MCEN 5228-002/4228-002 and MCDB 4100-002/6440-002
Molecular Biology and Micro/Nano-Scale Engineering
Mid-Term Examination, 12:30 to 1:45 p.m., Tuesday, March 7, 2008

Last Name: _____ First Name: _____

Molecular Biology (total 50 points)

1. (5pts) From a chemical point of view what distinguishes biological systems from inorganic systems.

2. (3pts)List three common CHEMICAL reactions of nucleic acids.

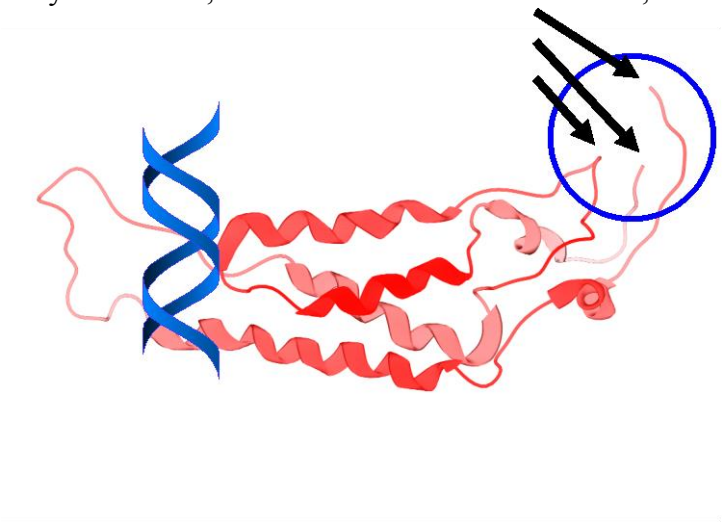
3. Given the following protein sequence: Trp-Asp-Tyr-Pro-Leu-Lys-Met-Phe-Glu.
   a. (5pts) Write a corresponding RNA sequence that encodes for this protein?
   b. (5pts) Write the DNA equivalent?
   c. (5pts) What is the minimal number of DNA bases that would need to be changed to mutate the single Pro to an Asp.

4. (8pts) You have just purchased an old DNA synthesizing instrument. You find that when you use this instrument the coupling efficiency is only 89%. In addition the deprotection step is only 92% efficient. You need 1 micromole of DNA that is 30 nucleotides long for your gene chip experiment. What is the MINUMUM number of micromoles of starting base linked material needed to ensure that you have enough material for your gene chip? (assume that all other chemical step besides coupling and deprotection are 100% efficient).

5. (5pts) Explain SELEX and how this can be used to obtain a high affinity nucleotide molecule?

6. (6pts) Explain the three steps of the polymerase chain reaction (PCR) and what they achieve?

7. (8pts) The figure below illustrates the TMV that was used as a template to make nanowires. Name the three areas designated by the arrows, the mutation that was introduced, and why?



MCEN 5228-002/4228-002 and MCDB 4100-002/6440-002
Molecular Biology and Micro/Nano-Scale Engineering
Mid-Term Examination, 12:30 to 1:45 p.m., Tuesday, March 7, 2008

Last Name: _____ First Name: _____

Nanoscale Engineering (8 questions worth 25 total points)

True or False? Write your answer in the space provided. (2 points each)

1. If the hydrogen atom behaves quantum mechanically, the calculated de Broglie wavelength for the hydrogen atom will be immeasurably small.

2. Experimental observation of the Photoelectric Effect resulted in the development of the Quantum Theory of Light by theoreticians Davisson and Germer in 1925.

3. The silicon bulk crystal structure is comprised of two ionically bonded interpenetrating *fcc* lattices, thus giving silicon semiconducting behavior.

4. Carbon creates nanotubes (hollow) as opposed to nanowires (solid) because it can form double bonds between neighboring atom pairs.

5. A nanoparticle will tend to display low index crystallographic faces with decreasing temperature.

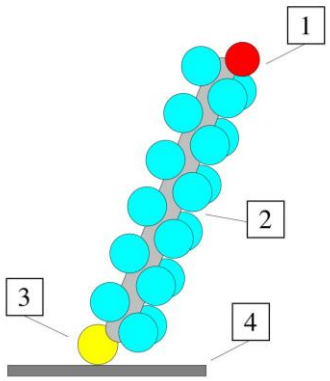
6. Quantum effects in semiconductor nanoparticles result from a large Exciton Bohr radius that yields a continuum of quantized electronic energy states.

7. The Scanning Tunneling Microscope (STM) is best operated with a long tip-to-sample distance so as to maximize the electron tunneling current and to minimize the tip-sample interaction.

Thought experiment. Please answer the following questions. (11 points total)

8. Suppose you want to design a sensor interface that is selective to the ovarian cancer biomarker CA-125 (a blood serum protein) using Self Assembled Monolayer (SAM) technology. To accomplish this, you need to choose a SAM molecule that can be conjugated to the CA-125 antibody, thus targeting the monolayer and resulting sensor interface to the CA-125 protein. A schematic of a typical SAM molecule is shown below.

(a) Identify



by number the key physical components of the SAM molecule shown above. *Briefly* state each component's function in the monolayer.

1.

2.

3.

4.

(b) What region of the SAM molecule will conjugate to the CA-125 antibody? Circle this location in the schematic above.

(c) Describe *briefly* in the space below how 'steric hindrance' between adjacent SAM molecules can result in fabrication and performance problems for your sensor interface.

(d) Describe *briefly* in the space below how you can engineer your sensor interface to overcome 'steric hindrance' problems.

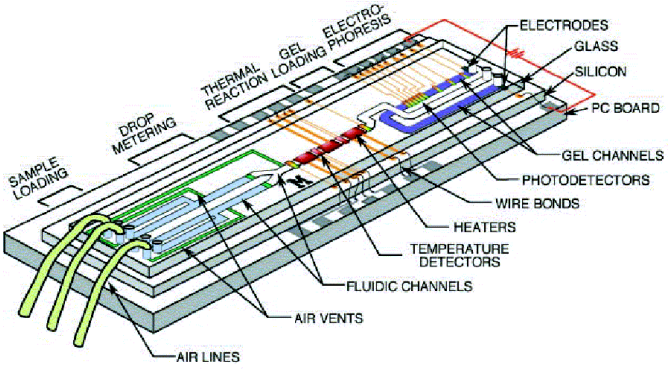
(e) Describe *briefly* in the space below how you can directly visualize the resulting antibody spatial distribution on your completed sensor interface.

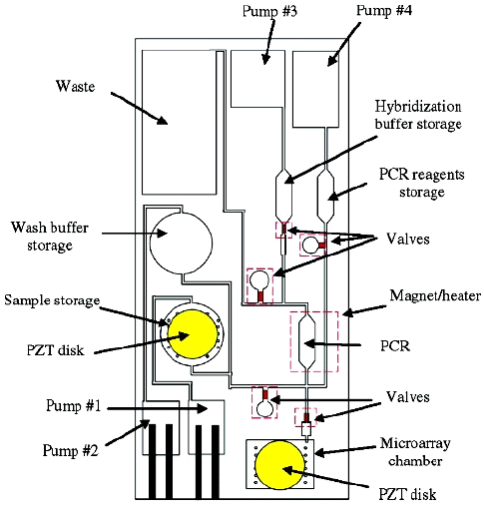
MCEN 5228-002/4228-002 and MCDB 4100-002/6440-002
Molecular Biology and Micro/Nano-Scale Engineering
Mid-Term Examination, 12:30 to 1:45 p.m., Tuesday, March 7, 2006

Last Name: _____ First Name: _____

Micro-Scale Engineering (25 points)

I. Integrated Nanoliter DNA Analysis Device (Michigan Device) and *Self-sustained, fully integrated biochip* (Motorola Device) studied are shown below. Answer the following questions by filling in the right feature/function noted in the figures. For example, silicon was used to fabricate the photodetectors in the Michigan device. You may find several correct answers for each blank to be filled; you need to write only one answer. (12 points total with one point for each blank)





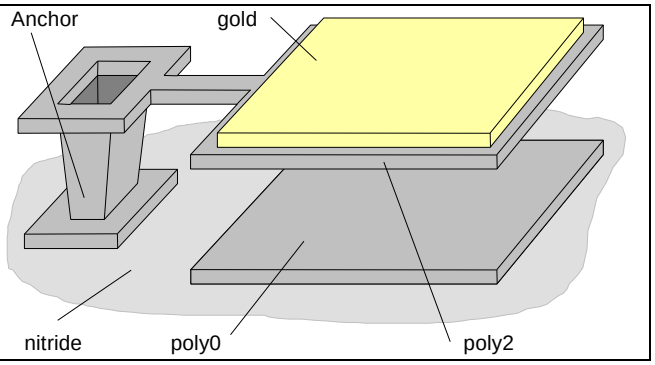
1. The PCR shown in the Motorola device is equivalent to _____ in the Michigan device.
2. In the Motorola device, _____ was used to enhance mixing.
3. Antibodies were used in _____ in the Motorola device.
4. Paraffin was used for _____.
5. The function of the electrophoresis and gel channels in the Michigan device is equivalent to _____ in the Motorola device.
6. Blood sample was loaded into _____.
7. _____ in the Motorola device was not used in the Michigan device.
8. _____ in the Michigan device was not used in the Motorola device.
9. The fabrication technology for _____ in the Michigan device has been covered by the lectures in Nano-Scale Engineering.

10. _____ in the Michigan device has been covered by the lectures in Molecular Biology.
11. Thermopneumatic air pump was used for _____.

12. Heaters used in the Michigan device are equivalent to _____ in the Motorola device.

II. *Identify three common features* between integrated circuits (IC) and biological cells. (3 points)

III. *Identify three MEMS devices* that can be represented by the figure as shown right. (3 points)



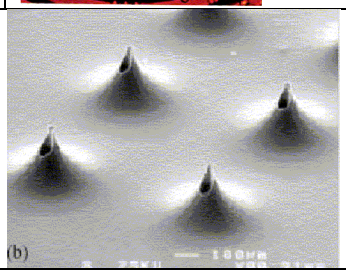
IV. *Circle the right answer* (4 points total)

1. Spiral electrodes as shown right can be used to collect target cells at their center. This cell collection is accomplished by (dielectrophoresis, electrophoresis or electro-osmosis).
2. (Dielectrophoresis, Electrophoresis or Electro-osmosis) is an effective means to move electrolyte with charged surfaces.
3. Crossover frequency is associated with (dielectrophoresis, electrophoresis or electro-osmosis).
4. In the Michigan device, (dielectrophoresis, electrophoresis or electro-osmosis) was used to move DNA fragments.

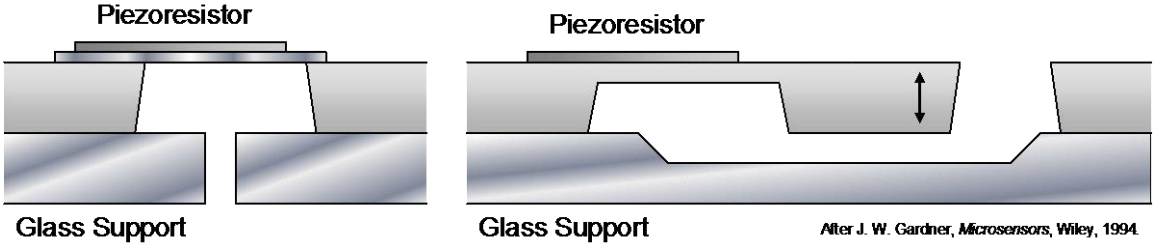
V. *Circle the right answer* (2 points)

1. The figure right shows a (micro-mirror, accelerometer, micro-needle, or pressure sensor.

2. The sharp tips are usually fabricated by (isotropic or anisotropic) etching.



VI. *Circle the right answer*. The (left or right) figure shown below can be used as a pressure sensor.



(1 point)