

**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) Microfluidic devices are characterized by
(a) large radius to length ratios in channels
(b) large fluid velocities in channels
(c) large surface to volume ratios within channels
(d) none of these.
- (ii) Glass transition temperature
(a) is the same as melting temperature
(b) only occurs in amorphous polymers
(c) is experienced by crystalline material
(d) none of these.
- (iii) The following method cannot be classified as polymer micromachining
(a) thin film lithography (b) hot embossing
(c) solid gas reaction in a plug flow reactor (d) 3D printing.
- (iv) The development stage of thick resist lithography involves
(a) baking the SU8 polymer (b) evaporating the solvent from SU8
(c) exposing the SU8 to irradiation (d) dissolving the unpolymerized SU8.
- (v) The spin-coating process fabricates films through
(a) layer by layer assembly (b) self-assembled monolayer
(c) Langmuir-Blodgett process (d) none of these.
- (vi) Langmuir Blodgett process uses the following reagents
(a) polyvinylchloride (b) DNA
(c) long chain amphiphilic molecules (d) gaseous hydrocarbons.
- (vii) Third generation hydrogels are primary _____.
(a) pH sensitive hydrogels (b) temperature sensitive hydrogels
(c) enzyme sensitive hydrogels (d) stereo-complexed hydrogels

- (viii) HLB value for surfactant is _____ to produce oil-in-water emulsion.
 (a) in between 8 and 16 (b) in between 3 and 6
 (c) in between 6 and 8 (d) in between 16 and 18
- (ix) A widely used method for attaching templated SAM on substrate is through
 (a) covalent bonding (b) mechanical robots
 (c) micro-contact printing (d) spray painting.
- (x) LIGA uses the following form of irradiation
 (a) UV light (b) infra red radiation
 (c) gamma radiation (d) none of these.

Fill in the blanks with the correct word

- (xi) The Van der Waal packing radius is defined as _____.
- (xii) The three distinct forces that contribute to Van der Waals force are _____.
- (xiii) A special characteristic of a photopolymer is _____.
- (xiv) Two factors that control the self-assembly process are (i) _____ and (ii) _____.
- (xv) Two factors that control the adherence of ink to the tip in Dip-pen lithography are (i) _____ and (ii) _____.

Group - B

2. (a) Define Van der Waals packing radius. What radii are taken into account when calculating the effective Van der Waals radius of a molecule with multiple covalent bonds? [[CO1](Remember/LOCQ)]
- (b) Define work of cohesion. How is it different from work of adhesion? [[CO1](Remember/LOCQ)]
- (c) What is spreading coefficient? Under which conditions, will there be complete wetting and no wetting? [[CO1](Apply/IOCQ)]
4 + 4 + 4 = 12
3. (a) If a cube of side length 10 micron is uniformly divided into cubes of side length 10 nm, N number of spheres are obtained. What is N ? [[CO1](Analyse/HOCQ)]
- (b) What is the percent increase in surface area from the original 10 micron length cube to the N 10 nm length cubes produced? [[CO1](Analyse/IOCQ)]
- (c) What do you mean by surface curvature at a point on the surface? Surface curvature causes a change in surface pressure – justify the statement mathematically. [[CO1](Analyse/IOCQ)]
4 + 4 + 4 = 12

Group - C

4. (a) What is photopolymerization? What are the components of photopolymeric resin? [[CO2](Remember/LOCQ)]

- (b) Draw a schematic of explain the process of 3D object formation using micro stereolithography. [[CO2](Remember/LOCQ)]
- (c) Explain the two proposed mechanisms of polymerization. [[CO2](Remember/LOCQ)]
4 + 4 + 4 = 12
5. (a) State one difference between dry and wet etching. At which step of a process is etching necessary? [[CO2](Analyse/HOCQ)]
- (b) Compare the difference between a crystalline polymer and an amorphous polymer with the help of a temperature vs. deformation resistance graph. [[CO2](Remember/LOCQ)]
- (c) With a schematic, explain one processes that can be classified as soft-lithographic process. [[CO2](Apply/IOCQ)]
4 + 4 + 4 = 12

Group - D

6. (a) Classify hydrogel according to the generation. [[CO3](Remember/LOCQ)]
- (b) If the pH of the water in which hydrogel is suspended will be increased, whether the swelling of the hydrogel happens? Explain in the light of swelling mechanism. [[CO3](Analyse/HOCQ)]
4 + (2 + 6) = 12

7. (a) At 300 K, measurements of the surface tension of the solutions of the surfactant $C_{12}H_{25}(OC_2H_4)_2OH$ in water as a function of its concentration are given in the following table

Concentration (mmol/m ³)	0.001	0.0018	0.0032	0.0056	0.01	0.018	0.032	0.056
Surface tension (mN/m)	69	64	59	52	45	38	31	29.5

- Find out the critical micelle concentration (CMC) of the surfactant with the help of the above information in the table. [[CO3](Evaluate/HOCQ)]
- (b) “After attaining CMC, a dynamic equilibrium is setup for the surfactant at the interface of the micelle with the dispersed phase”. – Comment of the appropriateness of the statement based on the graphical plot you had in the previous question. [[CO3](Analyse/IOCQ)]
- (c) What is meant by anionic and cationic hydrogels? Identify the functional groups responsible for their surface charge. [[CO3](Remember/LOCQ)]
4 + 2 + (4 + 2) = 12

Group - E

8. (a) What do you mean by a Zwitterionic amphiphile? Give an example and draw a schematic of the structure demonstrating this. [[CO4](Remember/LOCQ)]
- (b) How would you characterize the hydrophobicity of a substrate? Describe the instrument used for this. [[CO4](Remember/LOCQ)]

- (c) What kind of interactions are present in a self-assembled monolayer? Compare the interactions strengths with respect to a covalent bond. [[CO4](Analyse/IOCQ)]
4 + 4 + 4 = 12
9. (a) Describe the process of Dip-pen lithography. [[CO4](Analyse/IOCQ)]
(b) With a schematic describe the formation of stamp formation in microcontact printing. [[CO4](Remember/LOCQ)]
(c) What would constitute a thiol derivative? State two characteristics of a thiol derivative. [[CO4](Apply/IOCQ)]
4 + 4 + 4 = 12
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	47.92	31.25	20.83