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
<u>any 4 (four)</u> from Group B to E, taking <u>one</u> 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) A device can be termed microfluidic if
(a) flowis in micron size channels
(b) the fluid velocity is in micron/second
(c) the Reynolds number is less than 10
(d) all of these.

(ii) A 1D nanomaterial has
(a) two dimensions in the nanoscale   (b) one dimensions in the nanoscale
(c) zero dimensions in the nanoscale   (d) none of these.

(iii) At the equilibrium spacing, r_0 between two atomic centers
(a) the sum of attractive and repulsive force is a positive number
(b) the sum of attractive and repulsive force is a negative number
(c) is zero
(d) is infinity.

(iv) A good example of an elastomer is
(a) rubber   (b) polystyrene
(c) polycarbonate   (d) epoxies.

(v) At the temperature where a polymer changes from liquid to rubbery is called
(a) melting point   (b) glass transition temperature
(c) crystallization temperature   (d) none of these.

(vi) A vacancy defects in a material
(a) is created by a hole in the material
(b) is the absence of an atom in a crystal structure
(c) is the absence of a proton from an atom
(d) is none of these.

(vii)   Hot embossing is a type of microfabrication that requires
(a) high pressure at room temperature
(b) high temperature but no extra pressure needed
(c) high pressure and high temperature
(d) Does not require increased pressure or temperature.

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

(ix)   Microsteroelithogprahy occurs through the process of
(a) wet etching   (b) photoresist deposition
(c) replica moulding   (d) resinphotopolymerization.

(x)   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

Fill in the blanks with the correct word

(xi)   The Langmuir Blodget technique is used to _____.

(xii)   Phospholipids in biomembranes are composed of _____.

(xiii)   Amphiphiles are _____.

(xiv)   If a 1 m³ cube is divided into 10 pieces, the percent increase in surface area of the subdivided cubes is _____.

(xv)   Reynolds number measures the ratio of _____.

Group - B

2.   (a)   What do you mean by the radius of curvature at a point on the surface? Explain with a labelled diagram.   *[(CO1)(Understand/LOCQ)]*
     (b)   How is the vacancy concentration affected by the local radius of curvature for a convex and concave surface? Explain mathematically.   *[(CO1)(Analyze/IOCQ)]*
     (c)   "Nanoparticles exhibit a tendency to sinter even at room temperature" – Explain why.   *[(CO1)(Analyze/IOCQ)]*
                                                                                      3 + 4 + 5 = 12

3.   (a)   The force between two simple non-polar molecule is given by
$$F(r) = 24\varepsilon\left[\left(\frac{\sigma^{12}}{r^{13}}\right) - \left(\frac{\sigma^6}{r^7}\right)\right]$$
          What is r and σ? How does the force, $F(r)$ scale as with r ?   *[(CO1)(Analyse/HOCQ)]*
     (b)   What is the effect of dispersion forces on small and large molecules?
                                                                                      [(CO1)(Remember/LOCQ)]
     (c)   Explain the 'water dilemma' in hydrophobic interaction of non-polar molecules like hydrocarbons.   *[(CO1)(Apply/IOCQ)]*
                                                                                      6 + 3 + 3 = 12

Group - C

4. (a) Explain with a graph how percent crystallinity in polymers affects its flow behaviour with increased temperature? *[(CO2)(Analyse/HOCQ)]*

    (b) What is SU8? Explain why SU 8 is used in thick resist lithography. *[(CO2)(Remember/LOCQ)]*

    (c) State and elaborate on two post-processing steps in thick resist lithography that follow resist patterning. *[(CO2)(Apply/IOCQ)]*

    4 + 4 + 4= 12

5. (a) Describe with a schematic the process of X-ray LIGA. *[(CO2)(DEscribe/LOCQ)]*

    (b) What is dry etching? How is it different from wet etching? *[(CO2)(Analyse/HOCQ)]*

    (c) Describe the two categories of polymerization with one example for each. *[(CO2)(Remember/LOCQ)]*

    4 + 5 + 3 = 12

Group - D

6. (a) What is meant by anionic and cationic hydrogels? Identify the functional groups responsible for their surface charge. *[(CO3)(Remember/LOCQ)]*

    (b) "During the block copolymerization with polyethylene oxide (PEO) and polypropylene oxide (PPO) it is seen that copolymers with the larger hydrophobic PPO block shows low critical micelle concentration value." – Comment on the appropriateness of the statement with proper justification. *[(CO3)(Apply/IOCQ)]*

    (c) A monomer and its polymer both are hydrophobic in nature. If a hydrogel needs to be prepared from it, which of the polymerization technique you prefer - emulsion or precipitation, when water is used as the solvent medium? *[(CO3)(Apply/IOCQ)]*

    (2 + 2 + 2) + 4 + 2 = 12

7. (a) "Lattice mismatch reduces the chances of core shell formation, as the mismatch increases the interfacial energy." - Elaborate the concept of the statement. *[(CO3)(Apply/IOCQ)]*

    (b) "For a cationic hydrogel if pH is more than that of pKa for the pendant group, more water adhesion will take place on the surface."– Comment on the appropriateness of the statement. *[(CO3)(Apply/IOCQ)]*

    (c) 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)(Analyse/HOCQ)]*

    4 + 4 + 4 = 12

Group - E

8. (a) What are organic monolayers? With a schematic explain how a bio-inactive surface can be transformed to a bio-active surface? *[(CO4)(Apply/IOCQ)]*

(b) With a diagram explain the detailed structure of a SAM (Self assembled monolayer) assembly citing at least one SAM example. *[(CO4)(Remember/LOCQ)]*

(c) What are the different forces that are present in various parts of the SAM assembly? *[(CO4)(Understand/LOCQ)]*

4 + 4 + 4 = 12

9. (a) Describe the Langmuir Blodgett (LB) process with a schematic of the system. *[(CO4)(Describe/LOCQ)]*

(b) The surface pressure changes as the LB process advances. Draw the graph that depicts this change in surface pressure and explain the primary graph points that demonstrate LB process initiation and termination. *[(CO4)(Apply/IOCQ)]*

(c) Both the Langmuir Blodgett (LB) and LBL deposition produces thin films. Under which instance would you use each of these methods? *[(CO2)(Evaluate/HOCQ)]*

6 + 4 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.4	44.8	19.8

Course Outcomes (CO):

The objective of the course is to provide an elaborated concept of different unit operations that are required in an industry. After completion of the course students will be able to:
1. Demonstrate the concept of microscopic system.
2. Identify various applications and fabrication methods of microfluidics.
3. Illustrate the basics of hydrogels and its fabrication technologies.
4. Summarise the concept of organometallic structure and compare various methods of self-assembly of organic molecules in nanostructures.

LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.