InkChemistry

ANSWER BOOK

Brønsted–Lowry acids and bases, pH and strong acids

Acids and bases · Unit C11

AQA 3.1.12.1, 3.1.12.2 · OCR A 5.1.3

16 questions · 58 marks

NAVY EDITION

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SECTION B · Standard, 3 to 5 marks

B1 BN-Q9

B1 the acid is fully dissociated, so a tenfold dilution divides $[H^+]$ by ten. **B1** pH is a logarithm to base 10, so a factor of ten in $[H^+]$ changes the pH by exactly one. **B1** water itself dissociates and supplies H^+ at about 1.0×10^{-7} mol dm^{-3}. **B1** at this dilution the acid supplies less H^+ than the water does, so the water's H^+ cannot be ignored. **B1** the total $[H^+]$ is a little above 1.0×10^{-7} mol dm^{-3}, so the pH is just below 7 and the solution is still acidic. [5]

B2 BN-Q1

B1 a Brønsted–Lowry acid is a proton donor; allow 'H^+ ion donor', reject 'hydrogen donor'. **B1** a Brønsted–Lowry base is a proton acceptor, a species that accepts an H^+ ion. **B1** NH_4^+ and NH_3 are a conjugate pair, with NH_4^+ the acid and NH_3 the base. **B1** H_2O and OH^- are a conjugate pair, with H_2O the acid and OH^- the base. [4]

B3 BN-Q4

M1 nitric acid is fully dissociated, so $[H^+] = 0.0350$ mol dm^{-3} and pH = -log(0.0350). **A1** pH = 1.46, to two decimal places. **M1** $[H^+]$ = 10^(-pH) = 10^(-3.65). **A1** $[H^+] = 2.24 \times 10^{-4}$ mol dm^{-3}, to three significant figures. [4]

B4 BN-Q5

M1 fully dissociated, each H_2SO_4 releases two H^+, so $[H^+] = 2 \times 7.50 \times 10^{-3} = 0.0150$ mol dm^{-3}. **A1** pH = -log(0.0150) = 1.82. **M1** first dissociation only, $[H^+] = 7.50 \times 10^{-3}$ mol dm^{-3}. **A1** pH = $-\log(7.50 \times 10^{-3})$ = 2.12, to two decimal places. [4]

B5 BN-Q16

B1 a tribasic acid is one of which each molecule can donate three protons (H^+ ions). **M1** moles of $H_3PO_4 = 0.0500 \times 20.0 \div 1000 = 1.00 \times 10^{-3}$ mol. **M1** H_3PO_4 is tribasic, so $3 \times 1.00 \times 10^{-3} = 3.00 \times 10^{-3}$ mol of NaOH is needed. **A1** volume = $3.00 \times 10^{-3} \div 0.150 = 0.0200$ dm^3 = 20.0 cm^3, to three significant figures. [4]

B6 BN-Q18

B1 $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$, balanced, with the nitrate ion left out as a spectator. **B1** state symbols $CaCO_3(s)$, $H^+(aq)$, $Ca^{2+}(aq)$, $CO_2(g)$ and $H_2O(l)$. **B1** $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$, balanced, with no nitrate ion. **B1** state symbols $Mg(s)$, $H^+(aq)$, $Mg^{2+}(aq)$ and $H_2(g)$; a missing state symbol on one species loses this mark only. [4]

B7 BN-Q3

B1 the conjugate base of HSO_4^- is SO_4^{2-}. **B1** the conjugate base of H_2O is OH^-. **B1** the conjugate base of NH_4^+ is NH_3. [3]

B8 BN-Q7

M1 moles of HCl = $0.200 \times 10.0 \div 1000 = 2.00 \times 10^{-3}$ mol. **M1** new $[H^+] = 2.00 \times 10^{-3} \div 0.250 = 8.00 \times 10^{-3}$ mol dm^{-3}. **A1** pH = $-\log(8.00 \times 10^{-3})$ = 2.10, to two decimal places. [3]

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B9 BN-Q10 **M1** a rise of one pH unit means $[H^+]$ must fall by a factor of ten, from 0.100 to 0.0100 mol dm^{-3}. **M1** the amount of HCl is unchanged, so the final volume is ten times the original, 500 cm^3. **A1** volume of water added = 500 - 50.0 = 450 cm^3, to three significant figures. [3]

B10 BN-Q11 **B1** hydrochloric acid is a strong acid that dissociates completely, so $[H^+]$ = 0.100 mol dm^{-3}. **B1** ethanoic acid is a weak acid that dissociates only partially, in an equilibrium lying well to the left. **B1** so $[H^+]$ in the ethanoic acid is much lower than 0.100 mol dm^{-3} and its pH is higher. [3]

B11 BN-Q12 **B1** nitric acid acts as a Brønsted–Lowry base, accepting a proton from sulfuric acid. **B1** H_2SO_4 and HSO_4^- are a conjugate pair, with H_2SO_4 the acid. **B1** $H_2NO_3^+$ and HNO_3 are a conjugate pair, with $H_2NO_3^+$ the acid. [3]

B12 BN-Q13 **B1** the first dissociation, $H_2SO_4 \rightarrow H^+ + HSO_4^-$, is complete, which alone would give $[H^+]$ = 0.0500 mol dm^{-3} and pH 1.30. **B1** the second dissociation, $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$, is partial, so some extra H^+ is released and the pH is lower than 1.30. **B1** the second proton is not fully released, so $[H^+]$ is less than 0.100 mol dm^{-3} and the pH is higher than 1.00. [3]

B13 BN-Q14 **B1** ethanoic acid is weak, partially dissociated, while hydrochloric acid is strong, fully dissociated. **B1** the ethanoic acid is the more concentrated solution, by a factor of 200. **B1** the hydrochloric acid has pH 2.00, lower than 2.23, so it has the higher $[H^+]$ even though it is far less concentrated. [3]

B14 BN-Q15 **B1** 2.00 mol dm^{-3} HCl is fully dissociated, so $[H^+]$ = 2.00 mol dm^{-3}. **B1** pH = $-\log(2.00) = -0.30$, a negative value. **B1** the claim is wrong: any strong acid with $[H^+]$ above 1 mol dm^{-3} has a negative pH, and 0 to 14 covers only the usual range. [3]

B15 BN-Q17 **B1** the reacting species is H^+: $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$, and $[H^+]$ is much higher in the fully dissociated hydrochloric acid, so the rate is greater. **B1** as H^+ is used up in the ethanoic acid, the equilibrium $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ shifts to the right and more acid dissociates. **B1** both solutions contain 2.50×10^{-3} mol of acid, all of which eventually reacts, giving 1.25×10^{-3} mol of H_2 in each. [3]

SECTION C · Long, 6 marks or more

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C1 BN-Q2 **Indicative content** [6]

B1 a strong acid is one that dissociates completely in aqueous solution, and a weak acid is one that dissociates only partially. **B1** strength is a property of the acid, the extent of its dissociation, whereas concentration is the amount of acid in each cubic decimetre of solution. **B1** diluting 0.100 mol dm^{-3} hydrochloric acid tenfold gives 0.0100 mol dm^{-3} acid, still completely dissociated, so $[H^+]$ = 0.0100 mol dm^{-3} and the pH is 2.00. **B1** dilution lowers the concentration and raises the pH, but the acid stays strong because no HCl molecules re-form at any concentration. **B1** 0.100 mol dm^{-3} ethanoic acid has pH 2.88, higher than the 1.00 of hydrochloric acid at the same concentration, because it is only partly dissociated. **B1** the claim is wrong because it confuses 'dilute' with 'weak': the watered-down acid is a dilute solution of a strong acid.

Levels

Level 3 (5–6 marks) strength and concentration are defined and kept apart throughout, the diluted hydrochloric acid is shown to stay fully dissociated with its pH worked to 2.00, the ethanoic acid comparison is used to show what weak actually looks like, and the claim is judged wrong for confusing dilute with weak.

Level 2 (3–4 marks) the strong/weak distinction is stated correctly and the claim is rejected, with one of the two comparisons worked through; the other pH value goes unused, or strength and concentration slide together in places.

Level 1 (1–2 marks) the answer agrees with the claim, or takes the higher pH of the diluted acid as proof that it has turned weak; strength and concentration are used as if they meant the same thing.

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