

Solutions

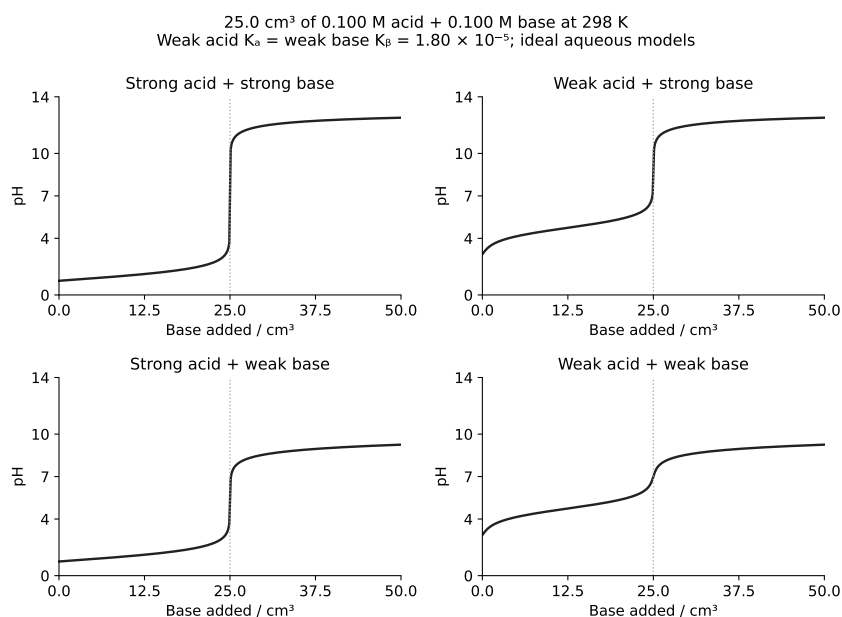
Original marking guidance: M1 method, A1 accuracy, B1 explanation.

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 $n(H_2A) = 0.150 \times 0.0200 = 0.00300$ mol. First volume = $0.00300/0.100 = 0.0300$ dm³ = 30.0 cm³. Second total volume = 60.0 cm³ for two OH^- equivalents.

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.

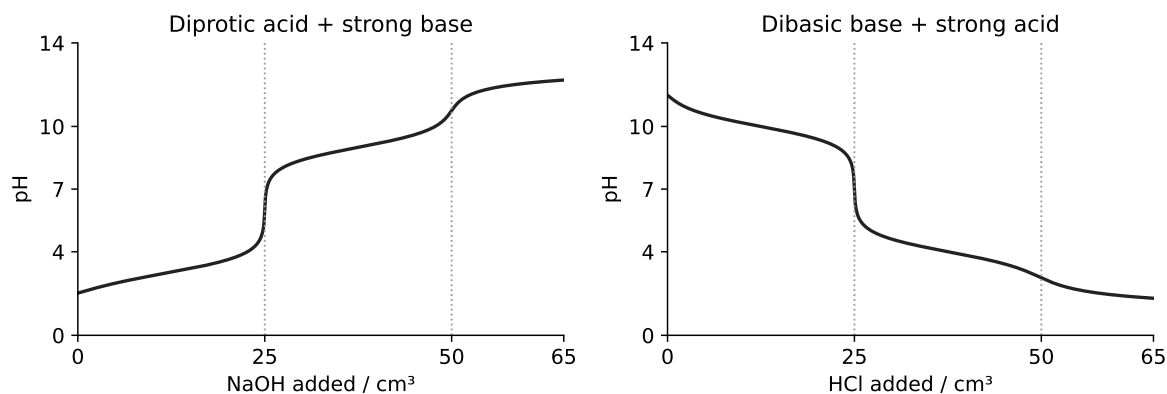
3.1 Completed model curves:



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.

3.2 $B + H^+ \rightarrow BH^+$ and $BH^+ + H^+ \rightarrow BH_2^{2+}$. Initial B amount is 0.00250 mol, so total HCl volumes are 25.0 and 50.0 cm³. Added acid lowers pH, giving the falling curve.

Two neutralisation stages: 25.0 cm³ of 0.100 M solute + 0.100 M titrant
 Illustrative separated dissociations, 298 K; dotted lines at 25 and 50 cm³



3.3 At 10.0 cm³ the first-stage acid/conjugate-base amounts are equal, so $\text{pK}_{\text{a}1} \approx 3.5$. At 30.0 cm³ the second-stage $\text{HA}^-/\text{A}^{2-}$ amounts are equal, so $\text{pK}_{\text{a}2} \approx 8.0$. Indicator choice needs its transition interval and the actual steep-region pH ranges; half-neutralisation pH alone does not give them.