Midterm 2 Key (High 99, Low 67, Ave 86)
BE-410, Spring '09, Dr. C. S. Tritt

I noticed a few of you may be suffering from what I'll call the trivia affect. What I mean by this is you are answering questions with a lot of true statements but not stating the most important feature or issue. Try to put what you know into a hierarchy, rather than just cramming it all into your brains where ever it fits.

1. Explain the key difference between thermoplastic and thermosetting type polymers.

Irreversible crosslinks form in thermosetting polymers when they are heated. Thermoplastic polymers melt when heated. Thermosetting materials are generally pressed into molds and then heated to "cure" or "set" them. Once set, they cannot be melted and reshaped. Thermoplastic materials are generally formed by melting them and force the molten polymer into molds. The polymer is the cooled. At least theoretically, thermoplastic materials can be melted and reformed numerous times.

2. Name a general type of polymerization reaction and a particular polymer of biomedical interest produced by this reaction method. Not making the distinction between how the two are processed was −1 or 2.

3. Describe in reasonable detail the injection molding process.

Polymer beads or chips are heated, melted and pressurized in an extruder. The molten polymer is forced into molds where it cools and solidifies. The part is then ejected from the mold.

Note that the molten polymer is generally very viscous and therefore must be forced into the mold under pressure (as opposed to being "poured" into a mold). Some setting type polymers resins are fluid enough to pour into open molds.

Longing is the core of mystery.
Longing itself brings the cure.
The only rule is, Suffer the pain.

Your desire must be disciplined,
and what you want to happen
in time, sacrificed.

Rumi – 'The Essential Rumi ' – Coleman Barks

4. Describe a biomedical application of poly-methyl-methacrylate (PMMA) or PMMA containing copolymers or blends.

Bone cement, contact lens, etc. To be clear, bone cement generally consists of methyl-methacrylate (the liquid monomer), PMMA (powdered solid polymer) and other ingredients. The bonding between ordinary bone cement and bone is purely mechanical (as opposed to chemical or biological bonding which can occur with "bioglasses" and "bioceramics.")

5. Several types of thermoplastic elastomers were described in lecture and the textbook. Briefly describe the two phase model explaining the behavior of these polymers.

It is believed that at least some thermoplastic elastomers consist of 2 phases at room temperature. One of these phases is hard and crystalline while the other is soft and flexible. The crystalline phase provides virtual crosslinks within the softer phase. When heated, these 2 phases merge reversibly destroying the crosslinks and allowing the polymer to melt.

Do not confuse thermoplastic elastomers with liquid crystal polymers (LCPs) like PET. LCPs are generally quite strong and tough, but are not particularly elastic. Also, while the liquid crystal state of many materials only occurs over a very limited temperature range, LCPs exist in the liquid state over a relatively large temperature range.

Also don't confuse with materials being brittle below their glass transition temperature. While true, this isn't particularly related to thermoplastic elastomers (the hard phase of which are generally below its T_g while the soft phase is above its T_g under normal operating conditions).

This was by far the most missed question on the test, so expect it again on the final.

6. Name and describe a biomedical application of a particular polymer or type of polymer, other than PMMA.

Any of the polymers we discussed. Note that a significant use of polyurethanes in medical devices is in VAD and artificial heart bladders. This was seldom, if ever, mentioned in your answers.

7. Name and describe one of the “big three” natural materials.

Any one of the following:

Collagen – the fibrous protein responsible for most of the structural strength the extracellular matrix. There are many different types with somewhat different structures and functions and occurring in different tissues. Many growth factors and other ECM components bind to collagen. Many cell types have collagen receptors.

Elastin – a cross linked protein largely responsible for the elasticity of tissues. Elastin has a much lower modulus and strength than does collagen, but it has a much greater elastic and ultimate strain.

Proteoglycans/GAG’s – Proteoglycans/GAG’s are complex amino-sugar/protein compounds with many functions. Proteoglycans/GAG’s modify solution viscosity and chemically interact with other ECM components. guidance

The Morning Wind Spreads
The morning wind spreads its fresh smell.
We must get up and take that in,
that wind that lets us live.
Breathe before it's gone.

Rumi - 'The Essential Rumi' - Coleman Barks

8. Describe an advantage of knitting has relative to weaving in the production of textile tubes for vascular implants.

Knitting can provide a seamless tube with lots of stretch, weaving cannot. Accepted either high stretch or seamlessness.

9. Say you are working for a company and designing a medical device. The device needs a mechanical part, specifically a cam, which is to be light, strong and tough. It must not be electrically conductive. It will not be in contact with water, so hydrolysis

is not an issue. The maximum temperature to which it will be exposed will be 50°C. Suggest of general class of materials and a particular material, or materials if you suggestion is a composite, from which to make this part. Briefly justify your answer.

The best choice would be a polyamide (Nylon). Polyacetal (also called polyoxymethylene or (POM)) and also commonly known under DuPont's brand name, Delrin, was also an acceptable answer. Polycarbonate was also accepted for full credit. Accepted polypropylene (some grades don't creep and coefficient of friction would be low). High durometer neoprene was accepted as it might work. I accepted PVC which would be acceptable for low performance parts at minimal costs, but otherwise generally is not good for mechanical parts. Most other answers were wrong, but given some credit. Saying composites in general was too general. Just saying carbon fibers or fiberglass without naming the polymer in which the fibers would be embedded was −4. Rubber (without specifying high durometer or hard) or other elastomer was −5 (it's too soft). PE (it's not particularly strong and would probably creep), PET (it would be hard to orient to get optimal properties) and PU (it's too expensive for the necessary properties) were −3.

All engineers should know what cams, levers, pivots, hinges, gears, racks and pinion are. If you don't, look them up.

10. Write your own biomaterials related question relevant to topics covered on this exam and answer it. Part of your score will depend on the rigor and relevance of your question (i.e., a trivial question will not result in a good score even if answered correctly).

I graded these on an individual basis. The question had to be relevant and non-trivial and the answer had to be correct for full credit.

Be humble.
Only fools take pride in their station here, trapped in
a cage of dust, moisture, heat and air.
No need to complain of calamities,
this illusion of a life lasts but a moment.

Shaikh Abu Saeed Abil Kheir - 'Nobody, Son of Nobody ' - Vraje Abramian

Sufi poetry provided in honor of UWM's Poetry Everywhere project tonight at the Downer Theater (http://www4.uwm.edu/about_uwm/news_press/today_at_uwm_detail.cfm).