

Exercise walk-through

4.4.4

Acid–base data, buffer design and independent curve transfer

Pearson Edexcel · International A-Level · Chemistry

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

Hydrogen bonds require a donor and acceptor

- 1** Carbonyl O accepts a hydrogen bond from water. Simple aldehydes/ketones lack an O–H donor.
- 2** Acids form hydrogen-bonded associations; compare similar-sized molecules for boiling points.
- 3** A longer non-polar chain can reduce water solubility without removing the polar group.

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 2.1·2.2

2.1 Initially $0.100 \text{ mol dm}^{-3}$ HCl and monoprotic HA are separately diluted at constant temperature. Analyse the supplied measurements. Find the HCl pH rise at each dilution; compare HA with the half-log dilution rule. At 1000-fold dilution calculate $[\text{H}^+]$ and the percentage of HA dissociated. Explain why the small-dissociation assumption is then poor. Do not solve a quadratic. [6]

Dilution factor	HCl pH	HA pH
1	1.00	3.00
10	2.00	3.51
100	3.00	4.02
1000	4.00	4.57

2.2 Design 250.0 cm^3 of a buffer at pH 5.00 with final $[\text{HA}] + [\text{A}^-] = 0.120 \text{ mol dm}^{-3}$.

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1000	4.00	4.57

2.1 HCl rises by 1, 2 and 3 pH units relative to the original. HA rises by 0.51, 1.02 and 1.57, near but increasingly above the 0.50, 1.00 and 1.50 predictions. At factor 1000, $c = 0.100/1000 = 1.00 \times 10^{-4} \text{ mol dm}^{-3}$, $[H^+] = 10^{-4.57} = 2.69 \times 10^{-5} \text{ mol dm}^{-3}$. Dissociation is approximately $100[H^+]/c = 26.9\%$, too large to replace equilibrium HA by initial c . Water is not the main explanation at this pH.

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2.2 $[H^+] = 10^{-5}$ and $[A^-]/[HA] = 2.00$. $3[HA] = 0.120$ gives final HA = 0.0400 and

Exercise 2.3

2.3 25.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ weak base B is titrated with $0.100 \text{ mol dm}^{-3}$ HCl.

3 Exam-style questions

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2.3 BH^+ is the conjugate acid. Initial B = 0.00250 mol ; at 12.5 cm^3 H^+ added is 0.00125 mol , leaving equal B/ BH^+ . Hence $\text{pK}_a(\text{BH}^+) \approx 9.25$, $K_a = 10^{-9.25} = 5.62 \times 10^{-10} \text{ mol dm}^{-3}$. At 20.0 cm^3 , B = 0.000500 and $\text{BH}^+ = 0.00200 \text{ mol}$; $\text{pH} = 9.25 + \log_{10}(0.000500/0.00200) = 8.65$. Added acid converts B to BH^+ ; the ratio changes moderately while appreciable quantities of both remain, rather than leaving the added H^+ free.

Exercise 3.1

3.1 Draw two separate smooth pH–volume curves using all supplied points: 25.0 cm³ of 0.0600 mol dm⁻³ diprotic H₂A with 0.100 mol dm⁻³ NaOH, and the same amount of dibasic B with 0.100 mol dm⁻³ HCl. Mark the two equivalence amounts calculated from moles; identify the opposite directions. Exact vertical jumps are not required. [8]

Added titrant / cm ³	H ₂ A + NaOH pH	B + HCl pH
0	2.14	11.38
7.5	3.03	10.00
15.0	6.01	7.00
22.5	9.00	4.01
30.0	10.71	2.80
35.0	11.92	2.06

Exercise 3.1

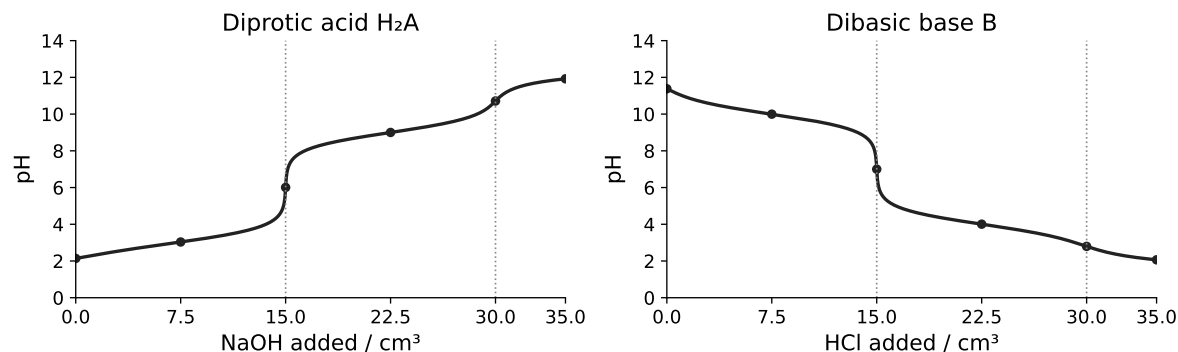
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Full solution 3.1

3.1 Completed ideal-model curves through the supplied points:

25.0 cm³ of 0.0600 M solute + 0.100 M titrant, 298 K
Illustrative aqueous models; dotted lines mark 15.0 and 30.0 cm³



For each curve: B1 for axes/direction and appropriate end regions; B1 for plotting all six points with a smooth curve; B1 for first equivalence 15.0 cm³; B1 for second total equivalence 30.0 cm³. $n = 0.0600(0.0250) = 0.00150$ mol; one and two titrant equivalents require 0.00150 and 0.00300 mol. Do not require a discontinuity: finite-concentration curves are continuous. Model constants are illustrative and supplied data, not a claim about every diprotic substance.

Exercises 3.2·3.3

3.2 A student says: “Blood buffers remove every added acid permanently, and a food buffer kills microbes.” Use the $\text{H}_2\text{CO}_3/\text{HCO}_3^-$ pair to correct the blood claim with equations for added H^+ and OH^- . Explain why stable pH matters in cells and why buffering food can limit deterioration without proving sterility. State the capacity limit.[5]

3.3 Propose a method to find K_a of a supplied pure monoprotic solid acid of known molar mass using a balance, volumetric flask and pH meter. Explain concentration determination, two pH-measurement controls, the calculation without assuming $c - x = c$ and one reason repeated readings alone cannot remove a systematic error. [6]

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3.2 $\text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3$; $\text{H}_2\text{CO}_3 + \text{OH}^- \rightarrow \text{HCO}_3^- + \text{H}_2\text{O}$. Limiting pH changes

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3.3 Weigh an accurately known mass m , dissolve completely, transfer/rinse quantitatively and make up to known volume V in a volumetric flask; $c = m/(MV)$ with V in dm^3 . Calibrate the meter with suitable standard buffers and maintain stated temperature/rinse the electrode between solutions. Measure equilibrium pH; $x = 10^{-\text{pH}}$, $[\text{HA}] = c - x$, $K_a = x^2/(c - x)$ when HA is the sole significant H^+ source. Repetition improves random scatter but does not correct a biased calibration, contaminated standard or wrong final volume. This is assessed method knowledge, not certification of practical performance.