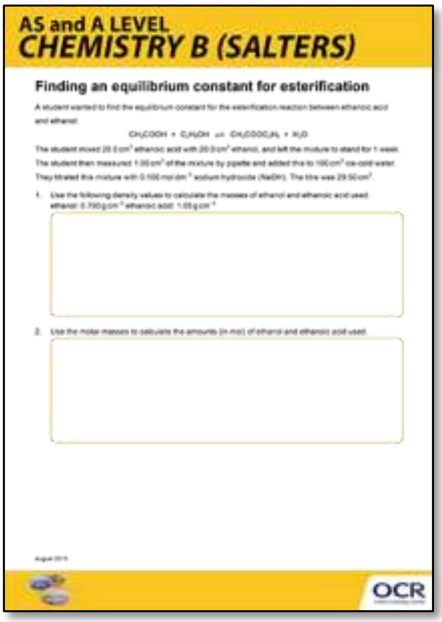
AS and A LEVEL
CHEMISTRY B (SALTERS)

Finding an equilibrium constant for esterification

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Finding an equilibrium constant for esterification' which supports OCR A Level Chemistry B.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Finding an equilibrium constant for esterification

The Activity:

Learners follow a worksheet to set up a mixture of ethanoic acid and ethanol to form an ester (the strong acid catalyst is omitted for simplicity). They could make the mixture and leave it for a week to reach equilibrium before titrating the remaining ethanoic acid to find the equilibrium constant. Alternatively, this can be carried out as a theoretical exercise using specimen results.

This activity offers an opportunity for maths skills development.

Learning outcomes:

This lesson element relates to the specification learning outcome CI(h).

Associated materials:

'Finding an equilibrium constant for esterification' Lesson Element learner activity sheet.

Introduction

Learners need to know the definition of pH, strong and weak acids, and how to calculate pH. They should be shown how to calibrate and use a pH meter.

Instructions

The activity sheet is provided as a question worksheet with specimen experimental results. Learners are guided through the calculation of the equilibrium constant.

Learners could also follow the method themselves and work through the calculation using their own results.

Health and safety

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer's requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

Learners should wear eye protection throughout the procedure if running this as a practical activity.

Answers to questions

1. Multiply volume by density.
   ethanol: 0.790 × 20.0 = 15.8 g
   ethanoic acid: 1.05 × 20.0 = 21.0 g

2. Divide the mass by the molar mass.
   $n(\text{ethanol}) = \frac{15.8}{46.0} = 0.343\text{ mol}$
   $n(\text{ethanoic acid}) = \frac{21.0}{60} = 0.350\text{ mol}$

3. $n(\text{NaOH}) = 0.100 \times 29.50/1000 = 0.00295\text{ mol}$

4. It is a 1 to 1 reaction with ethanoic acid so there was 0.00295 mol ethanoic acid in the 1.00 cm^3 taken from the reaction mixture.

5. 40 × 0.00295 mol = 0.118 mol ethanoic acid at equilibrium

6. The amount of ethanoic acid has reduced from 0.350 mol to 0.118 mol, so 0.350 – 0.118 = 0.232 mol has reacted.

7. 1 mol ethanoic acid reacts to produce 1 mol ester and 1 mol water.
   So, at equilibrium there is 0.232 mol ester and 0.232 mol water.

8. 0.232 mol ethanol has reacted, so there is 0.343 – 0.232 = 0.111 mol remaining.

9. The total volume is 40.0 cm^3, or 0.0400 dm^3, so:

   $[CH_3COOH] = \dfrac{0.118}{0.0400} = 2.95\ mol\ dm^{-3}$

   $[C_2H_5OH] = \dfrac{0.111}{0.0400} = 2.78\ mol\ dm^{-3}$

   $[CH_3COOC_2H_5] = [H_2O] = \dfrac{0.232}{0.0400} = 5.80\ mol\ dm^{-3}$

10. $K_c = \dfrac{[CH_3COOC_2H_5][H_2O]}{[CH_3COOH][C_2H_5OH]} = \dfrac{5.80 \times 5.80}{2.95 \times 2.78} = 4.10$ (no units)

11. The mixture needed to be left for a week to reach equilibrium.

12. As 1 cm^3 is a small volume it needs to be measured accurately to reduce the uncertainty in the final value.

13. The mixture was added to a large amount of cold water to quench it. Cooling and diluting the reaction mixture slows down the reaction. If the reaction was not quenched, the equilibrium position would shift during the titration as the sodium hydroxide reacted with the acid.

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