B.E. CHEMICAL ENGINEERING FOURTH YEAR FIRST SEMESTER
SUPPLEMENTARY EXAM - 2018

Interfacial Science and Engineering

Time: Three Hours   Full marks: 100

*Answer **any four** questions.*
Assume any missing data.
Write all assumptions clearly.

1. a) A material of density ρ, exists as uniform cylindrical particles of radius R, and length L. Derive an expression for specific surface area, for this material and examine the limiting forms when either R, or L is very small. [8]
    b) Derive the expression for sedimentation equilibria in centrifuge. [10]
    c) What should be the speed of an ultracentrifuge so that the boundary associated with the sedimentation of a particle of molecular weight 60,000 g mole^{-1} moves from $r_1 = 6.314$ cm to $r_2 = 6.367$ cm in 10 min? The densities of the particle and the medium are 0.998 and 0.728 g cm^{-3}, respectively, and the friction factor of the molecule is 5.3×10^{-11} kg s^{-1}. [7]

2. a) Derive the Laplace equation for pressure difference across a surface (a) for spherical surface, (b) for cylindrical surface, and for (c) planar surface. [10]
    b) The surface tension of a liquid that wets glass is measured by determining the vertical distance, h, between levels of the two menisci in a U-tube having a small bore $r1$ on one side and a larger bore $r2$ on the other. The following data are known: $\Delta h = 1.90$ cm, $r1 = 0.1$ cm, $r2 = 1.00$ cm, and $\rho_L = 0.95$ g cm^{-3}. Calculate the surface tension of the liquid using the simple capillary rise treatment. [10]
    c) Justify the statement "colloid stability represents kinetic stability". [5]

3. a) What are the three van der Waals forces, and what is the molecular origin of each of them? [7]
    b) Water at 20°C rests on solid naphthalene with a contact angle of 90°, while a water-ethanol solution of surface tension 35dyn/cm shows an contact angle 30°. Calculate work of adhesion of water to naphthalene, (b) γ^d for naphthalene. [10]
    c) Calculate the height to which an n-octane surface will climb on a teflon wall. Given $\gamma = 22$ mJ/m^2, $\theta = 30°$, and $\rho = 0.70$ g/cm^3. [8]

4. a) Explain DLVO theory and draw the energy curves for different conditions of colloid stability. [10]
    b) What is the diffuse layer, and what is its relation to the *Gouy-Chapman theory* of electrical double layers? [8]
    c) What is point of zero charge? Explain its significance. [7]

5. a) Mercury shows capillary depression rather than capillary rise. Explain why? [6]
    b) Why does a drop of pentane spread into a thin film when placed on a water surface, whereas a larger hydrocarbon such as dodecane breaks up into smaller droplets? [7]
    c) Explain photo lithography technique. [6]
    d) Explain different methods for nanoparticle synthesis. [6]