CHEMISTRY
Stage 6

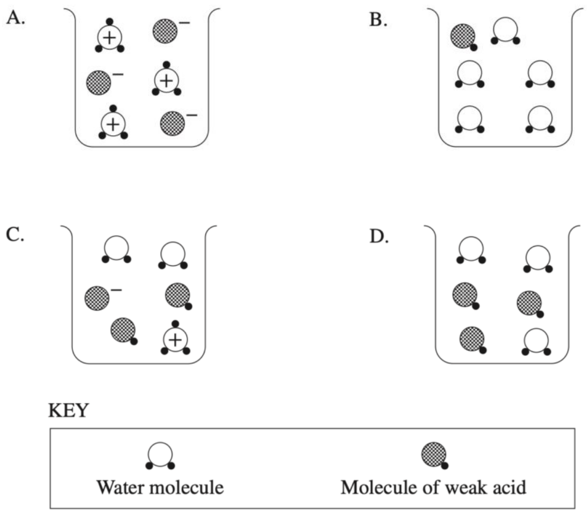
Module 6: Acid/Base Reactions
Bronsted-Lowry Theory

Teacher: Samantha Wong
Exam Equivalent Time: 157.5 minutes *(based on allocation of 1.5 minutes per mark)*

Questions

1. CHEMISTRY, M6 2018 HSC 7 MC

Which diagram represents ionisation of a weak acid?



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2. CHEMISTRY, M6 2008 HSC 14 MC

20 mL 0.08 mol L^{-1} HCl is mixed with 30 mL of 0.05 mol L^{-1} NaOH.

What is the pH of the resultant solution?

A. 1.1
B. 2.7
C. 4.0
D. 7.0

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3. CHEMISTRY, M6 2016 HSC 10 MC

Which of the following is the conjugate base of the $H_2PO_4^-$ ion?

A. H_3PO_4
B. H_3PO_3
C. HPO_4^{2-}
D. HPO_3^{2-}

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4. CHEMISTRY, M6 2016 HSC 12 MC

Which of the following could be added to 100 mL of 0.01 mol L^{-1} hydrochloric acid solution to change its pH to 4?

A. 900 mL of water
B. 900 mL of 0.01 mol L^{-1} hydrochloric acid
C. 9900 mL of water
D. 9900 mL of 0.01 mol L^{-1} hydrochloric acid

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5. CHEMISTRY, M6 2016 HSC 18 MC

40 mL of 0.10 mol L^{-1} NaOH is mixed with 60 mL of 0.10 mol L^{-1} HCl.

What is the pH of the resulting solution?

A. 7.0
B. 1.7
C. 1.4
D. 1.2

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6. CHEMISTRY, M6 2016 HSC 6 MC

Which combination of equimolar solutions would produce the most basic mixture?

A. Acetic acid and barium hydroxide
B. Acetic acid and sodium carbonate
C. Sulfuric acid and barium hydroxide
D. Sulfuric acid and sodium carbonate

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7. CHEMISTRY, M6 2017 HSC 5 MC

Which of the following substances is amphiprotic in nature?

A. HSO_4^-
B. H_2SO_4
C. SO_4^{2-}
D. H_2SO_3

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8. CHEMISTRY, M6 2018 HSC 18 MC

The pH of a 0.080 mol L^{-1} solution of acetic acid is 2.9.

What percentage of the acetic acid has dissociated into ions?

A. 1.0%

B. 1.3%

C. 1.6%

D. 2.8%

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9. CHEMISTRY, M6 2018 HSC 6 MC

Sodium hydrogen carbonate is often used to clean up large spills of acids and alkalis.

Why is it a suitable chemical for this application?

A. It is diprotic and is readily neutralised.

B. It is amphiprotic, stable and easily handled.

C. It is diprotic and easily cleaned up when neutralised.

D. It is amphiprotic and only small quantities are required.

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10. CHEMISTRY, M6 2019 HSC 15 MC

What is the concentration of hydroxide ions (in mol L^{-1}) in a solution that has a pH of 8.53?

A. 3.0×10^{-9}

B. 3.4×10^{-6}

C. 5.5

D. 3.0×10^{5}

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11. CHEMISTRY, M6 2020 HSC 14 MC

The equation for the autoionisation of water is shown.

$$2\,\mathrm{H_2O\,(l)} \rightleftharpoons \mathrm{H_3O^+\,(aq)} + \mathrm{OH^-\,(aq)}$$

At 50°C the water ionisation constant, K_w, is 5.5×10^{-14}.

What is the pH of water at 50°C?

A. 5.50

B. 6.63

C. 6.93

D. 7.00

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12. CHEMISTRY, M6 2022 HSC 10 MC

Which equation shows the hydrogen carbonate ion acting as a Brønsted-Lowry acid?

A. $\mathrm{HCO_3^-\,(aq)} \rightleftharpoons \mathrm{CO_3^{2-}\,(aq)} + \mathrm{H^+\,(aq)}$

B. $\mathrm{HCO_3^-\,(aq)} + \mathrm{H_2O\,(l)} \rightleftharpoons \mathrm{H_2CO_3\,(aq)} + \mathrm{OH^-\,(aq)}$

C. $\mathrm{HCO_3^-\,(aq)} + \mathrm{NH_3\,(aq)} \rightleftharpoons \mathrm{CO_3^{2-}\,(aq)} + \mathrm{NH_4^+\,(aq)}$

D. $\mathrm{HCO_3^-\,(aq)} + \mathrm{HCOOH\,(aq)} \rightleftharpoons \mathrm{HCOO^-\,(aq)} + \mathrm{H_2CO_3\,(aq)}$

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13. CHEMISTRY, M6 2023 HSC 6 MC

The pH of a solution changes from 8 to 5.

What happens to the concentration of hydrogen ions during this change of pH?

A. It increases by a factor of 3.

B. It decreases by a factor of 3.

C. It increases by a factor of 1000.

D. It decreases by a factor of 1000.

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14. CHEMISTRY, M6 2024 HSC 6 MC

What is the hydroxide ion concentration of a solution of potassium hydroxide with a pH of 11 ?

A. $10^{-11}\ \mathrm{mol\ L^{-1}}$

B. $10^{-3}\ \mathrm{mol\ L^{-1}}$

C. $10^{3}\ \mathrm{mol\ L^{-1}}$

D. $10^{11}\ \mathrm{mol\ L^{-1}}$

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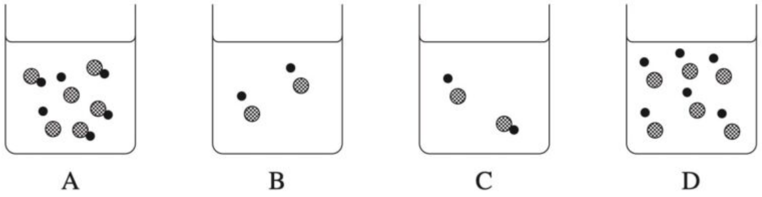
15. CHEMISTRY, M6 EQ-Bank 5 MC

Which beaker contains a concentrated strong acid?



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16. CHEMISTRY, M6 2015 HSC 13 MC

Which of the following solutions has the highest pH?

A. $1.0\ \mathrm{mol\ L^{-1}}$ acetic acid

B. $0.10\ \mathrm{mol\ L^{-1}}$ acetic acid

C. $1.0\ \mathrm{mol\ L^{-1}}$ hydrochloric acid

D. $0.10\ \mathrm{mol\ L^{-1}}$ hydrochloric acid

17. CHEMISTRY, M6 2015 VCE 22 MC

What is the pH of a 0.0500 M solution of barium hydroxide, $\mathrm{Ba(OH)_2}$?

A. 1.00

B. 1.30

C. 12.7

D. 13.0

18. CHEMISTRY, M6 2016 VCE 20 MC

How does diluting a 0.1 M solution of lactic acid, $\mathrm{HC_3H_5O_3}$, change its pH and percentage ionisation?

	pH	Percentage ionisation
A.	increase	decrease
B.	increase	increase
C.	decrease	increase
D.	decrease	decrease

19. CHEMISTRY, M6 2017 HSC 20 MC

20.0 mL of 0.020 mol L^{-1} barium hydroxide solution is added to 50.0 mL of 0.040 mol L^{-1} hydrochloric acid solution.

What is the pH of the final solution?

A. 0.2

B. 1.6

C. 1.8

D. 2.9

20. CHEMISTRY, M6 2021 HSC 15 MC

What is the pH of the resultant solution after 20.0 mL of 0.20 mol $\mathrm{L^{-1}}$ $\mathrm{HCl}(aq)$ is mixed with 20.0 mL of 0.50 mol $\mathrm{L^{-1}}$ $\mathrm{NaOH}(aq)$?

A. 11.8

B. 13.2

C. 13.5

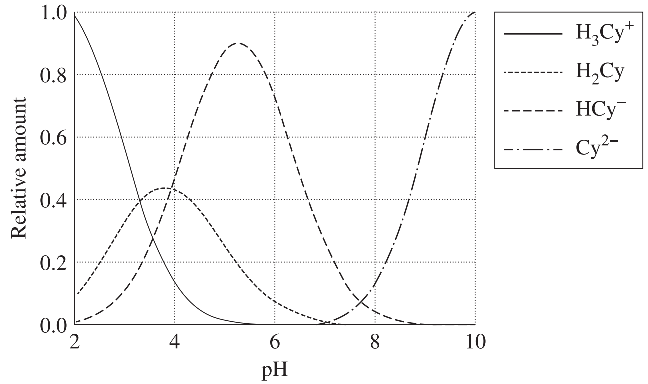
D. 14.0

21. CHEMISTRY, M6 2022 HSC 20 MC

Cyanidin is a plant pigment that may be used as a pH indicator. It has four levels of protonation, each with a different colour, represented by these equilibria:

$$\underset{\text{Red}}{\mathrm{H_3Cy^+}} \underset{+\mathrm{H^+}}{\overset{-\mathrm{H^+}}{\rightleftharpoons}} \underset{\text{Colourless}}{\mathrm{H_2Cy}} \underset{+\mathrm{H^+}}{\overset{-\mathrm{H^+}}{\rightleftharpoons}} \underset{\text{Purple}}{\mathrm{HCy^-}} \underset{+\mathrm{H^+}}{\overset{-\mathrm{H^+}}{\rightleftharpoons}} \underset{\text{Blue}}{\mathrm{Cy^{2-}}}$$

The following graph shows the relative amount of each species present at different pH values.



What colour would the indicator be if added to a 0.75 mol L^{-1} solution of hypoiodous acid, HIO $(pK_a = 10.64)$?

A. Red

B. Colourless

C. Purple

D. Blue

22. CHEMISTRY, M6 2020 HSC 18 MC

An aqueous solution of sodium hydrogen carbonate has a pH greater than 7 .

Which statement best explains this observation?

A. $H_2O(l)$ is a stronger acid than $HCO_3^-(aq)$.

B. $HCO_3^-(aq)$ is a weaker acid than $H_2CO_3(aq)$.

C. $Na^+(aq)$ reacts with water to produce the strong base $NaOH(aq)$.

D. The conjugate acid of $HCO_3^-(aq)$ is a stronger acid than $H_2O(l)$.

23. CHEMISTRY, M6 2021 HSC 20 MC

The trimethylammonium ion, $[(CH_3)_3NH]^+$, is a weak acid. The acid dissociation equation is shown.

$$[(CH_3)_3NH]^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + (CH_3)_3N(aq) \quad K_a = 1.55 \times 10^{-10}$$

At 20°C, a saturated solution of trimethylammonium chloride, $[(CH_3)_3NH]Cl$, has a pH of 4.46.

What is the K_{sp} of trimethylammonium chloride?

A. 1.26×10^{-9}

B. 7.76

C. 60.2

D. 5.01×10^{10}

24. CHEMISTRY, M6 2021 HSC 6 MC

Which row of the table describes what happens when a solution of a weak acid is diluted? (Assume constant temperature.)

	K_a	*Extent of acid ionisation*
A.	Decreases	Increases
B.	Decreases	Decreases
C.	Remains the same	Increases
D.	Remains the same	Decreases

25. CHEMISTRY, M6 2022 HSC 22

The following equation describes an equilibrium reaction.

$$HF\,(aq) + PO_4^{3-}\,(aq) \rightleftharpoons HPO_4^{2-}\,(aq) + F^-\,(aq)$$

Identify ONE base and its conjugate acid in the above equation. ***(2 marks)***

Base	*Conjugate acid*

26. CHEMISTRY, M6 2012 HSC 28

A solution was made by mixing 75.00 mL of 0.120 mol L^{-1} hydrochloric acid with 25.00 mL of 0.200 mol L^{-1} sodium hydroxide.

What is the pH of the solution? ***(3 marks)***

27. CHEMISTRY M6 2016 VCE 21*

The ammonium ion NH_4^+ acts as a weak acid according to the equation

$$NH_4^+ (aq) + H_2O (l) \rightleftharpoons NH_3 (aq) + H_3O^+ (aq)$$

Given the $K_a(NH_4^+) = 5.6 \times 10^{-10}$, determine the $[H_3O^+]$ of a 0.200 M ammonium chloride solution. ***(2 marks)***

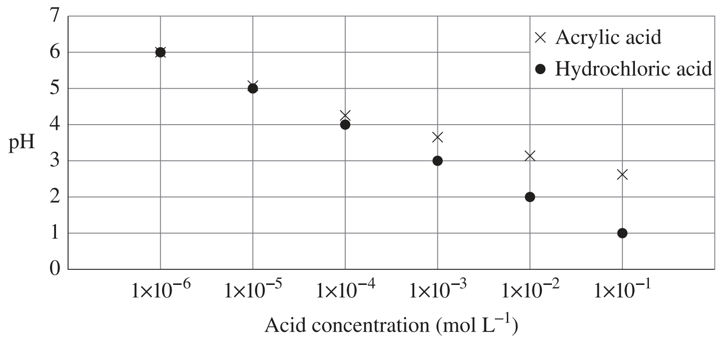
28. CHEMISTRY, M6 2019 HSC 33

A student adds 1.17 g of $Al(OH)_3 (s)$ to 0.500 L of 0.100 mol L^{-1} $HCl (aq)$.

Calculate the pH of the resulting solution. Assume that the volume of the resulting solution is 0.500 L. ***(4 marks)***

29. CHEMISTRY, M6 2020 HSC 34

The effect of concentration on the pH of acrylic acid (C_2H_3COOH) and hydrochloric acid (HCl) solutions is shown in the graph. Both of these acids are monoprotic.



Explain the trends in the graph. Include relevant chemical equations in your answer. ***(4 marks)***

30. CHEMISTRY, M6 2021 HSC 23

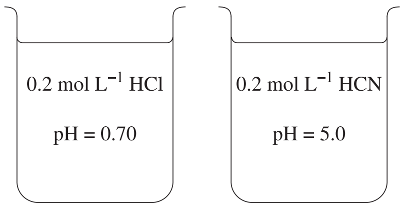
Methanoic acid reacts with aqueous potassium hydroxide. A salt is produced in this reaction.

a. Write a balanced chemical equation for this reaction. ***(2 marks)***

b. Is the salt acidic, basic or neutral? Justify your answer. ***(2 marks)***

31. CHEMISTRY, M6 2022 HSC 25

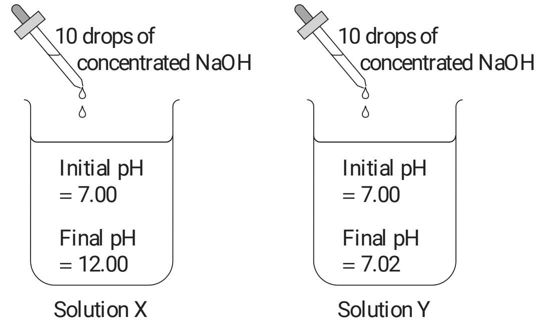
The pH of two aqueous solutions was compared.



Explain why the $HCN(aq)$ solution has a higher pH than the $HCl(aq)$ solution. Include a relevant chemical equation for the $HCN(aq)$ solution. ***(3 marks)***

32. CHEMISTRY, M6 2023 HSC 23

The pH of two solutions, X and Y, were measured before and after 10 drops of concentrated $NaOH$ was added to each.



Explain the pH changes that occurred in solutions X and Y. ***(3 marks)***

33. CHEMISTRY, M6 2023 HSC 24

The hydrogen oxalate ion $(HC_2O_4^-)$ is classified as amphiprotic.

Describe, using chemical equations, how this ion is amphiprotic. ***(2 marks)***

34. CHEMISTRY, M6 2024 HSC 28

Iodic acid and sulfamic acid are monoprotic acids. A 0.100 mol L^{-1} solution of iodic acid has a pH of 1.151, as does a 0.120 mol L^{-1} solution of sulfamic acid.

Show that neither iodic acid nor sulfamic acid dissociates completely in water, and determine which is the stronger acid. ***(3 marks)***

35. CHEMISTRY, M6 2024 HSC 29

150 mL of a 0.20 mol L^{-1} sodium hydroxide solution is added to 100 mL of a 0.10 mol L^{-1} sulfuric acid solution.

Calculate the pH of the resulting solution, assuming that the volume of the resulting solution is 250 mL and that its temperature is 25°C. ***(4 marks)***

36. CHEMISTRY, M6 EQ-Bank 23

Propanoic acid dissociation in water can is represented in the following equation:

$$CH_3CH_2COOH(aq) + H_2O(l) \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq)$$

Explain how the pH of the propanoic acid solution would change if it was diluted. ***(3 marks)***

37. CHEMISTRY, M6 2015 VCE 8

Hydrogen sulfide, in solution, is a diprotic acid and ionises in two stages.

$$H_2S\,(aq) + H_2O\,(l) \rightleftharpoons HS^-\,(aq) + H_3O^+\,(aq) \quad K_{a1} = 9.6\times10^{-8}\ M$$

$$HS^-\,(aq) + H_2O\,(l) \rightleftharpoons S^{2-}\,(aq) + H_3O^+\,(aq) \quad K_{a2} = 1.3\times10^{-14}\ M$$

A student made two assumptions when estimating the pH of a $0.01\ M$ solution of H_2S:

Assumption 1: The pH can be estimated by considering only the first ionisation reaction.

Assumption 2: The concentration of H_2S at equilibrium is approximately equal to $0.01\ M$.

a. Explain why these two assumptions are justified. ***(2 marks)***

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b. Use the two assumptions given above to calculate the pH of a 0.01 M solution of H_2S. ***(3 marks)***

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c. Some solid sodium hydrogen sulfide, $NaHS$, is added to a 0.01 M solution of H_2S.

Predict the effect of this addition on the pH of the hydrogen sulfide solution. Justify your prediction. ***(2 marks)***

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38. CHEMISTRY, M6 2017 HSC 24

A solution of sodium hydroxide was titrated against a standardised solution of acetic acid which had a concentration of 0.5020 mol L^{-1}.

a. The end point was reached when 19.30 mL of sodium hydroxide solution had been added to 25.00 mL of the acetic acid solution.

Calculate the concentration of the sodium hydroxide solution. ***(3 marks)***

b. Explain why the pH of the resulting salt solution was not 7. Include a relevant chemical equation in your answer. ***(2 marks)***

39. CHEMISTRY, M6 2019 HSC 27

The relationship between the acid dissociation constant, K_a, and the corresponding conjugate base dissociation constant, K_b, is given by:

$$K_a \times K_b = K_w$$

Assume that the temperature for part (a) and part (b) is 25°C.

a. The K_a of hypochlorous acid (HOCl) is 3.0×10^{-8}.

Show that the K_b of the hypochlorite ion, OCl^-, is 3.3×10^{-7}. ***(1 mark)***

b. The conjugate base dissociation constant, K_b, is the equilibrium constant for the following equation:

$$\mathrm{OCl}^-(aq) + \mathrm{H_2O}(l) \rightleftharpoons \mathrm{HOCl}(aq) + \mathrm{OH}^-(aq)$$

Calculate the pH of a 0.20 mol L^{-1} solution of sodium hypochlorite (NaOCl). ***(4 mark)***

40. CHEMISTRY, M6 2022 HSC 34

Sodium hypochlorite $NaOCl$ is the active ingredient in pool chlorine. It completely dissolves in water to produce the hypochlorite ion (OCl^-), which undergoes hydrolysis according to the following equilibrium.

$$OCl^- (aq) + H_2O (l) \rightleftharpoons HOCl (aq) + OH^- (aq)$$

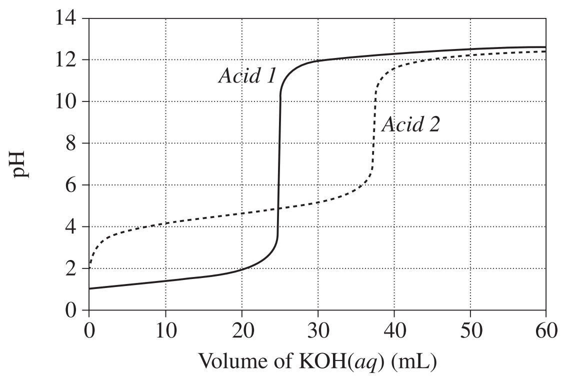
The equilibrium constant for this reaction at 25°C is 3.33×10^{-7}.

For pool chlorine to be effective the pH is maintained by a different buffer at 7.5 and the hypochlorous acid $(HOCl)$ concentration should be 1.3×10^{-4} mol L^{-1}.

Calculate the volume of 2.0 mol L^{-1} sodium hypochlorite solution that needs to be added to a 1.00 × 10^4 L pool to meet the required conditions. ***(4 marks)***

41. CHEMISTRY, M6 EQ-Bank 25

The graph shows changes in pH for the titrations of equal volumes of solutions of two monoprotic acids, *Acid 1* and *Acid 2*.



Explain the differences between *Acid 1* and *Acid 2* in terms of their relative strengths and concentrations. ***(3 marks)***

42. CHEMISTRY, M5 2020 HSC 27

A student makes up a solution of propan-2-amine in water with a concentration of 1.00 mol L^{-1}.

a. Using structural formulae, complete the equation for the reaction of propan-2-amine with water. ***(2 marks)***

$$\boxed{} + H_2O \rightleftharpoons \boxed{} + OH^-$$

b. The equilibrium constant for the reaction of propan-2-amine with water is 4.37×10^{-4}.

Calculate the concentration of hydroxide ions in this solution. ***(3 marks)***

43. CHEMISTRY, M6 2020 HSC 33

Excess solid calcium hydroxide is added to a beaker containing 0.100 L of 2.00 mol L^{-1} hydrochloric acid and the mixture is allowed to come to equilibrium.

a. Show that the amount (in mol) of calcium hydroxide that reacts with the hydrochloric acid is 0.100 mol. ***(2 marks)***

b. It is valid in this instance to make the simplifying assumption that the amount of calcium ions present at equilibrium is equal to the amount generated in the reaction in part (a).

Calculate the pH of the resulting solution. ***(4 marks)***

44. CHEMISTRY, M6 2015 HSC 24

a. Explain why the salt, sodium acetate, forms a basic solution when dissolved in water. Include an equation in your answer. ***(2 marks)***

b. A solution is prepared by using equal volumes and concentrations of acetic acid and sodium acetate.

Explain how the pH of this solution would be affected by the addition of a small amount of sodium hydroxide solution. Include an equation in your answer. ***(3 marks)***

45. CHEMISTRY, M6 2021 HSC 32

The molar enthalpies of neutralisation of three reactions are given.

Reaction 1:

$$\mathrm{HCl}(aq) + \mathrm{KOH}(aq) \longrightarrow \mathrm{KCl}(aq) + \mathrm{H_2O}(l) \qquad \Delta H = -57.6\ \mathrm{kJ\,mol^{-1}}$$

Reaction 2:

$$\mathrm{HNO_3}(aq) + \mathrm{KOH}(aq) \longrightarrow \mathrm{KNO_3}(aq) + \mathrm{H_2O}(l) \qquad \Delta H = -57.6\ \mathrm{kJ\,mol^{-1}}$$

Reaction 3:

$$\mathrm{HCN}(aq) + \mathrm{KOH}(aq) \longrightarrow \mathrm{KCN}(aq) + \mathrm{H_2O}(l) \qquad \Delta H = -12.0\ \mathrm{kJ\,mol^{-1}}$$

Explain why the first two reactions have the same enthalpy value but the third reaction has a different value. ***(4 marks)***

Worked Solutions

Worked Solutions

1. CHEMISTRY, M6 2018 HSC 7 MC

→ Partial ionisation will result in a solution that contains hydronium, anions and water.

$\Rightarrow C$

2. CHEMISTRY, M6 2008 HSC 14 MC

$\text{n(HCl)}_{\text{excess}} = 0.0016 - 0.0015 = 0.0001\,\text{mol}$

$[\text{HCl}] = \dfrac{0.0001}{0.020 + 0.030} = 0.002\,\text{mol L}^{-1}$

$[\text{HCl}] = [\text{H}^+]$

$\text{pH} = -\log(0.002) = 2.7$

$\Rightarrow B$

3. CHEMISTRY, M6 2016 HSC 10 MC

→ Any conjugate base will have 1 less proton.

$\Rightarrow C$

4. CHEMISTRY, M6 2016 HSC 12 MC

By Elimination:

→ If 0.01 mol L^{-1} hydrochloric acid is added, $[\text{H}^+]$ remains unchanged and hence pH is unchanged (eliminate B and D)

Mean mark 59%.

→ If 900 mL of water added, $[\text{H}^+]$ dilutes to 0.001 mol L^{-1}, with a pH = 3 (eliminate A)

→ If 9900 mL of water added, $[\text{H}^+]$ dilutes to 0.0001 mol L^{-1}, with a pH = 4

$\Rightarrow C$

5. CHEMISTRY, M6 2016 HSC 18 MC

$\text{n(HCl)}_{\text{excess}} = 0.006 - 0.004 = 0.002\,\text{mol}$

$[\text{HCl}] = \dfrac{0.002}{0.040 + 0.060} = 0.0200\,\text{mol L}^{-1}$

$[\text{HCl}] = [\text{H}^+]$

$\text{pH} = -\log(0.0200) = 1.7$

$\Rightarrow B$

6. CHEMISTRY, M6 2016 HSC 6 MC

→ Acetic acid (CH_3COOH) is a monoprotic acid, which when mixed with barium hydroxide $(Ba(OH)_2)$, leaves excess hydroxide ions creating a basic solution.

→ When acetic acid reacts with sodium carbonate (Na_2CO_3), it leaves excess sodium carbonate in the solution. Although this is the same concentration as the hydroxide ions above, it is a weaker base.

→ Sulfuric acid (H_2SO_4) is a strong diprotic acid and the mixtures in C and D will produce more neutral solutions.

$\Rightarrow A$

7. CHEMISTRY, M6 2017 HSC 5 MC

$HSO_4{}^-$ is amphiprotic.

→ It can accept a proton to form H_2SO_4

→ It can donate a proton to form $SO_4{}^{2-}$

$\Rightarrow A$

8. CHEMISTRY, M6 2018 HSC 18 MC

$\text{pH} = -\log[\text{H}^+]$

$[\text{H}^+] = 10^{-\text{pH}} = 10^{-2.9} = 1.259\,\text{mol L}^{-1}$

$\% = \dfrac{1.259}{0.08} \times 100 = 1.6$

$\Rightarrow C$

9. CHEMISTRY, M6 2018 HSC 6 MC

→ Sodium hydrogen carbonate can donate and accept protons (amphiprotic).

→ This allows it to neutralise both acids and bases.

→ Sodium hydrogen carbonate usage also benefits from its stability.

$\Rightarrow B$

10. CHEMISTRY, M6 2019 HSC 15 MC

$$\begin{aligned} pOH &= 14 - pH \\ &= 14 - 8.53 \\ &= 5.47 \end{aligned}$$

$$\begin{aligned} [OH^-] &= 10^{-pH} \\ &= 10^{-5.47} \\ &= 3.4 \times 10^{-6} \end{aligned}$$

$\Rightarrow B$

11. CHEMISTRY, M6 2020 HSC 14 MC

$K_w = [H_3O^+][OH^-]$

Since $[H_3O^+] = [OH^-]$:

$$[H_3O^+]^2 = 5.5 \times 10^{-14}$$

$$[H_3O^+] = 2.3 \times 10^{-7} \text{ mol L}^{-1}$$

$$pH = -\log_{10}(2.3 \times 10^{-7}) = 6.63$$

$\Rightarrow B$

12. CHEMISTRY, M6 2022 HSC 10 MC

HCO_3^- acts as a Bronsted-Lowry acid and donates a proton to NH_3.

$\Rightarrow C$

13. CHEMISTRY, M6 2023 HSC 6 MC

→ Each increase/decrease of pH by a magnitude of 1 represents a change in $[H^+]$ of a factor of 10.

→ Therefore, concentration change when pH moves from 8 to 5 = 10 × 3 = 1000 (increase).

$\Rightarrow C$

14. CHEMISTRY, M6 2024 HSC 6 MC

$pOH = 14 - 11 = 3$

$[OH^-] = 10^{-pOH} = 10^{-3} \text{ mol L}^{-1}$

$\Rightarrow B$

15. CHEMISTRY, M6 EQ-Bank 5 MC

→ A concentrated strong acid will have a greater number of molecules per unit volume, and completely dissociate in water.

$\Rightarrow D$

16. CHEMISTRY, M6 2015 HSC 13 MC

Mean mark 55%.

By Elimination:

→ Acetic acid is weaker than hydrochloric acid and therefore has a higher pH (eliminate C and D).

→ A more dilute acid has a higher pH (eliminate A).

$\Rightarrow B$

17. CHEMISTRY, M6 2015 VCE 22 MC

♦ Mean mark 49%.

$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2\,OH^-(aq)$

$[OH^-] = 2 \times [Ba(OH)_2] = 2 \times 0.0500 = 0.100\,M$

$$[H_3O^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{0.100} = 10^{-13}\,M$$

$pH = -\log_{10} 10^{-13} = 13$

$\Rightarrow D$

18. CHEMISTRY, M6 2016 VCE 20 MC

♦♦ Mean mark 34%.

→ Ionisation of lactic acid:

$HC_3H_5O_3(aq) + H_2O(l) \rightleftharpoons C_3H_5O_3^-(aq) + H_3O^+(aq)$

→ Adding water decreases $[H_3O^+]$. The equilibrium then shifts to partially compensate for this change, favouring the forward reaction.

→ $[H_3O^+]$ increases in this process although the new equilibrium $[H_3O^+]$ is lower (pH higher) than the original system.

→ Overall, the pH increases and the percentage ionisation increases.

$\Rightarrow B$

19. CHEMISTRY, M6 2017 HSC 20 MC

$n(Ba(OH)_2) = 0.020 \times 0.02 = 4.00 \times 10^{-4}$ mol

♦♦ Mean mark 33%.

$n(HCl) = 0.040 \times 0.05 = 2.00 \times 10^{-3}$ mol

$Ba(OH)_2\,(aq) + 2\,HCl\,(aq) \longrightarrow BaCl_2\,(aq) + 2\,H_2O\,(l)$

$Ba(OH)_2$ is limiting → HCl is in excess

$n(HCl)_{excess} = 2.00 \times 10^{-3} - 2\,(4.00 \times 10^{-4}) = 1.2 \times 10^{-3}$ mol

$$[H^+] = \frac{n}{\text{total V}} = \frac{1.20 \times 10^{-3}}{0.02 + 0.05} = 1.714 \times 10^{-2}\ \text{mol L}^{-1}$$

$pH = -\log_{10}[H^+] = -\log_{10}(1.714 \times 10^{-2}) = 1.8$

$\Rightarrow C$

20. CHEMISTRY, M6 2021 HSC 15 MC

The reaction when $HCl(aq)$ is mixed with $NaOH(aq)$ is:

♦ Mean mark 54%.

$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(aq)$

$$\begin{aligned} n(HCl) &= c \times V \\ &= 0.20 \times 0.020 \\ &= 0.0040\ \text{mol} \end{aligned}$$

$$\begin{aligned} n(NaOH) &= c \times V \\ &= 0.50 \times 0.020 \\ &= 0.010\ \text{mol} \end{aligned}$$

→ HCl is the limiting reagent and NaOH is the excess reagent.

$n(NaOH)$ leftover $= 0.010 - 0.0040 = 0.0060$ mol

$$\begin{aligned} c(NaOH) &= \frac{n(NaOH)}{V} \\ &= \frac{0.0060}{0.040} \\ &= 0.15\ \text{mol L}^{-1} \end{aligned}$$

$NaOH(aq) \longrightarrow Na^+ + OH^-$

Therefore,

$[NaOH] = [OH^-] = 0.15\ \text{mol L}^{-1}$

$pOH = -\log_{10}[OH^{-1}] = -\log_{10}(0.15) = 0.8239$

$$\begin{aligned} pH &= 14 - pOH \\ &= 14 - 0.8239 \\ &= 13.2 \end{aligned}$$

$\Rightarrow B$

21. CHEMISTRY, M6 2022 HSC 20 MC

♦ Mean mark 46%.

$HIO\,(aq) + H_2O\,(l) \leftrightharpoons IO^-\,(aq) + H_3O^+\,(aq)$

	HIO	IO^-	H_3O^+
Initial	0.75	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$0.75 - x$	x	x

$$K_a = \frac{[IO^-][H_3O^+]}{[HIO]} = \frac{x^2}{(0.75 - x)}$$

K_a is small $\Rightarrow 0.75 - x \approx 0.75$

$$\begin{aligned} K_a &= \frac{x^2}{0.75} \\ 10^{-10.64} &= \frac{x^2}{0.75} \\ x^2 &= 10^{-10.64} \times 0.75 \\ x &= \sqrt{10^{-10.64} \times 0.75} \\ &= 4.1 \times 10^{-6}\ \text{mol L}^{-1} \end{aligned}$$

$\therefore \left[H_3O^+\right] = 4.1 \times 10^{-6}$ mol L^{-1}

$pH = -\log_{10}\left[4.1 \times 10^{-6}\right] = 5.38$

The major species at pH (see graph) $= 5.38$ is purple.

$\Rightarrow C$

22. CHEMISTRY, M6 2020 HSC 18 MC

♦♦♦ Mean mark 23%.

→ $HCO_3{}^-$ can act as an acid or a base (amphiprotic).

→ H_2O is a stronger acid than $HCO_3{}^-$, so H_2O donates a proton to $HCO_3{}^-$.

→ As a result, this produces OH^- ions in solution, causing the pH to be greater than 7.

$\Rightarrow A$

23. CHEMISTRY, M6 2021 HSC 20 MC

♦♦♦ Mean mark 19%.

$[(CH_3)_3\,NH\,]^+(aq) + H_2O\,(l) \leftrightharpoons H_3O^+(aq) + (CH_3)_3\,N\,(aq)$

$$K_a = \frac{[(CH_3)_3N]\,[H_3O^+]}{[(CH_3)_3NH]^+}$$

To calculate K_{sp} equation:

$[(CH_3)_3\,NH\,]\,Cl\,(s) \leftrightharpoons [(CH_3)_3\,NH\,]^+(aq) + Cl^-\,(aq)$

$K_{sp} = [(CH_3)_3NH)^+]\,[Cl^-]$

$pH = 4.46 \rightarrow [H_3O^+] = 10^{-4.46}$

Using stoichiometry;

$[(CH_3)_3N)^+] = [H_3O^+] = 10^{-4.46}$

Using K_a:

$$1.55 \times 10^{-10} = \frac{(10^{-4.46} \times 10^{-4.46})}{(CH_3)_3NH^+}$$

$$[((CH_3)_3NH\,)^+] = \frac{(10^{-4.46} \times 10^{-4.46})}{1.55 \times 10^{-10}} = 7.7565\ldots \text{mol L}^{-1}$$

$[Cl^-] = [((CH_3)_3NH)^+] = 7.7565\ldots \text{mol L}^{-1}$

$\therefore K_{sp} = [((CH_3)_3NH)^+] \times [Cl^-] = 7.7565\ldots \times 7.7565\ldots = 60.2$

$\Rightarrow C$

24. CHEMISTRY, M6 2021 HSC 6 MC

♦♦♦ Mean mark 25%.

A weak acid has the following equilibrium:

$HA(aq) + H_2O(l) \leftrightharpoons A^-(aq) + H_3O^+(aq)$

$$K_a = \frac{[A^-]\,[H_3O^+]}{[HA]}$$

→ The value of K_a is only affected by temperature, and thus the value of K_a will remain the same.

→ When the solution is diluted, water is added. According to Le Chatelier's Principle, the equilibrium will shift to the right to counteract the change.

→ Thus, the equilibrium will shift to the right and increase the extent of ionisation.

$\Rightarrow C$

25. CHEMISTRY, M6 2022 HSC 22

Possible answers:

Base	Conjugate Acid
PO_4^{3-} (aq)	HPO_4^{2-} (aq)
F^- (aq)	HF (aq)

26. CHEMISTRY, M6 2012 HSC 28

$\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

$n(\text{H}_3\text{O}^+) = c \times V = 0.120 \times 0.07500 = 0.00900\,\text{moles}$

$n(\text{OH}) = c \times V = 0.02500 \times 0.200 = 0.00500\,\text{moles}$

$n(\text{H}_3\text{O}^+\ \text{excess}) = 9 \times 10^{-3} - 5 \times 10^{-3} = 4 \times 10^{-3}\ \text{moles}$

$$[\text{H}_3\text{O}^+] = \frac{4 \times 10^{-3}}{0.100} = 4.00 \times 10^{-2}$$

$\text{pH} = -\log_{10}[\text{H}_3\text{O}^+] = -\log_{10} 4.00 \times 10^{-2} = 1.4$

27. CHEMISTRY M6 2016 VCE 21*

$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4{}^+]}$$

Weak acid assumptions:

$[\text{NH}_4{}^+]_{\text{eq}} = 0.200\ \text{M}$ and $[\text{NH}_3] = [\text{H}_3\text{O}^+]$

$$5.6 \times 10^{-10} = \frac{[\text{H}_3\text{O}^+]^2}{0.200}$$

$$[\text{H}_3\text{O}^+]^2 = 0.200 \times 5.6 \times 10^{-10}$$

$$[\text{H}_3\text{O}^+] = \sqrt{1.12 \times 10^{-10}}$$

$$= 1.06 \times 10^{-5}\ \text{mol L}^{-1}$$

28. CHEMISTRY, M6 2019 HSC 33

Mean mark 56%.

$\text{Al(OH)}_3\,(s) + 3\,\text{HCl}\,(aq) \longrightarrow \text{AlCl}_3\,(aq) + 3\,\text{H}_2\text{O}\,(l)$

$$n(\text{Al(OH)}_3) = \frac{m}{MM} = \frac{1.17}{78.004} = 0.0150\,\text{mol}$$

$n(\text{HCl}) = c \times V = 0.500 \times 0.100 = 0.050\,\text{mol}$

→ Al(OH)_3 is limiting reagent → HCl is excess reagent

$n(\text{HCl})_{\text{reacted}} = 3 \times 0.015 = 0.0450\,\text{mol}$

$$\begin{aligned} n(\text{HCl})_{\text{excess}} &= n(\text{HCl})_{\text{init}} - n(\text{HCl})_{\text{reacted}} \\ &= 0.0500 - 0.0450 \\ &= 0.005\ \text{mol} \end{aligned}$$

$\text{HCl}\,(aq) \longrightarrow \text{H}^+\,(aq) + \text{Cl}^-\,(aq)$

$n(\text{H}^+) = n(\text{HCl})_{\text{excess}} = 0.005\,\text{mol}$

$$[\text{H}^+] = \frac{n}{V} = \frac{0.005}{0.5} = 0.010\,\text{mol L}^{-1}$$

$\text{pH} = -\log[\text{H}^+] = -\log(0.010) = 2.00$

29. CHEMISTRY, M6 2020 HSC 34

$\text{HCl}\,(aq) \longrightarrow \text{H}^+\,(aq) + \text{Cl}^-\,(aq)$

$\text{C}_2\text{H}_3\text{COOH}\,(aq) \rightleftharpoons \text{H}^+\,(aq) + \text{C}_2\text{H}_3\text{COO}^-\,(aq)$

→ HCl is a strong acid that fully dissociates in water, resulting in a high concentration of H^+ ions and a low pH.

→ Acrylic acid, on the other hand, is a weak acid that only partially dissociates in water, resulting in a lower concentration of H^+ ions and a higher pH.

→ When the concentration of HCl decreases by a factor of 10, its pH increases by 1 due to the decrease in H^+.

→ However, when the concentration of acrylic acid decreases by a factor of 10, its pH increases by less than 1.

→ This is due to the change in pH causing the equilibrium to shift right, producing more H^+ ions in response to the dilution, resulting in a smaller change in the concentration of H^+, and thus smaller change in pH.

→ At very dilute concentrations, the degree of dissociation of acrylic acid approaches 100% and its pH converges closely to that of HCl.

30. CHEMISTRY, M6 2021 HSC 23

a. $HCOOH_{(aq)} + KOH_{(aq)} \rightarrow KHCOO_{(aq)} + H_2O_{(l)}$, or

$HCOOH_{(aq)} + KOH_{(aq)} \rightarrow KHCOO_{(s)} + H_2O_{(l)}$

b. Potassium methanoate is a basic salt.

This is because the $HCOO^-$ is a moderately strong conjugate base as it comes from a weak acid $HCOOH$.

31. CHEMISTRY, M6 2022 HSC 25

→ HCl is a strong acid, ie it completely ionises in water to form H^+ ions.

Mean mark 57%.

→ On the other hand, HCN is a weak acid, ie it partially ionises in water to form H^+ ions.

$$HCl\,(aq) \longrightarrow H^+\,(aq) + Cl^-\,(aq)$$
$$HCN\,(aq) \rightleftharpoons H^+\,(aq) + CN^-\,(aq)$$

→ As $[H^+]$ decreases, pH increases $(pH = -\log\,[H^+])$

→ Therefore, at the same 0.2M, the HCN solution would have a lower $[H^+]$ and thus would have a higher pH than HCl.

32. CHEMISTRY, M6 2023 HSC 23

→ The diagram shows that the pH of solution X changes significantly with the introduction of the base $NaOH$, whereas the pH of solution Y only shows a small change in pH. This indicates that solution Y contains a buffer while solution X does not.

→ When $NaOH$ was added to solution X, the addition of OH^- ions caused the increase in pH $(pH = -\log_{10}[H_3O^+])$.

→ In contrast, the OH^- ions react with the buffer solution in solution Y. This has the effect of minimising the change in $[H_3O^+]$ and therefore pH.

33. CHEMISTRY, M6 2023 HSC 24

→ $HC_2O_4{}^-$ is amphiprotic because it can either accept or donate an H^+ as shown in the following equations:

$$HC_2O_4{}^-\,(aq) + H^+\,(aq) \rightleftharpoons H_2C_2O_4\,(aq)$$
$$HC_2O_4{}^-\,(aq) + OH^-\,(aq) \rightleftharpoons H_2O\,(l) + C_2O_4{}^{2-}\,(aq)$$

34. CHEMISTRY, M6 2024 HSC 28

→ Calculating the concentration of hydronium ions in solution for a pH of 1.151.

$$pH = -\log_{10}[H_3O^+]$$
$$[H_3O^+] = 10^{-pH} = 10^{-1.151} = 0.0706$$

→ As this is less than the concentration of both of the acids, neither acid completely dissociates in water.

→ A smaller concentration of iodic acid (0.100 mol/L compared to 0.120 mol/L sulfamic acid) produces the same pH level. Iodic acid must have a greater extent of ionisation compared to sulfamic acid.

→ Therefore iodic acid is a stronger acid than sulfamic acid.

35. CHEMISTRY, M6 2024 HSC 29

$$H_2SO_4\,(aq) + 2\,NaOH\,(aq) \longrightarrow Na_2SO_4 + 2\,H_2O\,(l)$$
$$n(NaOH) = 0.20\text{ mol L}^{-1} \times 0.150\text{ L} = 0.03\text{ mol}$$
$$n(H_2SO_4) = 0.10\text{ mol L}^{-1} \times 0.100\text{ L} = 0.01\text{ mol}$$
$$n(NaOH)\text{ required to react with }0.01\text{ mol of }H_2SO_4 = 2 \times 0.01 = 0.02\text{ mol.}$$
$$\Rightarrow\ \text{Remaining NaOH} = 0.01\text{ mol.}$$
$$[NaOH] = \frac{0.01\text{ mol}}{0.250\text{ L}} = 0.04\text{ mol L}^{-1} = [OH^-]$$
$$pOH = -\log_{10}[OH^-] = -\log_{10}(0.04) = 1.40$$
$$pH = 14 - 1.40 = 12.60$$

36. CHEMISTRY, M6 EQ-Bank 23

→ Propanoic acid only partially ionises in solution and is defined as a weak acid.

→ Any dilution of the acid will result in a decrease of the concentration of all species (including the hydronium ion).

→ According to Le Chatelier, the decreasing concentrations of dissolved species will cause the equilibrium to shift to the right.

→ While this effect causes an increase in ionisation, it is not sufficient to counter the decrease in hydronium ion concentration caused by the original dilution.

→ Since the net effect causes the hydronium ion concentration to decrease, the solution will become less acidic and the pH will increase.

37. CHEMISTRY, M6 2015 VCE 8

a. 1st assumption:

♦♦ Mean mark (a) 27%.

→ K_{a2} is significantly smaller than the first ionisation (K_{a1}), making its impact on the $[H_3O^+]$ / pH level negligible.

2nd assumption:

→ K_{a1} is very small, making the extent of the ionisation of H_2S very small and hence a minimal change in $[H_2S]$ results.

b.

$$K_{a1} = \frac{[HS^-][H_3O^+]}{[H_2S]}$$

$$9.6 \times 10^{-8} = \frac{[H_3O^+]^2}{0.01}$$

$$[H_3O^+]^2 = 0.01 \times 9.6 \times 10^{-8}$$

$$[H_3O^+] = \sqrt{9.6 \times 10^{-10}} = 3.1 \times 10^{-5}\text{ M}$$

$$\text{pH} = -\log 10(3.1 \times 10^{-5}) = 4.5$$

c. Adding NaHS:

♦♦ Mean mark (c) 35%.

→ Increases the $[HS^-]$.

→ This increase causes the 1st ionisation equilibrium back to the left.

→ This left shift in the equilibrium decreases the $[H_3O^+]$ and the pH will therefore increase.

38. CHEMISTRY, M6 2017 HSC 24

a. $CH_3COOH\,(aq) + NaOH\,(aq) \longrightarrow NaCH_3COO\,(aq) + H_2O\,(l)$

$n(CH_3COOH) = c \times V = 0.5020 \times 0.0250 = 0.01255\text{ mol}$

$n(NaOH) = n(CH_3COOH) = 0.01255\text{ mol}$

$$[NaOH] = \frac{n}{V} = \frac{0.01255}{0.01930} = 0.6503\text{ mol L}^{-1}$$

b. $CH_3COO^-\,(aq) + H_2O \rightleftharpoons CH_3COOH\,(aq) + OH^-\,(aq)$

♦♦ Mean mark (b) 34%.

→ The acetate ion is a weak base.

→ As a result, it has accepted a proton from the water resulting in production of hydroxide ions.

→ Therefore the solution has a pH > 7.

39. CHEMISTRY, M6 2019 HSC 27

a. $K_a \times K_b = K_w \quad \Rightarrow \quad K_b = \dfrac{K_w}{K_a}$

$$K_b = \frac{1.0 \times 10^{-14}}{3.0 \times 10^{-8}} = 3.3 \times 10^{-7}$$

b. $OCl^-\,(aq) + H_2O\,(l) \rightleftharpoons HOCl\,(aq) + OH^-\,(aq)$

♦ Mean mark (b) 45%.

	OCl^-	$HOCl$	OH^-
Initial	0.20	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$0.20 - x$	x	x

$$K_b = \frac{[HOCl][OH^-]}{[OCl^-]} = \frac{x^2}{(0.20 - x)}$$

Assume $0.20 - x \approx 0.20$ because x is negligible:

$$3.3 \times 10^{-7} = \frac{x^2}{0.20 - x}$$

$$x = \sqrt{3.3 \times 10^{-7} \times 0.20} = 2.5690 \times 10^{-4}\text{ mol L}^{-1}$$

$[OH^-] = 2.5690 \times 10^{-4}\text{ mol L}^{-1}$

$\text{pOH} = -\log_{10}[OH^-] = -\log_{10}(2.5690 \times 10^{-4}) = 3.59$

$\therefore \text{pH} = 14 - 3.59 = 10.41$

40. CHEMISTRY, M6 2022 HSC 34

♦ Mean mark 46%.

$$\text{pOH}_{eq} = 14.00 - 7.5 = 6.5$$

$$[\text{OH}^-]_{eq} = 10^{-\text{pOH}} = 10^{-6.5} \text{ mol L}^{-1}$$

$$\text{K}_{eq} = \frac{[\text{HOCl}]_{eq}[\text{OH}^-]_{eq}}{[\text{OCl}^-]_{eq}}$$

$$3.33 \times 10^{-7} = \frac{(1.3 \times 10^{-4}) \times (10^{-6.5})}{[\text{OCl}^-]_{eq}}$$

$$[\text{OCl}^-]_{eq} = \frac{(1.3 \times 10^{-4}) \times (10^{-6.5})}{3.33 \times 10^{-7}}$$

$$= 1.246 \times 10^{-4} \text{ mol L}^{-1}$$

	OCl^-	HOCl	OH^-
Initial	x	0	–
Change	-1.3×10^{-4}	$+1.3 \times 10^{-4}$	–
Equilibrium	$x - 1.3 \times 10^{-4}$	1.3×10^{-4}	$10^{-6.5}$

$$x - 1.3 \times 10^{-4} = 1.246 \times 10^{-4}$$

$$x = 2.546 \times 10^{-4}$$

$$[\text{OCl}^-]_i = 2.55 \times 10^{-4} \text{ mol L}^{-1} \quad (3 \text{ s.f.})$$

$$[\text{NaOCl}] \times \text{V(NaOC)}_{\text{req}} = [\text{OCl}^-](\text{pool}) \times \text{V(pool)}$$

$$\text{V(NaCl)}_{\text{req}} = \frac{2.55 \times 10^{-4} \times 10^4}{2}$$

$$= 1.3 \text{ L} \quad (2 \text{ s.f.})$$

41. CHEMISTRY, M6 EQ-Bank 25

→ Acid 1 is a strong acid. Its initial pH = 1 and its equivalence point is at pH = 7.

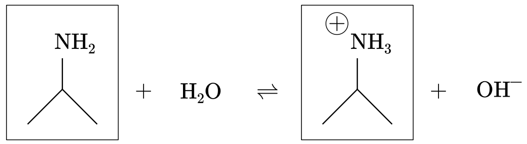
→ Acid 2 is a weaker acid. Its initial pH ~ 2 and its equivalence point is >7.

→ Acid 2 has a higher concentration than Acid 1 as it doesn't take that much more KOH to neutralise it.

42. CHEMISTRY, M5 2020 HSC 27

a.

♦ Mean mark (a) 48%.



b.

Mean mark (b) 51%.

	$C_3H_7NH_2$	$C_3H_7NH_3$	OH^-
Initial	1.00	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$1.00 - x$	x	x

$$K_b = \frac{[C_3H_7NH_3{}^+][OH^-]}{[C_3H_7NH_2]} = \frac{x^2}{(1.00 - x)}$$

Assume $1.00 - x = 1.00$ because x is negligible:

$$4.37 \times 10^{-4} = \frac{x^2}{1.00}$$

$$x = \sqrt{4.37 \times 10^{-4}}$$

$$= 0.0209 \text{ mol L}^{-1}$$

$$\Rightarrow [\text{OH}^-] = 0.0209 \text{ mol L}^{-1}$$

43. CHEMISTRY, M6 2020 HSC 33

a. $Ca(OH)_2\,(s) + 2\,HCl\,(aq) \longrightarrow CaCl_2\,(aq) + 2\,H_2O\,(l)$

$n(HCl) = c \times V = 2.00 \times 0.100 = 0.200 \text{ mol}$

$$n(Ca(OH)_2) = \frac{n(HCL)}{2} = \frac{0.200}{2} = 0.100\,\text{mol}$$

b. $Ca(OH)_2\,(s) \rightleftharpoons Ca^{2+}\,(aq) + 2\,OH^-\,(aq)$

♦♦♦ Mean mark (b) 20%.

$$[Ca^{2+}] = \frac{n}{V} = \frac{0.100}{0.100} = 1.00 \text{ mol L}^{-1}$$

$$\begin{aligned} K_{sp} &= [Ca^{2+}][OH^-]^2 \\ 5.02 \times 10^{-6} &= 1.00 \times [OH^-]^2 \\ [OH^-] &= \sqrt{5.02 \times 10^{-6}} \\ &= 2.24 \times 10^{-3} \text{ mol L}^{-1} \\ pOH &= -\log_{10}(2.24 \times 10^{-3}) \\ &= 2.650 \end{aligned}$$

$\therefore\ pH = 14 - 2.650 = 11.35$

44. CHEMISTRY, M6 2015 HSC 24

a. $CH_3COO^-\,(aq) + H_2O\,(l) \rightleftharpoons CH_3COOH\,(aq) + OH^-\,(aq)$

♦♦ Mean mark (a) 37%.

→ Sodium acetate is a basic salt.

→ Acetate is a strong base that accepts a proton, producing hydroxide.

→ The presence of OH^- ions produced by the hydrolysis of CH_3COO^- increases the pH, producing a basic solution.

b. $CH_3COO^-\,(aq) + H_3O^+\,(l) \rightleftharpoons CH_3COOH\,(aq) + H_2O\,(l)$

♦♦♦ Mean mark (b) 25%.

→ The OH^- ions introduced into the solution will react with the H_3O^+ ions, reducing their concentration in the equilibrium mixture.

→ By Le Chatelier's principle, this will subsequently move the reaction to the left to increase the H_3O^+ ions, thus minimising any change in pH.

45. CHEMISTRY, M6 2021 HSC 32

♦ Mean mark 44%.

→ Reaction 1 and reaction 2 are both neutralisation reactions between strong acids and strong bases. These reactions completely ionise in solution when added to water.

→ Both reactions have the same net ionic equation:

$$H^+(aq) + OH^-\,(aq) \rightarrow H_2O(l)$$

→ Therefore, the enthalpy values obtained are the same for both reactions.

→ In reaction 3, HCN is a weak acid that only partially ionises in an equilibrium reaction with water.

$$HCN(aq) + H_2O(l) \leftrightharpoons CN^-\,(aq) + H_3O^+(aq).$$

→ As the reaction continues, HCN will further ionise as the equilibrium shifts to the right.

→ The bond-breaking is an endothermic process and thus will consume energy to break the bonds. As a result, the overall reaction is less exothermic than reaction 1 and reaction 2.