WJEC (Wales) Chemistry A-level

SP 3.8 - Determination of an Equilibrium Constant

Flashcards

What is a reversible reaction?

What is a reversible reaction?

A reversible reaction is a reaction in which the products can react together to form the original reactants. They are denoted by the symbol $\rightleftharpoons$.

Define dynamic equilibrium

Define dynamic equilibrium

Dynamic equilibrium is reached by a reversible reaction when the concentration of products and reactants remains constant. This means the rate of the forwards reaction is equal to the rate of the backwards reaction.

Give the chemical equation for the reaction between ethanol and ethanoic acid

Give the chemical equation for the reaction between ethanol and ethanoic acid

Ethanol + ethanoic acid → ethyl ethanoate + water

$$CH_3CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_3 + H_2O$$

Describe how the equilibrium constant can be determined for the reaction that takes place between ethanol and ethanoic acid

Describe how the equilibrium constant can be determined for the reaction that takes place between ethanol and ethanoic acid

Known moles of ethanol and ethanoic acid are reacted together and allowed to reach equilibrium. The equilibrium mixture is then titrated against sodium hydroxide which reacts with the ethanoic acid present at equilibrium. This is used to calculate the number of moles of ethanoic acid, ethanol, ethyl ethanoate and water present at equilibrium. The equilibrium moles are converted into concentration for use in the equation for Kc.

What apparatus is required to determine the equilibrium constant for the reaction of ethanol with ethanoic acid?

What apparatus is required to determine the equilibrium constant for the reaction of ethanol with ethanoic acid?

- 2 x 100 cm^3 conical flask with stopper
- 2 x 250 cm^3 conical flask
- Burette
- Funnel
- Burette clamp and stand
- 1.0 cm^3 measuring cylinder
- 100 cm^3 measuring cylinder

What chemicals are required to determine the equilibrium constant for the reaction of ethanol with ethanoic acid?

What chemicals are required to determine the equilibrium constant for the reaction of ethanol with ethanoic acid?

- Glacial CH_3COOH (ethanoic acid)
- CH_3CH_2OH (ethanol)
- Deionised water
- 1.0 mol dm^{-3} HCl
- 0.1 mol dm^{-3} NaOH
- Phenolphthalein

Outline the procedure to determine the equilibrium constant for the reaction of ethanol with ethanoic acid

Outline the procedure to determine the equilibrium constant for the reaction of ethanol with ethanoic acid

1. Prepare the control and reaction flasks. The control must have 18 cm^3 H_2O and 2 cm^3 HCl. The reaction mixture must have 6 cm^3 CH_3CH_2OH, 6 cm^3 CH_3COOH, 6 cm^3 H_2O and 2 cm^3 HCl.
2. Stopper, label and shake both flasks and leave them for at least one week.
3. Calculate the initial amount of CH_3CH_2OH, CH_3COOH and H_2O in moles.
4. Empty the contents of the control flask mixture into a 250 cm^3 conical flask. Add 100 cm^3 of deionised H_2O and 2 drops of phenolphthalein to the flask. Titrate the mixture against NaOH.
5. Transfer 1.0 cm^3 of the reaction mixture to a 250 cm^3 conical flask. Add 100 cm^3 of deionised water and 2 drops of phenolphthalein to the flask. Titrate the mixture against the NaOH.
6. Repeat steps 7-9 until you have three concordant results.
7. Use the results of the titrations to calculate the equilibrium constant of the reaction.

What is the purpose of the control flask?

What is the purpose of the control flask?

The control flask is used to calculate how much NaOH will be required to neutralise the HCl in the reaction flask. Since the reaction flask contains both ethanoic acid and HCl, the NaOH will react with both acids. Therefore, the volume of NaOH required to neutralise the HCl in the control flask can be subtracted from the reaction flask titration, to calculate how much NaOH was required to neutralise only the ethanoic acid.

Why must the control and reaction flasks be stoppered with a rubber bung?

Why must the control and reaction flasks be stoppered with a rubber bung?

This sets up a ‘closed system’ where nothing can enter or leave the flask. This allows dynamic equilibrium to be reached.

Why are the control and reaction flasks left to sit for a week before titration?

Why are the control and reaction flasks left to sit for a week before titration?

The flasks are left to sit to give the reactions time to reach equilibrium.

What is the colour change of phenolphthalein and at what pH does the colour change occur?

What is the colour change of phenolphthalein and at what pH does the colour change occur?

- Colourless in acid
- Pink in alkali

Phenolphthalein will change colour in the pH range 8.3-10.

Give the chemical equation for the reaction that takes place between sodium hydroxide and hydrochloric acid

Give the chemical equation for the reaction that takes place between sodium hydroxide and hydrochloric acid

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Give the chemical equation for the reaction that takes place between sodium hydroxide and ethanoic acid

Give the chemical equation for the reaction that takes place between sodium hydroxide and ethanoic acid

$$NaOH + CH_3COOH \rightarrow CH_3COO^-Na^+ + H_2O$$

Give the formula of Kc for the reaction of ethanoic acid with ethanol

Give the formula of Kc for the reaction of ethanoic acid with ethanol

$$Kc = \frac{[CH_3COOCH_2CH_3][H_2O]}{[CH_3COOH][CH_3CH_2OH]}$$

Why might the titration be carried out on a white tile?

Why might the titration be carried out on a white tile?

The white tile allows the colour change of the phenolphthalein indicator (colourless to pink) to be easily and quickly identified.

Why might the burette be rinsed with sodium hydroxide before titration?

Why might the burette be rinsed with sodium hydroxide before titration?

Rinsing the burette with the solution it will hold removes any water which may be in the equipment. This is important because the water will affect the concentration of the sodium hydroxide. Therefore, rinsing ensures a more accurate titration experiment.

How can the results of the titration be used to determine the equilibrium constant?

How can the results of the titration be used to determine the equilibrium constant?

The titration results can be used to calculate the number of moles of ethanoic acid at equilibrium. This value is subtracted from the original moles of ethanoic acid to find out how much ethanoic acid reacted. The moles of ethanol that reacted will be equal since ethanol and ethanoic acid react in a 1:1 ratio. The number of moles of ethanoic acid which reacted is equal to the number of moles of ethyl ethanoate and number of moles of water formed. These equilibrium mole values can be converted to concentration to determine Kc.

Why are the solutions placed in a conical flask for titration?

Why are the solutions placed in a conical flask for titration?

The conical flask allows the reaction mixture to be easily swirled without losing any of the contents.

Why must the reaction mixture be swirled during the titration?

Why must the reaction mixture be swirled during the titration?

Swirling ensures all the reacting particles collide and react. This helps to give a more accurate end point for the reaction.

Why must the equilibrium reaction mixture be titrated against sodium hydroxide as quickly as possible?

Why must the equilibrium reaction mixture be titrated against sodium hydroxide as quickly as possible?

As soon as the bung is removed from the reaction mixture and the mixture is combined with water, the position of equilibrium will start to move since the concentration of water (one of the products) has increased. The titration must be done as quickly as possible so that the reaction solution being titrated remains as close to equilibrium as possible.

Why must the burette be filled below eye level?

Why must the burette be filled below eye level?

The burette should be filled below eye level so that if any of the sodium hydroxide spills whilst being poured in, it will not splash into your face.

Why must the readings from the burette be taken from eye level?

Why must the readings from the burette be taken from eye level?

The readings must be taken from eye level so that the meniscus can be easily lined up with the scale. Taken the readings from eye level will avoid parallax errors.