

Exercise walk-through

4.4.3

Drawing titration curves and resolving two neutralisation stages

Pearson Edexcel · International A-Level · Chemistry

Find the temperature boundary

Your turn

$\Delta H = +36.0 \text{ kJ mol}^{-1}$; $\Delta S(\text{system}) = +120 \text{ J mol}^{-1} \text{ K}^{-1}$. Which condition gives positive total entropy?

- A. T below 300 K
- B. T above 300 K
- C. Every temperature
- D. No temperature

Buffer after neutralisation

Your turn

0.0100 mol HA receives 0.00400 mol OH^- . Which HA:A⁻ ratio enters the buffer expression?

- A. 10:4
- B. 6:4
- C. 4:6
- D. 10:6

Independent structural identification

Your turn

$\text{C}_3\text{H}_6\text{O}$ has two carbon-13 signals, gives iodoform and no Tollens' silver. Which structure fits?

- A. Propanal
- B. Propanone
- C. Propan-1-ol
- D. Ethanoic acid

Exercises 2.1·2.3

2.1 State whether equivalence pH at 298 K is near, above or below 7 for strong acid–strong base, weak acid–strong base and strong acid–weak base. Explain one of the non-neutral cases using the ion present. [4]

2.2 20.0 cm³ of 0.150 mol dm^{−3} H₂A is titrated with 0.100 mol dm^{−3} NaOH. Calculate

2.3 Explain why a diprotic acid does not always show two clearly separated steep jumps. State what additional data are needed to interpret the shape. [2]

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2.1 Near 7; above 7; below 7 respectively. At weak-acid/strong-base equivalence, A^- accepts a proton from water to form OH^- , making the solution alkaline; or the conjugate acid of a weak base donates H^+ in the other case.

2.2 20.0 cm^3 of 0.150 mol dm^{-3} H_2A is titrated with 0.100 mol dm^{-3} $NaOH$. Calculate

2.2 $n(H_2A) = 0.150 \times 0.0200 = 0.00300\text{ mol}$. First volume = $0.00300/0.100 = 0.0300\text{ dm}^3 = 30.0\text{ cm}^3$. Second total volume = 60.0 cm^3 for two OH^- equivalents.

2.3 Explain why a diprotic acid does not always show two clearly separated steep jumps. State what additional data are needed to interpret the shape. [2]

2.3 Similar dissociation constants can merge the stages, or a very weak later dissociation can give a poorly defined jump. Use the dissociation constants, concentrations and measured pH–volume data.

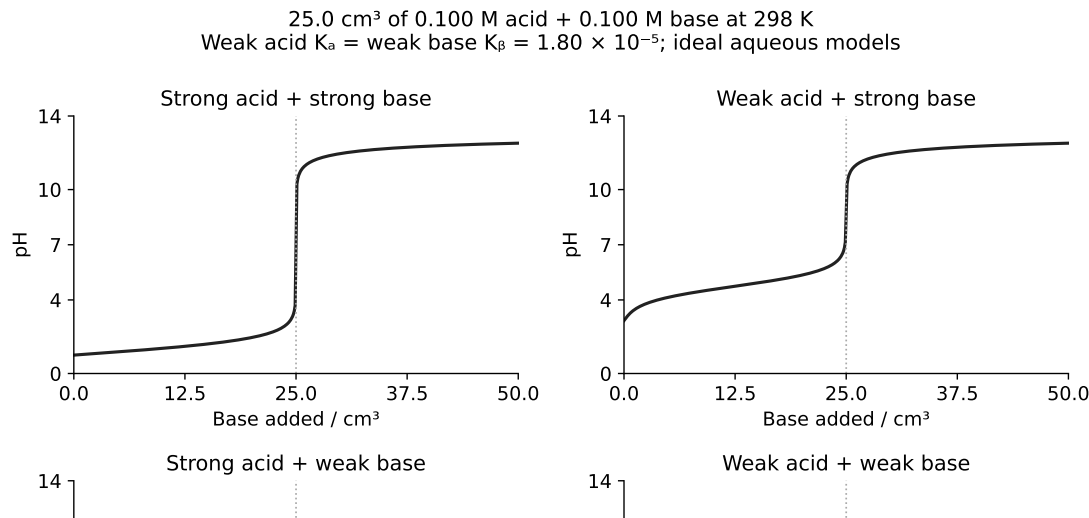
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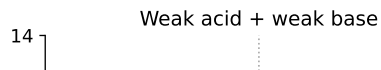
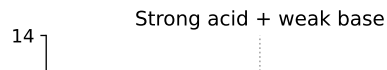
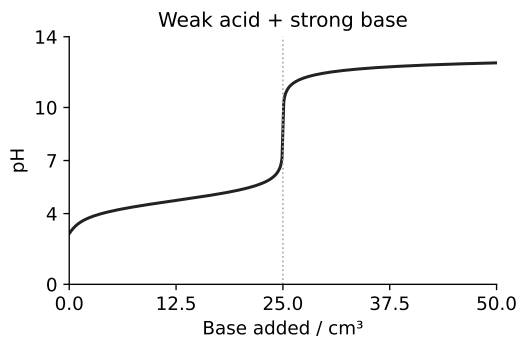
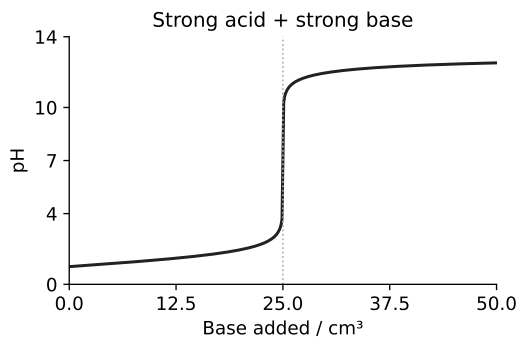
3.1 Completed model curves:



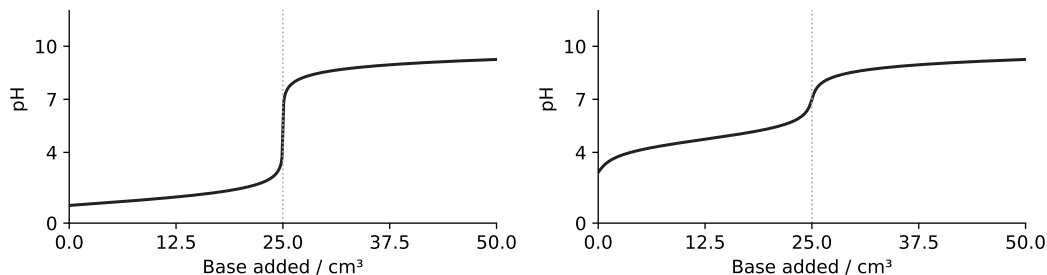
Full solution 3.1 (1/2)

3.1 Completed model curves:

25.0 cm³ of 0.100 M acid + 0.100 M base at 298 K
Weak acid K_a = weak base K_b = 1.80×10^{-5} ; ideal aqueous models



Full solution 3.1 (2/2)



For each curve, B1 for appropriate start and excess-base region, B1 for equivalence-region shape/pH and correct 25.0 cm³ location (eight points total). Axes must state pH and added base volume. Weak/weak has a gradual region rather than the sharp strong/strong jump. Model weak-species constants are illustrative; an answer need not match their exact numerical pH.

Exercise 3.2

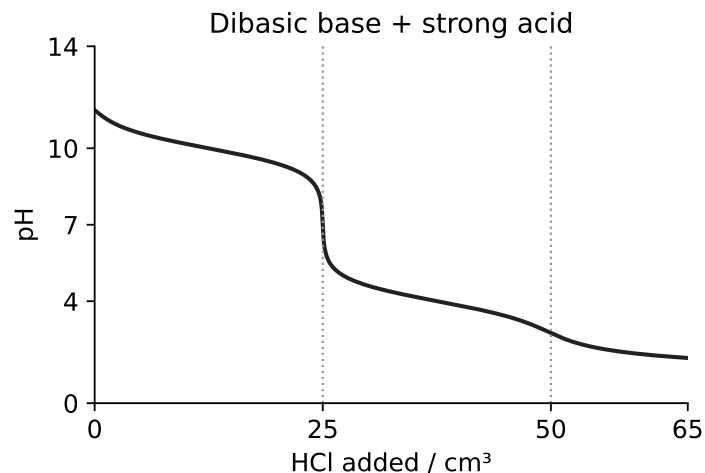
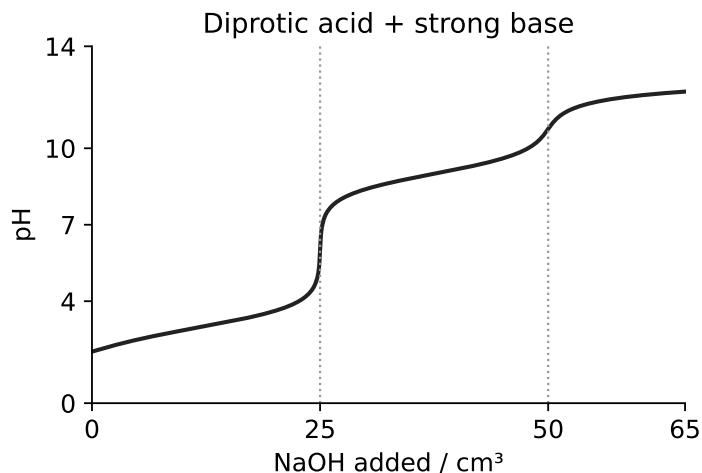
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3.2 $\text{B} + \text{H}^+ \rightarrow \text{BH}^+$ and $\text{BH}^+ + \text{H}^+ \rightarrow \text{BH}_2^{2+}$. Initial B amount is 0.00250 mol , so total

Two neutralisation stages: 25.0 cm^3 of 0.100 M solute + 0.100 M titrant
Illustrative separated dissociations, 298 K ; dotted lines at 25 and 50 cm^3



Exercise 3.3

3.3 A weak diprotic acid has sufficiently separated dissociations. On titration with strong base, first and second equivalence amounts occur at 20.0 and 40.0 cm³. Measured pH at 10.0 cm³ is 3.5; at 30.0 cm³ it is 8.0. Estimate pK_{a1} and pK_{a2} and explain the ratios used. Explain why these data do not by themselves select a colour indicator for either endpoint.

[5]

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3.3 At 10.0 cm³ the first-stage acid/conjugate-base amounts are equal, so pK_{a1} ≈ 3.5. At