this effect.

Piezoelectric effect is the deformation of a crystal resulting from the application of an electric field or the production of an electric field by the deformation of a crystal. Note that only certain types of crystalline materials exhibit this effect. Biomedical applications of the

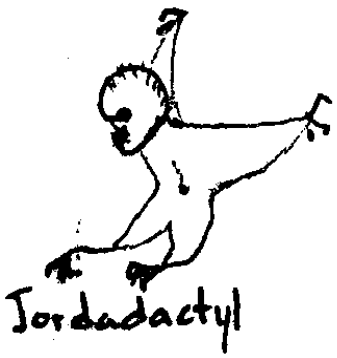
piezoelectric effect include medical ultrasound imaging transducers, scanning program microscopes and crystal controlled oscillators. Not providing an application was −4.

4. Describe in general terms and limited detail how **either** scanning electron microscopes **or** scanning probe microscopes work and the type of output (image, chemical analysis, etc.) produced.

See slide deck for description and sketch. Describing a device different from the one named was −3.

5. Use the attached phase diagram to find the sequence of states (just the phase or phases present, not its/their relative amounts) that an alloy containing 71% Zn and 29% Cu would go through when cooled from 1000°C to 300°C. Note the approximate temperature of each phase transition.

See the red line on the attached diagram. The phases are: all liquid, liquid and solid γ, solid γ and δ and, finally, solid γ and ε. Each incorrect pair about −3 points.



6. Continuing with the same phase diagram but now considering a mixture of 40% Zn with 60% Cu, in what relative amounts would the phase or phases be present at 500°C and what would its/their composition(s) be?

See the blue lines on the attached diagram. The phases present are α and β. The α phase consists of about 39% Zn, 61% Cu (3 pts) and the β phase consists of about 44% Zn, 56% Cu (3 pts). Using the inverse lever rule, the weight fraction of α would be:

$$x_\alpha = \frac{44-40}{44-39} = 0.80$$

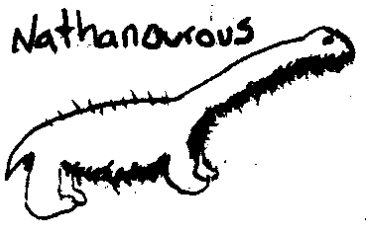
and the weight fraction of β would be:

$$x_\beta = 1.0 - 0.80 = 0.20$$

Weight fractions worth 4 points.

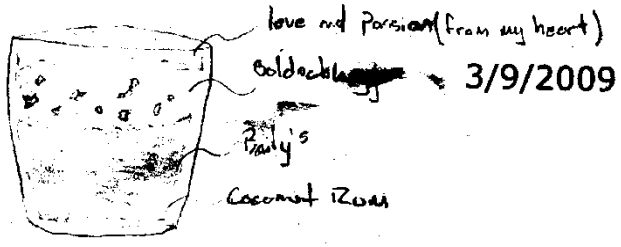
7. Describe in some detail some particular metal forming or processing technique including typical applications of it (what types of shapes it is used to produce and/or in what types of situations it used).

Any of the following: casting (particularly lost wax or investment casting), forging, machining, welding, stamping, rolling, powdered metal sintering, pasivation, anodization or galvanization. See slide decks for descriptions.



8. Choose a particular metal or metallic alloy commonly used a biomaterial and describe in some detail its general and specific features that make it of value to particular applications. Your answer should address some relatively unique characteristic of the material.

See slide deck for particular metals and their relatively unique features.

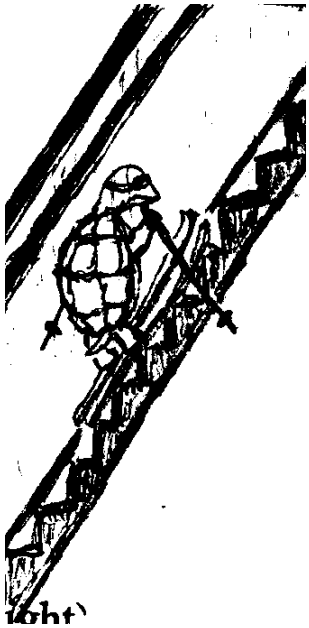


9. Name and describe in some detail a particular ceramic material commonly used in biomaterials applications.

See slide deck for particular ceramics and their details.

10. Briefly describe how glass-ceramic items are typically processed (produced).

Glass-ceramics are formed from molten materials like glasses, and then heat treated to induce crystal growth. Implying, but not clearly stating they are formed from a melt and then heat treated −3 each. Not knowing glass-ceramics are a particular type of material was −10.



Artwork by: Issac Reifschneiderschlagermueller

Stupid question of the day (found on http://www.answerbag.com when I Goggled *Gold Schlager* to check the spelling): “I was told the Gold in Gold Schlager

actually cuts your throat very minutely, so that your body can absorb the alcohol more... is this true?"

No, this is false. Gold is a very soft, ductile metal. The gold leaf in Gold Schlager is extremely thin. The throat (actually, I'm sure they meant the esophagus), is lined with relatively tough tissue and mucus. Since eating abrasive foods like corn chips doesn't harm the esophagus, the gold in Gold Schlager wouldn't either. Furthermore, alcohol is readily absorbed through the stomach wall, it does need any help to get into the circulation rapidly.