CHEM 324 Analytical and Environmental Chemistry – Mid-Semester Test 2007

Wednesday 2 May
8:00 – 8:50 a.m.
Room 431 Chemistry Department

Answer all questions (3 in all)
Total Marks 50 (1 mark per minute)

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1. a) *(12 marks)*

Ozonesonde and lidar are two independent methods for the measurement of ozone as a function of altitude in the atmosphere.

Either

i) Explain how ozone concentration is determined using ozonesonde and sketch a plot to illustrate a typical profile for ozone from 0 to 40 km altitude.

Or

ii) Explain how ozone levels as a function of altitude are determined using ground-based focused lidar and sketch a plot to illustrate a typical profile for ozone from 0 to 40 km altitude.

b) *(5 marks)*

Explain how the electron capture detector (ECD), used with gas chromatography, works; comment on the levels of CFCs in the atmosphere and note the detection limit of the ECD for CFCs.

2. Aerosol Time-Of-Flight Mass Spectrometry (ATOFMS) is used to measure the size and composition of individual aerosol particles sampled directly from the atmosphere.

i) *(3 marks)*

Sketch a graph to illustrate the size distribution and mean lifetimes for atmospheric aerosols.

ii) *(3 marks)*

Explain the term and the significance of negative radiative forcing as it applies to aerosols.

iii) *(10 marks)*
Explain how ATOFMS measures size and composition by describing the flight of a single aerosol particle through the instrument.

3. a) *(12 marks)* Answer ***TWO*** of the following, **(i) – (iii):**

(i) Explain why changes in solution ionic strength can lead to the coagulation of colloid particles. Your answer should make reference to Figure 14.10 on the attached sheet. Give one environmental example of coagulation being promoted by an increase in ionic strength.

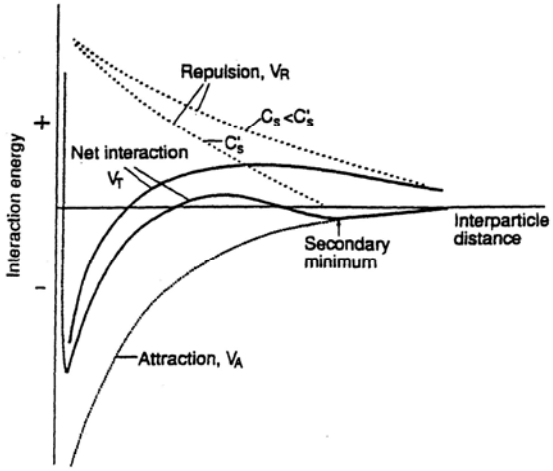

Figure 14.10. Physical model for colloid stability. Schematic forms of the curves of interaction energies [electrostatic repulsion V_R, van der Waals attraction V_A, and total (net) interaction V_T] as a function of the distance of surface separation. Summing up repulsive (conventionally considered positive) and attractive energies (considered negative) gives the total energy of interaction. Electrolyte concentration C_s is smaller than C'_s. At very small distances a repulsion between the atomic electronic clouds (Born repulsion) becomes effective

(ii) Explain why complexation of anions to a colloid at pH < pH_{pzc} can lead to colloid coagulation. Your answer should make reference to Figure 14.12. Is there a critical anion concentration for this reaction? Is this concentration dependent on the colloid concentration?

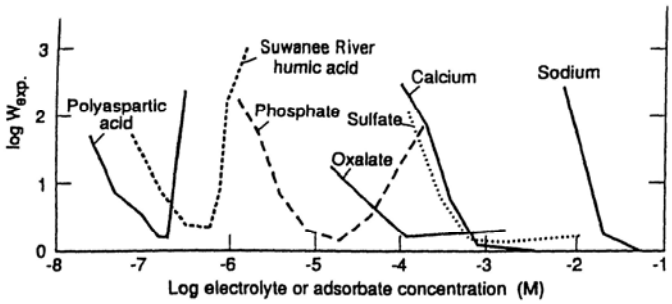

Figure 14.12. Summary plot of experimentally derived stability ratios, W_{exp}, of hematite suspensions, as a function of added electrolyte or adsorbate concentration (in case of polymers, monomer units) at pH around 6.5 (pH = 10.5 for Ca^{2+} and Na^+). Hematite concentration is about 10–20 mg $liter^{-1}$. The stability ratio, W_{exp}, was determined from measurements on the coagulation rate; it is the reciprocal of the experimentally determined collision efficiency factor, α_p. (From Liang and Morgan, 1990.)

(iii) Sketch and label curves as a function of pH for the adsorption of cations onto a ferrihydrite surface (FeOOH, pH_{pzc} = 8.1). Are these experimental curves consistent with an electrostatic model for surface adsorption? Explain.

b) *(5 marks)*

Write descriptive notes on **one** of the following:

(i) the use of FeOOH to remove PO_4^{3-} from domestic waste water;

(ii) the use of hydrolysed Al^{3+} to clarify potable water;

(iii) the difference in clarity of natural waters that contain high concentrations of Ca^{2+} or humic substances.