pH, water and weak acids

OCR A H432 · Full A-level

Answer on your own paper. Show your working where needed.

1. Nitric acid at 298 K

Calculate the pH of 0.0145 mol dm^{-3} HNO_3 at 298 K. Give your answer to two decimal places.

2. Find the conjugate pairs

$HCOOH + H_2O \rightleftharpoons HCOO^- + H_3O^+$. Identify the proton donor and proton acceptor in the forward direction. Write both conjugate acid-base pairs.

3. Barium hydroxide solution

A barium hydroxide solution contains 0.00500 mol dm^{-3} $Ba(OH)_2$. Assume complete dissociation. At this temperature $K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}.

Find $[OH^-]$ and the pH.

4. Pure water at a higher temperature

At a temperature above 298 K, $K_w = 5.80 \times 10^{-14}$ mol^2 dm^{-6}. Calculate the pH of pure water at this temperature. Use your result and the ion concentrations to decide whether the water is acidic, alkaline or neutral.

5. Ethanoic acid in water

Ethanoic acid has $K_a = 1.80 \times 10^{-5}$ mol dm^{-3}. Write the K_a expression and calculate the pH of a 0.120 mol dm^{-3} solution. State any assumptions.

6. Determine Ka from a pH reading

A 0.0800 mol dm^{-3} solution of a weak monobasic acid has pH 2.92. Calculate K_a using the weak-acid approximation, then calculate pKa.

7. Evaluate a pH estimate

A student uses $[HA] \approx 0.00500$ mol dm^{-3} for a monobasic acid with $K_a = 1.00 \times 10^{-3}$ mol dm^{-3} and starting concentration 0.00500 mol dm^{-3}. Their estimate is $[H^+] = 0.00224$ mol dm^{-3}.

Assess the approximation using the data. Neglect water's ionisation and write the equilibrium concentration of HA in terms of $x = [H^+]$.

8. Hydrochloric acid and sodium hydroxide

Mix 25.0 cm^3 of 0.144 mol dm^{-3} HCl with 20.0 cm^3 of 0.150 mol dm^{-3} NaOH. Assume the volumes are additive. Calculate the pH after mixing and identify the reagent in excess.

9. Extra challenge · What changes when a weak acid is diluted?

A 0.0400 mol dm^{-3} solution of a weak monobasic acid has pH 2.90. A second sample of the same solution is diluted to five times its original volume at the same temperature.

Use the weak-acid approximation to calculate K_a and the pH after dilution. Use the percentage ionisation of each sample to compare how well the approximation applies.

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