PhD Qualifier Examination Questions

Bioengineering

(Please answer all questions)

Questions of Biomedical Materials:

Four-Part Question [1]. All types of materials and devices suitable for implantation into the human body must be treated to assure they are sterile. Sterilization is usually by (a) ionizing radiation, (b) dry heat, (c) wet heat, autoclaving, (d) ethylene oxide, (e) chemicals, such as glutaraldehyde, and (f) filtration. Regarding these techniques, correctly answer the questions below :

A. For each technique (a), (b), (c), (d), (e), (f) named, list some types of materials that can be safely and effectively sterilized by each method, AND state some benefits and problems with that method.

(a) ionizing radiation

(b) dry heat

(c) wet heat, autoclaving

(d) ethylene oxide

(e) chemicals(glutaraldehyde is one example)

(f) filtration

B. For approval by the US Food and Drug Administration (FDA), the dose of ionizing radiation that must be applied to assure sterilization is {circle all the correct answers}

2.5 MegaRads = 25 kiloGrays? or 2.5 MilliRads? or 25 Grays?

Delivered by

Gamma irradiation? or Laser beam? or X-Ray beam? or Electron beam?

C. Polyethylene (PE) and Polypropylene (PP) are two very similar and common biomaterials utilized in many medical devices, but only PP is safely and effectively sterilized by ionizing radiation. Why is PP not routinely sterilized by ionizing radiation ?

D. Tissue Engineering is a major current theme in Bioengineering research/development. What is a "tissue engineered" biomedical device, and how would you assure that it is safely and effectively sterilized without killing the living tissue components of that device?

Five-Part Question [2].

A. Draw and label the diagram for a Contact Angle Measurement (a liquid droplet on a solid surface), including the locations of the contact angle, the liquid/vapor surface tension vector, the liquid/solid surface tension vector, and the solid/vapor surface tension vector.

B. Write the Equation (Young's Equation), relating the surface tension components of your diagram, above, to the Contact Angle measured when the system is at Equilibrium (the liquid droplet is not moving or changing in shape).

C. Draw a graph showing how the Critical Surface Tension is determined from a set of data of measured Contact Angles versus the known Liquid/Vapor Surface Tensions of the test contact angle liquids. Label the Critical Surface Tension intercept.

D. Draw a graph showing the nonlinear relationship observed for the Strengths of Adhesion of flowing blood component deposits on materials of increasing Critical Surface Tensions placed in contact with that flowing blood. Label the Critical Surface Tension zone associated with lowest degree of deposit retention, where the materials exhibit the greatest thromboresistance or "blood compatibility".

E. Draw a schematic diagram of the earliest deposits retained on every material's surface immediately (within 5 minutes) after its first exposure to flowing whole blood, and label the blood components and thicknesses of those features called the "conditioning film" and the "primary film". [examples of components to consider: fibrinogen, albumin, gamma globulin, red blood cells, white blood cells, platelets, chylomicra, others?]

Questions of Modern Theory of Materials:

Problem (a)

For a diatomic linear chain, the dispersion relation $\omega(K)$ is shown below

$$\omega^2 = \frac{C}{M_1 M_2}\left\{(M_1 + M_2) \pm [M_1^2 + M_2^2 + 2M_1 M_2 \cos(Ka)]^{\frac{1}{2}}\right\}$$

There are two atoms in the unit cell with masses M_1 and M_2, and the force constant of the nearest-neighbor interaction is given by C.

(a) If $M_1 = M_2$, can you observe acoustic and optical dispersions in this diatomic chain? Why?

(b) Can you observe thermal expansion in this diatomic chain? Why?

Problem (b)

In a one-dimensional system, assume an array of particles of mass *m* interconnected with massless springs of length *h* (shown below); each spring has a stiffness of *K*. Also assume that $u(x)$ is the distance of a particle away from its equilibrium location. Try to derive the wave equation of the particles.