Answers   Colloids 2021

1)   (i) Electrical double layer interaction is due to the overlap of the edl of two colloidal particles. It's a combination of an osmotic pressure and an electrostatic term. The edl comprises the charge on the surface and a diffuse layer of ions close to the surface but of opposite charge

(ii) The depletion interaction occurs when a polymer does not adsorb on a surface so that there is a layer depleted of polymer. If 2 particles approach such that the separation is less than the size of the polymer ca. $2R_g$, if the polymer does not adsorb the polymer would need to be distorted from its random coil configuration. It does not like that so moves away from the gap, setting up a concentration gradient. This concentration gradient (or osmotic pressure) is overcome by the particles moving close together and hence there is an attraction.

(iii) The interaction is oscillatory in nature due to successive depletion effects

(iv) There is more polymer there so the oscillations are stronger and so more distinct

(v) Polystyrene sulfonate is a polyelectrolyte and so the -ve charges on the polymer expand the polymer so these are 10 times as many counterions at the higher polymer concentration, this interaction will be screened more at high concentration and so the polymer will be smaller, hence the higher frequency of the oscillations.

(vi) At higher concentrations the depletion interaction which is osmotic in nature is stronger

(vii)   Again because the polymer is smaller at low molar mass

(viii) That part of the interaction is due to the edl of the particles and so is logarithmic in nature and hence linear on the semi-log scale

2.

(i) Interfacial tension simply 72-45 = 27 mN.m^{-1}

(ii) Height will be given by the capillary rise relation which is a balance if the Laplace pressure and the gravitational force

So that h=$\frac{2\gamma cos\theta}{\rho gr}$

For water $cos\theta$ = 1   so h = $\frac{144 \times 10^{-3}}{1000 \times 10 \times .001}$

=14.4 mm

(iii) Now θ is 120, so $cos\theta$ = -0.5, so the water is depressed by 7.2 mm.

(iv)

Electrolyte Concentration (mol.dm^{-3})	Electrical double layer thickness, nm
1.0	0.256
0.1	0.811
0.01	2.56
0.0001	25.6

(v) Firstly it lowers the interfacial tension, then surfactant diffuses under any dirt and so gets between the dirt and surfactant, because of the lower IFT, this lifts the dirt off finally the surfactant provides a repulsion preventing aggregation or re-adsorption.

(vi) Using the Debye approximation

$\psi_x = \psi_o e(-\kappa D)$ In the example κ=1/10^{-8} = 10^8 m^{-1} and D = 10 nm =10^{-8} m,

So $\psi_x = \psi_o e(-1)$ 240/2.72= 88.2 mV

3.

(i) Basically use floatation. Oil droplets would be hydrophobic and so be picked up by bubbles which would be introduced into a chamber and the oil droplets carried up. It does not matter if the drops break as oil is lighter than water and would stay at the surface and can be skimmed off. There is no need for a surfactant in this case as the oil is hydrophobic.

Some kind of sketch would probably help.

If they mention dissolved air floatation extra credit

Marks deducted if surfactants are used, because they would make the process worse.

Note centrifugation would work but is far more expensive, so some credit if that is an idea.

They may come up with other ideas, such as a super-oleophilic cloth for which marks given based on quite what they say

(ii) a) anionic surfactant would adsorb at the air water interface and lower it. It would not adsorb at the solid vapour or solid liquid interfaces as both the surfactant and quartz are negatively charged, so $\cos\theta$ term would have to increase to compensate for a smaller γ_{lv}.

b) non-ionic surfactant will adsorb at both liquid vapour and liquid solid interfaces, strongly at the vapour interface, less strongly at solid interface. Hard to say what the contact angle would do actually.

c) Cationic surfactant adsorb at both liquid and solid liquid interface reducing the interfacial tension of both. Initially at solid interface it would become hydrophobic and contact angle would increase. However if it's then hydrophobic a second layer of surfactant would adsorb rendering it hydrophilic again and a decrease in contact angle.

d) Can now relate to the work of adhesion so that

$$W_A = \gamma_{lv}(\cos\theta)$$