CERAMIC AND COLLOIDAL PROCESSING - EXERCISES

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Exercises 8

1. What are the different steps to follow for suspending a powder in a liquid?

Solution

First, the surface of the powder must be wetted with the liquid (adhesion, penetration and then spreading if we take the example of a cube). The powder is then dispersed in the bulk by stirring and mixing. Then most of the time it will be necessary to use a milling or ultrasonic treatment to break up aggregates and agglomerates. Finally, it is necessary to succeed in maintaining the powder in suspension in the dispersing medium i.e. to avoid re-agglomeration and sedimentation for a period long enough for shaping and forming of the ceramic piece.

2 Calculate the surface charge density σ of a surface immersed in an electrolyte solution, knowing its surface potential and the composition of the solution.

Examples:
a) Φ_o = –75.0 [mV]; 0.15 [M] aqueous solution in NaCl, T = 25 ° C (ε_r = 78.5 [-]).
b) Φ_o = –35.0 [mV]; 0.010 [M] aqueous solution in NaCl, T = 75 ° C (ε_r = 78.5 [-]).
Note: Watch out for units! It is recommended to convert all numeric data in the international system of units before performing calculations.

Solution

By applying Eq. (3.8.15) we find:
NB - c_0 is - no ions / m^3

$$\sigma = (8kT\varepsilon_o\varepsilon_r c_o)^{1/2}\sinh\left(\frac{ze\Phi_0}{2kT}\right) \qquad (3.8.15)$$

a) σ = –92.6 [mC / m^2].
b) σ = –7.8 [mC / m^2].

3 Knowing the temperature (T = 25 ° C), calculate the Debye length 1 / κ in aqueous solutions containing various concentrations of electrolytes.

Examples:

a) Pure water at T = 25 ° C, ([H +] = [OH–] = 10^{-7} M).
b) 0.010 [M] aqueous solution in NaCl.
c) 0.010 [M] aqueous solution in Na_2SO_4.
d) 0.010 [M] aqueous solution in $Al_2(SO_4)_3$.

Solution

Appliquer l'Eq. (3.8.13).

$$\frac{1}{\kappa}=\left(\frac{\varepsilon_o\varepsilon_r kT}{\sum_i (z_i e)^2 c_{io}}\right)^{1/2}=\frac{(\varepsilon_o\varepsilon_r kT)^{1/2}}{e}\times\left(\frac{1}{\sum_i (z_i)^2 c_{io}}\right)^{1/2}\quad \frac{1}{\kappa}=\frac{1.06\times10^4}{(2I)^{1/2}}$$

A 25°C, la relation précédente se réduit à :

$$\frac{1}{\kappa}=\frac{1.06\times10^4}{\sqrt{2I}}$$

où I est la force ionique :

$$I=\frac{1}{2}\sum_i (z_i)^2 c_{io}$$

On trouve pour $1/\kappa$:

a) $[H^+] = [OH^-] = 10^{-7}$ [M] ; d'où :

$$I=0.5\times\left[(1)^2+(-1)^2\right]\times10^{-7}=10^{-7}\ [\text{M}]=10^{-4}\ [\text{mol/m}^3]$$

$1/\kappa = 962.1$ [nm]

b) $NaCl \rightarrow Na^+ + Cl^-$; d'où :

$$I=0.5\times\left[(1)^2+(-1)^2\right]\times0.010=0.010\ [\text{M}]=10.00\ [\text{mol/m}^3]$$

$1/\kappa = 3.0$ [nm]

c) $Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$; d'où :

$$I=0.5\times\left[2\times(1)^2+(-2)^2\right]\times0.010=0.030\ [\text{M}]=30.00\ [\text{mol/m}^3]$$

$1/\kappa = 1.8$ [nm]

d) $Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$; d'où :

$$I=0.5\times\left[2\times(3)^2+3\times(-2)^2\right]\times0.010=0.150\ [\text{M}]=150.0\ [\text{mol/m}^3]$$

$1/\kappa = 0.8$ [nm]

4.How is the electrical double layer formed at a charged surface in an electrolyte?

Solution

We speak of the electrical double layer when talking of a charged surface in an electrolyte. The two layers correspond to the near surface layer (adsorbed ions in the Stern layer included) and the diffuse layer further away from the surface. The first layer, is the charged surface and the Stern layer (ions adsorbed strongly on the surface of the powder). If the surface is negative there will be a majority of positive ions from the electrolyte (e.g. Na^+) if the surface is positive there will be a majority of negative ions (e.g. Cl^-). The second diffuse layer has a more diffuse ionic distribution and the potential decreases much faster and the electrolytes are no longer strongly bound to the surface. Slowly the ionic concentrations (e.g. Na^+ and Cl-) approach the bulk concentration far away from the surface e.g. see slide 26 – week 8.

5.What is the sign of the zeta potential on the surfaces of SiO_2, ZrO_2, TiO_2, Al_2O_3, ZnO_2 and MgO powders in water at pH 7.5.

Solution

See table dia. 30 - week 8.

In water at pH = 7.5,

the potential is ***negative*** for SiO_2, ZrO_2, TiO_2 and

is ***positive*** for Al_2O_3, ZnO_2 and MgO

because their isoelectric points are respectively lower and higher than pH = 7.5

6. What is the isoelectric point (iep)?

Solution

The pH at which the zeta potential is equal to 0.