MSE/BioE C118 - Biological Performance of Materials

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465 Evans Hall

Exam 1: October 18, 2001 **Closed Book Exam**
Please answer all of the questions clearly and box your final answer. Useful equations, data, and physical constants appear at the end of the exam.

NAME:_____

ID NUMBER:_____ _____

Prob. 1	Prob. 2	Prob. 3	Prob. 4	Total
Max = 20	Max = 25	Max = 25	Max = 30	Max = 100

Extra Credit (2 pts.)
The password for your eRes is "stensness," which is the name of your TA's (Tim's) favorite player for a particular sport. Name the sport he plays?

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1. You work for a medical device company, and have developed a TMJ replacement that has been fabricated from a polymer substrate and has a self assembled monolayer coating to improve bonding with bone. Consider the relevant bulk and surface properties of the device, and describe how you would characterize them. Describe the interfacial hierarchy that would form once you place this device in the body? (20 pts.)

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2. You're developing a diagnostic assay and you discover the performance of the test is seriously degraded by the adsorption of a single protein (e.g., fibrinogen). You recall that protein adsorption to materials can be approximated by multiple equilibria analysis for protein-ligand interactions. Develop a Langmuir form expression for adsorption of a single protein from solution to a solid surface with n identical, independent, and non-cooperative sites. What assumptions did you make in your derivation? Now extend your equation to include two non-identical binding sites. What would a curve of [Protein] vs. Γ look like? How could you use this better understand the problem with your diagnostic device? Could you think of anything you might do to the surface to reduce the protein adsorption? (25 pts)

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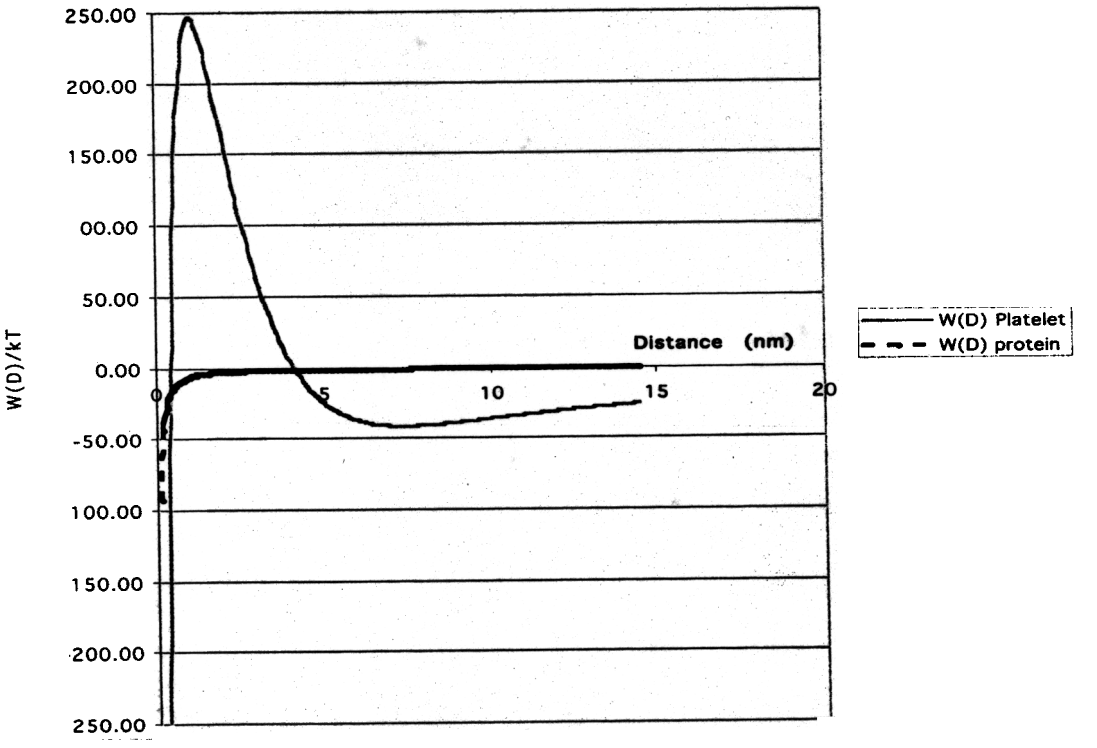
3. As a first approximation to understanding the biological performance of a new polymer, you use DLVO theory to approximate the interaction free energy as a function of distance between the polymer and either proteins or platelets. The following electrostatic contribution for $W_E(D)$ was used along with the appropriate $W_A(D)$ to calculate the **total** interaction free energy W(D) curve (below) for both a protein and a platelet approaching the surface.

$$W_E(D) = \pi\varepsilon\varepsilon_o R_2\left(\phi_{13}^2 + \phi_{23}^2\right)\left[2\frac{\phi_{13}\phi_{23}}{\phi_{13}^2 + \phi_{23}^2}\ln\left(\frac{1+e^{-\kappa D}}{1-e^{-\kappa D}}\right) + \ln\left(1-e^{-2\kappa D}\right)\right]$$

Where 1= polymer surface
2= cell
3= medium

The curves were generated using the following parameters: Polymer surface potential of -8 mV; surface potential of -10 mV for the platelet; surface potential of -10 mV for the protein; a 1:1 electrolyte with a concentration of 0.2M and a Debye length (κ^{-1}) of 1.48 nm; at body temperature (37 °C).



a) What van der Waals interaction free energy equation, between two macroscopic bodies, would you use to generate your total interaction free energy graph? (5 pts.)

b) Based on this graph and DLVO theory, describe initial events occurring at the surface after exposure to a solution containing both proteins and platelets (e.g., blood). (10 pts.)

c) What parameters could you manipulate to alter the DLVO curve and minimize platelet interaction with the surface? Be sure to draw new total interaction free energy curves demonstrating the influence of your perturbation. (10 pts.)

4. You are asked to evaluate a new polymer for cardiovascular applications. You perform a contact angle study with water and the polymer and determine $\theta_{adv} \sim 100°$. You then design and conduct a protein adsorption experiment to determine whether the adsorbed proteins change protein orientation or conformation as a function of time?

a) How would you perform this experiment? What would you measure? (10 pts.)

b) What would a typical protein adsorption curve look like? Make sure to identify appropriate regions of the curve? Do proteins change conformation on this surface? (10 pts.)

c) Based on what we discussed in class, would you expect a material with the aforementioned contact angle to adsorb more or less proteins compared to a material with $\theta_{adv} \sim 20°$? (5 pts.)

d) Based on your answer for b) & c), which surface would you expect to integrate better with surrounding tissue such as muscle and bone? (5 pts.)