

Acid-base indicators

This resource accompanies the article **Ocean acidification** in *Education in Chemistry* which can be viewed at: <https://rsc.li/368k27r>

Learning objectives

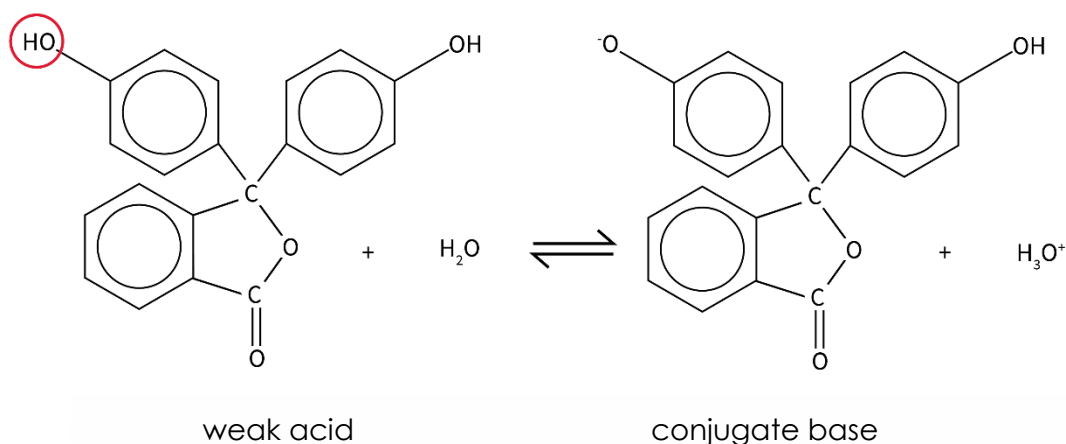
- 1 To understand that indicators are weak acids in which the colour of the aqueous solution of the acid is distinctly different from that of its conjugate base.
- 2 To know that the pH range over which a colour change occurs can be estimated by $\text{pH} = -\text{p}K_{\text{in}} \pm 1$.
- 3 To be able to sketch the pH curves for different acid-base titrations and suggest suitable indicators based on data given.

Introduction

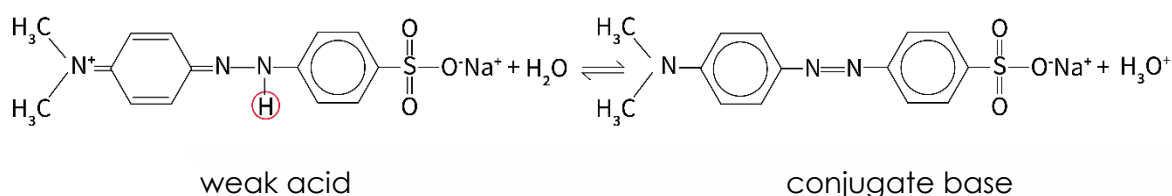
Test learners' understanding of acid-base equilibria with this series of questions on indicators.

Answers

1. phenolphthalein:

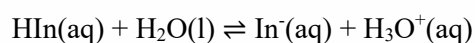


methyl orange:



2.

- (a) The alkaline solution reacts with the H^+ ions and removes them from the equilibrium. As a result, according to le Chatelier's principle the equilibrium shifts to the right to replace the lost H^+ ions. The concentration of yellow weak acid is reduced and the concentration of the red conjugate base is increased.
- (b) According to le Chatelier's principle, on the addition of H^+ ions the equilibrium shifts to the left in favour of the yellow weak acid to remove the extra H^+ ions added.
- (c) We can express this equilibrium as:



At the theoretical point of a colour change $[\text{HIn}(\text{aq})] = [\text{In}^-(\text{aq})]$ meaning that at this point $K_{\text{In}} = [\text{H}_3\text{O}^+]$ and therefore $\text{p}K_{\text{In}} = \text{pH}$.

If K_{In} for this equilibrium is $1.26 \times 10^{-8} \text{ mol dm}^{-3}$ then the theoretical pH at the point of colour change can be determined as:

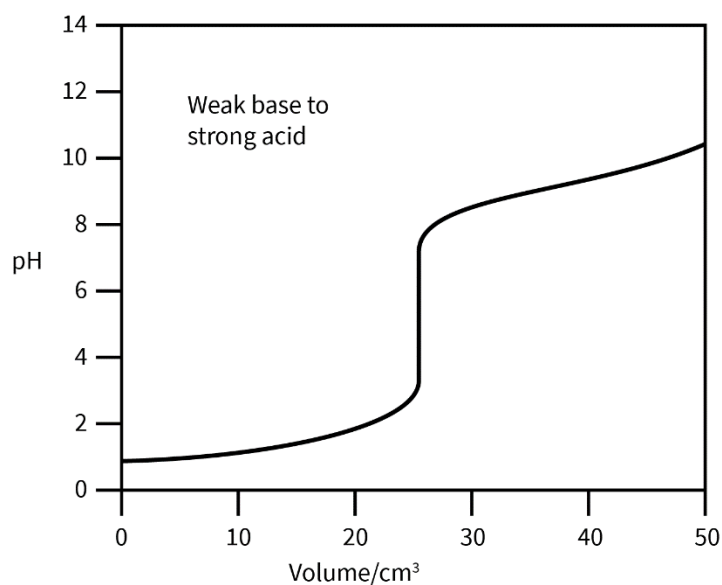
$$\text{pH} = -\log(1.26 \times 10^{-8}) = 7.9$$

The colour change is assumed to be distinguishable when $[\text{HIn}]$ and $[\text{In}^-]$ differ by a factor of 10 meaning that the pH range over which the colour change occurs can be estimated as:

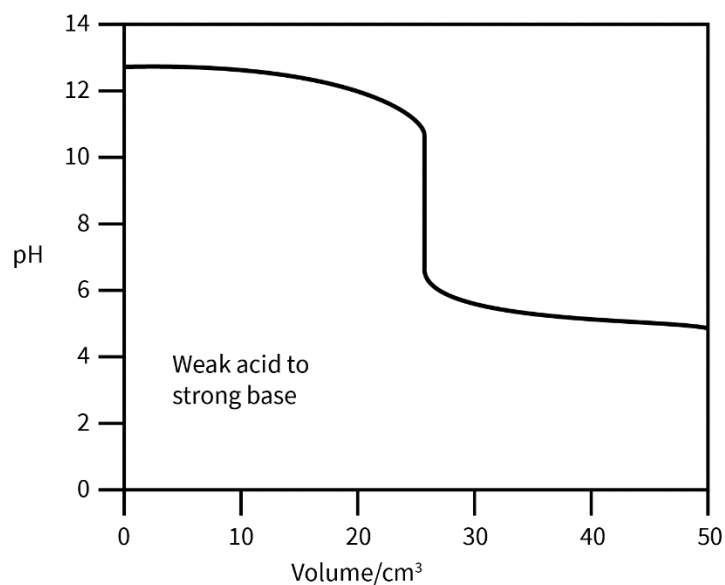
$$7.9 \pm 1 = \mathbf{6.9-8.9}$$

3.

(a) Addition of ammonia solution to hydrochloric acid:

Suitable indicator = **methyl orange** or **4-nitrophenol**

(b) Addition of ethanoic acid to sodium hydroxide.

Suitable indicator = **phenolphthalein**