Chemistry TAS Report

1. Experiment Number : 11
2. Date : 29/01/2008
3. Title : Determination of the partition coefficient of ethanoic acid between
       water and 2-methylpropan-1-ol

4. Aims/Objective :
   To determine the partition coefficient of ethanoic acid between water and
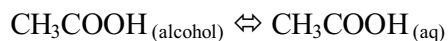   2-methylpropan-1-ol.

5. Introduction / Theory:
   If a solute is added to two immiscible solvents, A and B, in contact with each
   other, it is distributed between the two solvents and an equilibrium is set up
   between the solute molecules in solvent A and B. The ratio of the concentration of
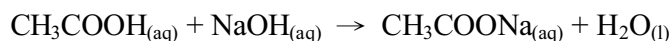   the solute in the two solvents is
   K = concentration of solution in solvent A / concentration of solution in solvent B
   where K is known as the partition coefficient or distribution coefficient.

6. Relevant Equations/Chemical Reactions Involved :
   (1)   At dynamic equilibrium,
   $$CH_3COOH_{(alcohol)} \Leftrightarrow CH_3COOH_{(aq)}$$
   (2)   Titration
   $$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$$

7. Chemicals :
0.2 M ethanoic acid	120 cm^3
0.1 M NaOH	100 cm^3
2-Methylpropan-1-ol (density = 0.805 cm^3)	80 cm^3
phenolphthalein indicator	

8. Apparatus and equipment :

100 cm^3 separating funnel	1	burette	1
10.0 cm^3 pipette	1	filter funnel	1
white tile	1	pipette filler	1
250 cm^3 conical flask	4	thermometer	1
wash bottle	1	safety spectacle	1

9. Procedure :

1. The room temperature was recorded.
2. 25 cm^3 of aqueous ethanoic acid and 25 cm^3 of 2-methylpropan-1-ol were pipetted into a 100 cm^3 separating funnel. It was stoppered and shaken vigorously for 1 to 2 minutes. During that process, the tap was opened occasionally so that pressure in the funnel was released.
3. 20 cm^3 of each layer was separated approximately. And the fraction near the junction of the two layers should be discarded.
4. 10 cm^3 of the aqueous layer was pipetted into a conical flask and it was titrated with 0.1 M sodium hydroxide solution. Phenolphthalein was used as an indicator.
5. 10 cm^3 of the alcohol layer was pipetted into another conical flask and it was titrated with 0.1 M sodium hydroxide solution. Phenolphthalein was used as an indicator.
6. Steps 2 – 5 were repeated with
   a) 35 cm^3 of aqueous ethanoic acid and 25 cm^3 of 2-methylpropan-1-ol
   b) 45 cm^3 of aqueous ethanoic acid and 25 cm^3 of 2-methylpropan-1-ol

10. Observations :
   The solution changed from colourless to red at the end point.

11. Data, Calculation and Results :
   Room temperature : 14.5°C
   Volume of 2-methylpropan-1-ol : 25 cm^3

   K = concentration of acid in aqueous layer / concentration of acid in alcohol layer

Volume of 0.2 M ethanoic acid / cm^3	Volume of 0.1 M NaOH titre for aqueous layer / cm^3	Volume of 0.1 M NaOH titre for alcohol layer / cm^3	Partition coefficient , K
25	10.70	12.15	1.14
35	11.85	13.90	1.17
45	12.75	19.50	1.53

Average value of partition coefficient $K = (1.14 + 1.17 + 1.53) / 3 = 1.28$

12. Conclusion :
   The partition coefficient of ethanoic acid between water and 2-methylpropan-1-ol was found to be 1.28.

13. Discussion :
    1. Shaking is necessary in step (2) as equilibrium state can be attained more quickly.
    2. The partition coefficient varies with temperature because equilibrium constant (K) is temperature-dependent.
       When temperature increases, the solubility of the solute in the two solvents increase. But the rates of the increase in solubility are not the same so the partition coefficient varies with temperature.
    3. The aim of adding aqueous ethanoic acid and 2-methypropan-1-ol is to leave the mixture to attain equilibrium and provide enough solvent for the titration. Therefore, the amounts of aqueous ethanoic acid and 2-methypropan-1-ol placed in the funnel need not be measured out accurately.
       However, the aim of titration is to find the concentration of the solvent. So, the volumes of the aqueous and alcohol solution used in the titration must be known as accurately as possible in order to find the concentration accurately.
    4. (1) The temperature of the mixture remains constant throughout the experiment.
           This assumption is valid as the experiment was carried at room temperature.
       (2) The solute must be of the same molecular form in the two solvents.
           That means there is no dissociation and association (dimerization) in the ethanoic acid.
           This assumption is valid as the molecular form of ethanoic acid is the same in the two solvents.
       (3) The two solutions which are in contact must be reasonably dilute.
           This assumption is valid as the concentrations of the two solvents are low.
    5. Two successive extractions by using $25cm^3$ portions of solvent make a better interaction between two kinds of solutions than only one extraction during shaking. A better equilibrium is then set up, resulting a higher extraction efficient.
    6. (1) Solvent extraction :
           By partition law, the K_D can be found experimentally. The amount of the solute that can be extracted using solvent extraction can be predicted, instead of using other complex method.
       (2) Chromatography :

It is used to separate and analyse mixtures, based on the difference in solubilities of the solutes in the stationary and mobile phases.

At a given temperature, the R_f value of a solute is a constant for a given solvent

$$R_f = \text{Distance travelled by spot} / \text{Distance travelled by solvent}$$

7. Error analysis :

There are some possible errors,

(1) Wrong determination of end point and burette's reading in titration.

(2) The 100 cm^3 separating funnel, which contains the two solvents, are not shaken well and thus dynamic equilibrium may not be reached..