SOFT METHODS IN MICROSTRUCTURE FABRICATION
(CHEN 4127)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) In microfluidic channels, _____ tends to draw fluid into wetting microchannels
(a) capillary forces (b) solid liquid interfacial energy
(c) solid gas interfacial energy (d) laplace pressure

(ii) Elastomers are characterized by
(a) a permanent shape change due to stretching
(b) bonds between polymer chains that are non-flexible
(c) shape regain even after 100% percent elongation
(d) the formation of strong covalent bonds on heating

(iii) Soft lithography uses a polymer called
(a) polymethyl methacrylate (b) polyvinyl alchohol
(c) polydimethylsiloxane (d) none of these

(iv) Stereo-complexed hydrogels are _____ generation hydrogel.
(a) first (b) second (c) third (d) fourth

(v) Emulsion polymerization follows _____ to form polymer from monomer.
(a) initiation step (b) propagation step
(c) termination step (d) All of the above

(vi) Gel fraction percentage in hydrogel formation indicates _____.
(a) degree of cross-linking
(b) amount of water absorbed
(c) amount of monomer given into the reactor
(d) percentage yield of polymer

(vii) The interactions present in a SAM structure are
(a) purely ionic interactions (b) purely covalent interactions
(c) purely non-covalent interactions (d) purely electrostatic interactions

(viii) The material to be deposited in a Langmuir Blodgett film is
(a) directly coated on the substrate (b) first dissolved in a subphase
(c) first heated (d) directly reacted with the substrate

(ix) Dip-pen lithography uses _____ for printing patterns on substrates
(a) microneedle (b) atomic force microscope tip
(c) a micromask (d) none of these

(x) Surface free energy γ, is dependent on
(a) the vapor pressure at the interface (b) the bulk pressure of the system
(c) the temperature of the system (d) none of these

Fill in the blanks with the correct word

(xi) The collision diameter between two atoms is defined as _____.

(xii) The contact angle of a liquid drop on a solid surface is mathematically expressed as _____.

(xiii) Dry etching is usually done with the help of _____.

(xiv) For block copolymerisation between A and B the reactivity ratio r_A and r_B must be _____ respectively.

(xv) During the formation of PAMPS-PAAM double network hydrogel, *N,N,N′,N′*-tetramethylethylenediamine (TEMED) was used as _____.

Group - B

2. (a) Draw the graph for Lennard-Jones potential *w(r)* as a function of the separation distance r between two simple non-polar molecule. *[(CO1)(Remember/LOCQ)]*

(b) From the expression for Lennard-Jones potential : $w(r) = 4\epsilon\left[(\frac{\sigma}{r})^{12} - (\frac{\sigma}{r})^{6}\right]$, explain why the *w(r) = 0* when separation distance is equal to the collision diameter. At what separation distance, *r* would there be minimum energy and why? *[(CO1)(Analyse/IOCQ)]*

(c) In the equation mentioned in (b) which is the repulsive term? Explain how this term is affected when *r* is increased. *[(CO1)(Apply/IOCQ)]*

4 + 4 + 4 = 12

3. (a) Draw the graph that explains the difference in volume expansion versus increasing temperature for crystalline and amorphous polymer. Explain the graph. *[(CO1)(Analyse/IOCQ)]*

(b) What do you mean by the energy of adhesion and energy of cohesion? *[(CO1)(Remember/LOCQ)]*

(c) What is Laplace pressure and how is it mathematically defined. Explain each term of the equation. *[(CO1)(Analyse/IOCQ)]*

4 + 4 + 4 = 12

Group - C

4. (a) With a schematic, explain one process of microfabrication that takes help of a thermoplastic polymer. *[(CO2)(Apply/IOCQ)]*

   (b) What are the differences between a positive and negative tone photoresist? What reaction process occurs when SU8 is exposed to radiation? *[(CO2)(Remember/LOCQ)]*

   (c) What is a lithography mask? What process is used in mask formation in thick resist lithography and why*?* *[(CO2)(Apply/IOCQ)]*

4 + 4 + 4 = 12

5. (a) What material is used in soft-lithography and why? *[(CO2)(Analyse/IOCQ)]*

   (b) Describe the process by which a microfluidic channel can be built on a silicon wafer? *[(CO2)(Remember/LOCQ)]*

   (c) What type of bonding methods are used in fixing the microfluidic channel to a substrate? *[(CO2)(Analyse/IOCQ)]*

4 + 4 + 4 = 12

Group - D

6. (a) Briefly elaborate the principle of emulsion polymerization. *[(CO3)(Remember/LOCQ)]*

   (b) How much amount of each of the surfactants A and B to be mixed to achieve a HLB value of 4? HLB for surfactant A=10 and HLB for surfactant B=2. *[(CO3)(Evaluate/HOCQ)]*

   (c) "In order to destabilised an emulsion addition of ionic salt could be an easy option to carry out." Comment on the correctness of the statement with appropriate justification. *[(CO3)(Analyse/IOCQ)]*

4 + 4 + 4 = 12

7. (a) Below table shows the plot of swelling ratio with time for a dried hydrogel of weight 0.5 g immersed in water for 1 h. The swelling of hydrogel depends on the polymer relaxation instead of diffusion controlled mechanism. Calculate the rate constant for swelling of the hydrogel.

Time (min)	5	15	17	28	30	32	60
Swelling Ratio (g/g)	3.5	4.2	4.8	5.3	6.0	6.5	7.0

[(CO3)(Evaluate/HOCQ)]

   (b) For three different types of hydrogel the swelling ratio and the gel fraction percentage are given. Based on the data indicate which hydrogel will have better mechanical stability and why?

   Hydrogel A (formed through homopolymerization): Swelling ratio=10.2 and Gel fraction %=97%

   Hydrogel B (formed through copolymerization): Swelling ratio=20.5 and Gel fraction %=98%

   Hydrogel C (formed through IPN polymerization): Swelling ratio=9.8 and Gel fraction %=85% *[(CO3)(Analyse/IOCQ)]*

8 + 4 = 12

Group - E

8. (a) Describe the various interactions observed in building a quaternary protein structure from a polypeptide base. *[(CO4)(Analyse/HOCQ)]*
   (b) What do you mean by a patterned SAM? Give two examples. *[(CO4)(Remember/LOCQ)]*
   (c) What material is typically used as a stamp for microcontact printing and why? *[(CO4)(Apply/IOCQ)]*

4 + 4 + 4 = 12

9. (a) What are the various factors that control the adhesion of bacteria on surfaces? *[(CO4)(Remember/LOCQ)]*
   (b) A DNA is considered a natural self-assembled structure. Why? *[(CO4)(Analyse/IOCQ)]*
   (c) How would you measure the contact angle of a wetted surface? *[(CO4)(Apply/IOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.17	54.17	16.66