A5 Distribution Coefficient (Nernst's distribution law)

Task

The distribution coefficient of iodine for n-heptane and water is to be determined.

Basics

Nernst's distribution law applies for a special case of a ternary mixture which finds its application in extractions: a system of two non miscible liquids and a third substance soluble in both of them which may be gaseous, liquid or solid but may not produce miscibility of the liquids like e.g. a tenside does.

If the molecular state of the dissolved substance is equal in both liquids, Nernst's distribution law states: At constant temperature the relation of the concentrations c_1 and c_2 of a dissolved substance in two contacted, equilibrated solvent phases 1 and 2 is a constant,

$$K = \frac{c_1}{c_2}$$

This equation can be derived directly from the thermodynamic condition of equilibrium (see textbooks). It has to be modified, if the dissolved substance is not existent in the same molecular state in both solvent phases, like e.g. for partial or full dissociation or association (see textbooks like Brdicka).

Procedure

In three subsequential experiments 0.1; 0.2 and 0.4g iodine are pestled and dissolved in 50 mL n-heptane by stirring. Insoluble residues are decanted. The iodine containing heptane is given into a separatory funnel and 250 mL water are added. The funnel needs to be shaken strongly. Now the iodine content of 200 mL of the watery phase and 5 mL of the organic phase is determined by titration with an n/50 solution of sodium thiosulfate. For the titration of iodine in n-heptane 5 mL of the organic phase 100 mL water are added in a plug bottle. Both at the beginning and during the titration this bottle needs to be shaken. As an indicator for the titration starch is used.

To acquire decent results, mind the cleanliness of the jars.

Safety instructions

Wear protection glasses.

Use Peleus ball for pipetting.

Evaluation

You have two possibilities to evaluate:

a) Manual: the distribution law is converted in a manner that it only depends on the volumes. Apply the Gaussian error procedure to the final result.

b) Origin: plot c_1 vs. c_2. Use error bars from the Gaussian error procedure for your data points. Determine K by a linear fit with instrumental weighting.

Why is the Gaussian error procedure used here?

What should be known

1. Phase rule
2. Chemical potential for liquids and electrolytes
3. Standard / reference states
4. Henry's law

Additional assignments

1. Acetic acid dimerizes in carbon tetrachloride. How does Nernst's distribution law have to be modified to resemble this situation?
2. What experimental methods can be used to prove the dimerization of acetic acid?