ipt Instituto Politécnico de Tomar

MASTER in CHEMICAL TECHNOLOGY

SURFACE AND INTERFACE CHEMISTRY

Exercises – Surface Tension

1. For a water-air interface at 25° C and 1 atm, calculate the capillary rise in a glass tube with inner diameter of 0.2 mm. The surface tension of water at 25° C is 72 dine/cm. The specific masses of air and water at 25° C and 1 atm are, respectively, 0.001 $g.cm^{-3}$ and 0.997 $g.cm^{-3}$.

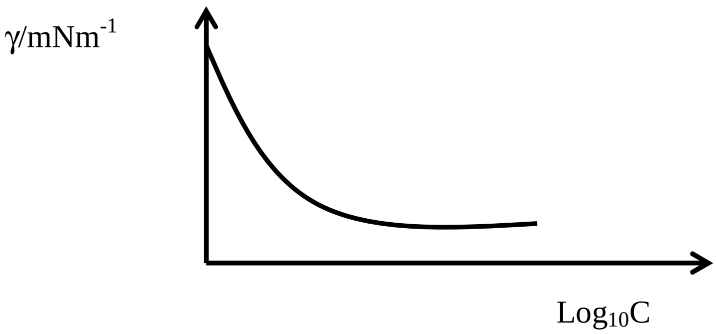
2. Two capillary tubes with internal radii of respectively 0.6 and 0.4 mm are dipped into a liquid of density 0.901 $g.cm^{-3}$, in contact with air of density 0.001 $g.cm^{-3}$. The difference recorded in capillary rise in the two tubes is 1 cm. Calculate the surface tension of the liquid assuming the contact angle is zero.

3. Calculate the vapor pressure of a spherical droplet with radius of 20 nm at 35° C. The intrinsic water vapor pressure at this temperature is 5.623 kPa and its density is 994.0 $kg.m^{-3}$. Consider the surface tension of water at this temperature equal to 7.275×10^{-2} Nm^{-1}.

4. The work of adhesion to the interface water-cellulose acetate is 115.9 $mJ.m^{-2}$. Knowing that the water wets a film of cellulose acetate with a contact angle of 53.7°, calculate the surface tension of the cellulose acetate. Consider as a good approximation for the interfacial tension between water-cellulose acetate:

$$\gamma_{LS} = \gamma_S + \gamma_L - 2(\gamma_S \gamma_L)^{1/2}$$

5. The figure below shows the variation of the surface tension for a given concentrated surfactant:



The slope at low concentrations is – 16.7 $mN.m^{-1}$. Calculate the surface excess concentration and the area occupied per molecule at the surface.

6. The following surface tensions have been measured for aqueous solutions of non-ionic surfactants $CH_3(CH_2)_9(OCH_2CH_2)_5OH$ at 25 °C:

$C/10^{-4}$ $mol.dm^{-3}$	0.1	0.3	1	2	5	8	10	20	30
$\gamma/mN.m^{-1}$	63.9	56.2	47.2	41.6	34.0	30.3	29.8	29.6	29.5

Determine the critical micelle concentration (c.m.c.) and calculate the area occupied by each molecule of surfactant adsorbed at c.m.c.

7. The surface tension of a series of surfactant aqueous solutions were measured, at 20° C, with the following results:

[A]/M	0	0.10	0.20	0.30	0.40	0.50
γ/mNm^{-1}	72.8	70.2	67.7	65.1	62.8	59.8

Calculate the surface excess concentration and the superficial pressure, π, exerted by the surfactant and investigate if the relation $\pi A_m = k_B T$ is obeyed.

8. The surface tension of aqueous solutions of carboxylic acids at 300 K can be expressed by the following empirical equation:

$$\gamma_0 - \gamma = a \log_{10}(1 + bC)$$

γ_0 is the surface tension of pure water, C/moldm^{-3} is the acid concentration, and a and b are constants given in the following table:

	C_2H_5COOH	C_3H_7COOH	$C_5H_{11}COOH$
10^3.a /Nm^{-1}	29.8	29.8	29.8
b /dm^{3}mol^{-1}	6.07	19.64	232.7

8.1. The surface adsorption of carboxylic acids is positive or negative?

8.2. Calculate the surface area occupied by each molecule of hexanoic acid at high concentrations (bC>>1).

8.3. What conclusions can we withdraw from the table on the way the molecules are occupying the surface?