

IB CHEMISTRY HL

Acid-Base Questions

Paper 1 / Paper 1A compilation

145 selected multiple-choice questions

Original question numbering is retained. Answer key is at the end.

1. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX | Original Q24

24. What is the conjugate base of H_2CO_3 according to the Brønsted-Lowry theory?

- A. CO_3^{2-}
- B. HCO_3^-
- C. H_3CO_3^+
- D. CO_2

8810-6101

2. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. A solution of acid A has a pH of 1 and a solution of acid B has a pH of 2. Which statement **must** be correct?

- A. Acid A is stronger than acid B
- B. $[\text{A}] > [\text{B}]$
- C. The concentration of H^+ ions in A is higher than in B
- D. The concentration of H^+ ions in B is twice the concentration of H^+ ions in A

3. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. Which mixtures act as buffer solutions?

- I. $100\text{ cm}^3\ 0.1\text{ mol dm}^{-3}$ ethanoic acid and $100\text{ cm}^3\ 0.1\text{ mol dm}^{-3}$ sodium ethanoate
 - II. $100\text{ cm}^3\ 0.1\text{ mol dm}^{-3}$ ethanoic acid and $50\text{ cm}^3\ 0.1\text{ mol dm}^{-3}$ sodium hydroxide
 - III. $100\text{ cm}^3\ 0.1\text{ mol dm}^{-3}$ ethanoic acid and $100\text{ cm}^3\ 0.5\text{ mol dm}^{-3}$ sodium hydroxide
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
-

4. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Which solutions have a pH less than 7?

- I. $\text{Na}_2\text{CO}_3(\text{aq})$
 - II. $[\text{Fe}(\text{H}_2\text{O})_6]\text{Cl}_3(\text{aq})$
 - III. $(\text{NH}_4)_2\text{SO}_4(\text{aq})$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

8810-6101

Turn over

5. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. Equal volumes and concentrations of hydrochloric acid and ethanoic acid are titrated with sodium hydroxide solutions of the same concentration. Which statement is correct?

- A. The initial pH values of both acids are equal.
 - B. At the equivalence points, the solutions of both titrations have pH values of 7.
 - C. The same volume of sodium hydroxide is needed to reach the equivalence point.
 - D. The pH values of both acids increase equally until the equivalence points are reached.
-

6. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. Bromophenol blue changes from yellow to blue over the pH range of 3.0 to 4.6. Which statement is correct?
- A. Molecules of bromophenol blue, HIn , are blue.
- B. At $\text{pH} < 3.0$, a solution of bromophenol blue contains more ions, In^- , than molecules, HIn .
- C. The pK_a of bromophenol blue is between 3.0 and 4.6.
- D. Bromophenol blue is a suitable indicator to titrate ethanoic acid with potassium hydroxide solution.
-

7. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. Which descriptions are correct for both a Brønsted–Lowry acid and a Lewis acid?

	Brønsted–Lowry acid	Lewis acid
A.	proton donor	electron pair donor
B.	proton donor	electron pair acceptor
C.	proton acceptor	electron pair donor
D.	proton acceptor	electron pair acceptor

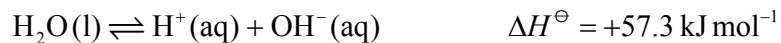
8. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. What is the pH of the solution formed when 10 cm³ of HCl(aq) with pH 1.0 is added to 990 cm³ of water?
- A. 1.5
B. 2.0
C. 2.5
D. 3.0

8811-6101

9. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Consider the equation for the dissociation of water:



Which statement is correct?

- A. The pH of pure water is always 7.
B. At temperatures above 298 K the pH of pure water is below 7.
C. At temperatures above 298 K the pH of pure water is above 7.
D. K_w decreases with increasing temperature.
-

10. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. Which combination of 1 mol dm^{-3} solutions produces an acidic buffer?

- A. $50 \text{ cm}^3 \text{ HCl(aq)}$ and $150 \text{ cm}^3 \text{ NH}_3 \text{(aq)}$
- B. $100 \text{ cm}^3 \text{ CH}_3\text{COOH(aq)}$ and $50 \text{ cm}^3 \text{ HCl(aq)}$
- C. $100 \text{ cm}^3 \text{ CH}_3\text{COOH(aq)}$ and $50 \text{ cm}^3 \text{ NaOH(aq)}$
- D. $50 \text{ cm}^3 \text{ CH}_3\text{COOH(aq)}$ and $50 \text{ cm}^3 \text{ NaOH(aq)}$

11. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. Which salt dissolves in water to form an acidic solution?

- A. Potassium ethanoate
- B. Calcium ethanoate
- C. Ammonium chloride
- D. Sodium carbonate

12. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX | Original Q25

25. Which is **not** a conjugate acid-base pair?

- A. HNO_3 and NO_3^-
- B. CH_3COOH and CH_3COO^-
- C. H_3O^+ and OH^-
- D. HSO_4^- and SO_4^{2-}

13. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. The pH of a solution changes from pH = 2 to pH = 5. What happens to the concentration of the hydrogen ions during this pH change?

- A. It decreases by a factor of 1000
- B. It increases by a factor of 1000
- C. It decreases by a factor of 100
- D. It increases by a factor of 100

14. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. Based on information in the table below, which acid is the strongest?

	Acid	pK_a	K_a
A.	HA	2.0	—
B.	HB	—	1×10^{-3}
C.	HC	4.0	—
D.	HD	—	1×10^{-5}

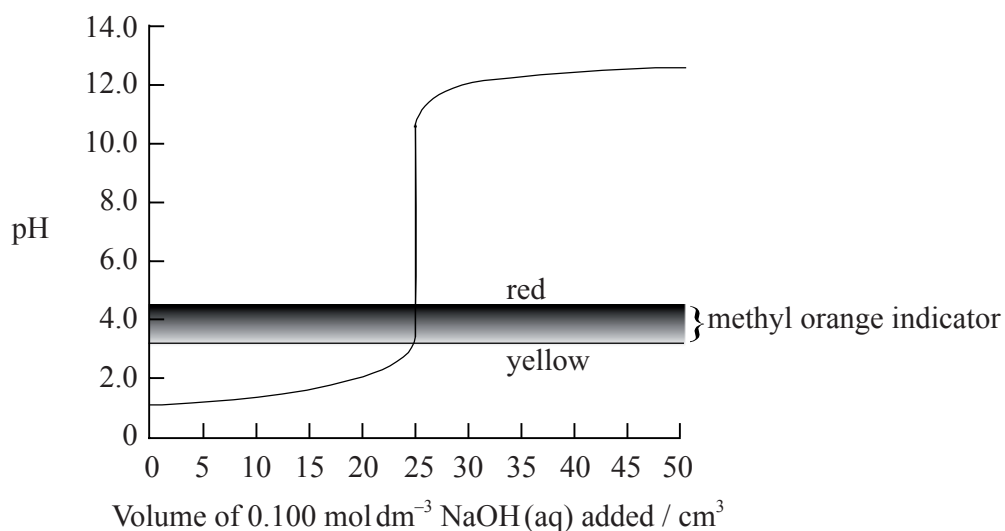
15. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX | Original Q28

28. Which combination will form a buffer solution?

- A. 100 cm³ of 0.10 mol dm⁻³ hydrochloric acid with 50 cm³ of 0.10 mol dm⁻³ sodium hydroxide.
- B. 100 cm³ of 0.10 mol dm⁻³ ethanoic acid with 50 cm³ of 0.10 mol dm⁻³ sodium hydroxide.
- C. 50 cm³ of 0.10 mol dm⁻³ hydrochloric acid with 100 cm³ of 0.10 mol dm⁻³ sodium hydroxide.
- D. 50 cm³ of 0.10 mol dm⁻³ ethanoic acid with 100 cm³ of 0.10 mol dm⁻³ sodium hydroxide.

16. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX | Original Q29

29. The graph below shows the titration curve of 25 cm^3 of 0.100 mol dm^{-3} of hydrochloric acid with sodium hydroxide, of 0.100 mol dm^{-3} concentration. The indicator methyl orange was used to determine the equivalence point. Methyl orange has a pH range of 3.2–4.4.



If the hydrochloric acid was replaced by ethanoic acid of the same volume and concentration, which property of the titration would remain the same?

- A. The initial pH
- B. The pH at the equivalence point
- C. The volume of strong base, NaOH, needed to reach the equivalence point
- D. The colour of the titration mixture just before the equivalence point is reached

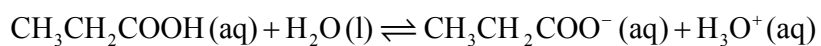
17. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. Which salts will produce an acidic solution when dissolved in water?

- I. CH_3COOK
 - II. NH_4NO_3
 - III. $\text{Al}_2(\text{SO}_4)_3$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

18. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. Consider the equilibrium below.



Which species represent a conjugate acid-base pair?

- A. $\text{CH}_3\text{CH}_2\text{COOH}$ and H_2O
 - B. H_2O and $\text{CH}_3\text{CH}_2\text{COO}^-$
 - C. H_3O^+ and H_2O
 - D. $\text{CH}_3\text{CH}_2\text{COO}^-$ and H_3O^+
-

19. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX | Original Q28

28. The K_b value for a base is $5.0 \times 10^{-2} \text{ mol dm}^{-3}$ at 298 K. What is the K_a value for its conjugate acid at this temperature?
- A. 5.0×10^{-2}
- B. 2.0×10^{-6}
- C. 2.0×10^{-12}
- D. 2.0×10^{-13}

2211-6107

Turn over

20. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX | Original Q29

29. Which compounds can be mixed together as solutions of equal volume and concentration to form a buffer solution?
- A. Nitric acid and potassium hydroxide
- B. Nitric acid and potassium nitrate
- C. Propanoic acid and potassium hydroxide
- D. Propanoic acid and potassium propanoate

21. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX | Original Q24

24. Which substance can act as a Lewis acid but not as a Brønsted–Lowry acid?
- A. HCl
- B. CH_3COOH
- C. BF_3
- D. CF_3COOH

8812-6101

Turn over

22. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. Which row correctly describes $1.0 \text{ mol dm}^{-3} \text{ NaOH(aq)}$?

	pH	Colour in universal indicator solution	Electrical conductivity
A.	14	purple	good
B.	10	green	poor
C.	14	red	good
D.	10	blue	poor

23. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. For pure water at 50°C , $K_w = 5.48 \times 10^{-14}$. What is the pH of this water?

- A. 4.8
 - B. 6.6
 - C. 7.0
 - D. 8.2
-

24. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Which is the strongest acid?

	Acid	pK_a
A.	chloroethanoic	2.87
B.	iodoethanoic	3.18
C.	benzoic	4.20
D.	pentanoic	4.83

8812-6101

25. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. Which salts will dissolve in water to give solutions with a pH above 7?

- I. Na_2CO_3
 - II. CH_3COONa
 - III. Na_2SO_4
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
-

26. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. During a titration, 0.1 mol dm^{-3} sodium hydroxide is added to 0.1 mol dm^{-3} ethanoic acid. Which indicator would be the **best** to use as an end point indicator in this titration?

	Indicator	pH range of indicator
A.	methyl orange	3.2–4.4
B.	bromophenol blue	3.0–4.6
C.	bromothymol blue	6.0–7.6
D.	phenolphthalein	8.2–10.0

27. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX | Original Q23

23. Which reaction represents an acid–base reaction according to the Lewis theory but not according to the Brønsted–Lowry theory?
- A. $\text{CO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq}) \rightleftharpoons \text{H}_2\text{O}(\text{l}) + \text{HCO}_3^-(\text{aq})$
- B. $\text{CH}_3\text{COOH}(\text{aq}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq})$
- C. $\text{NH}_3(\text{aq}) + \text{HF}(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{F}^-(\text{aq})$
- D. $\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$

28. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX | Original Q24

24. Four aqueous solutions are listed below.

W. $0.100 \text{ mol dm}^{-3} \text{ HNO}_3(\text{aq})$

X. $0.001 \text{ mol dm}^{-3} \text{ HNO}_3(\text{aq})$

Y. $0.100 \text{ mol dm}^{-3} \text{ KOH}(\text{aq})$

Z. $0.001 \text{ mol dm}^{-3} \text{ KOH}(\text{aq})$

What is the correct order of **increasing** pH of these solutions?

A. $W < X < Y < Z$

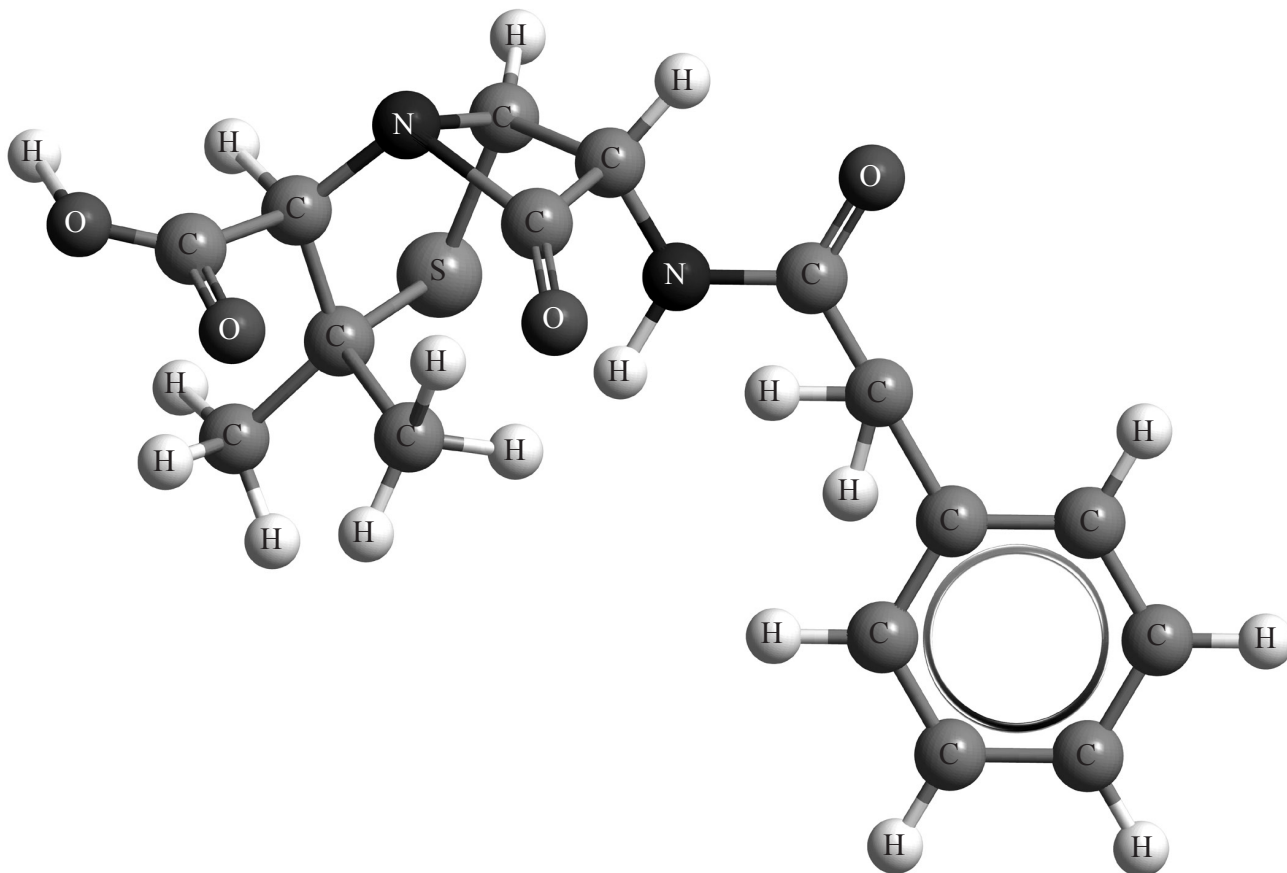
B. $W < X < Z < Y$

C. $X < W < Y < Z$

D. $X < W < Z < Y$

29. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX | Original Q25

25. Penicillin G (benzyl penicillin) contains a number of different functional groups and has the following structure:



It is a weak monoprotic acid ($pK_a = 2.79$ at 298 K). At 298 K, the ionic product constant for water, $K_w = 1.00 \times 10^{-14}$. What is the value of pK_b for the conjugate base of penicillin G and which functional groups are present in penicillin G?

	pK_b	Selected functional groups in penicillin G
A.	11.21	carboxylic acid, amine
B.	2.79	carboxylic acid, amide
C.	11.21	ketone, alcohol
D.	11.21	carboxylic acid, benzene ring

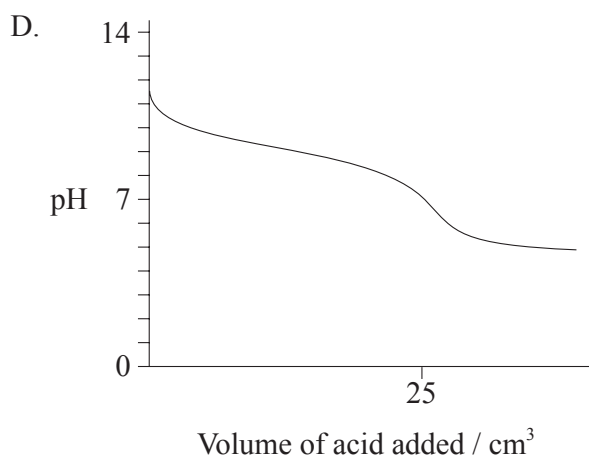
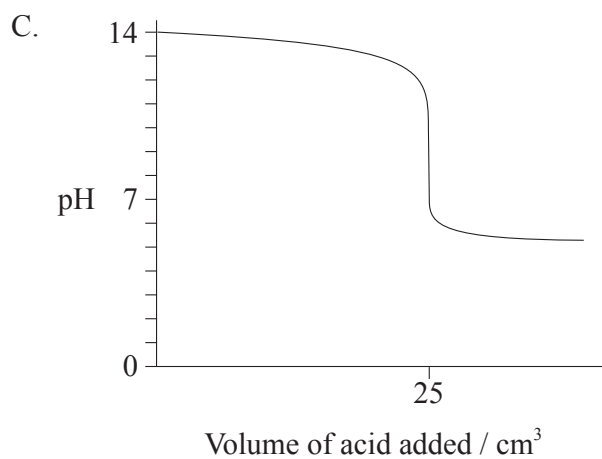
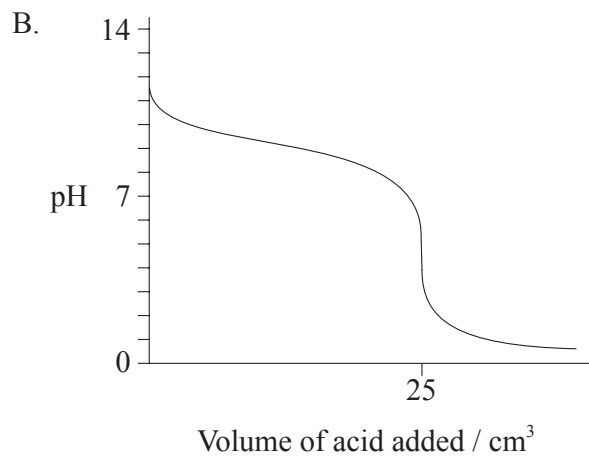
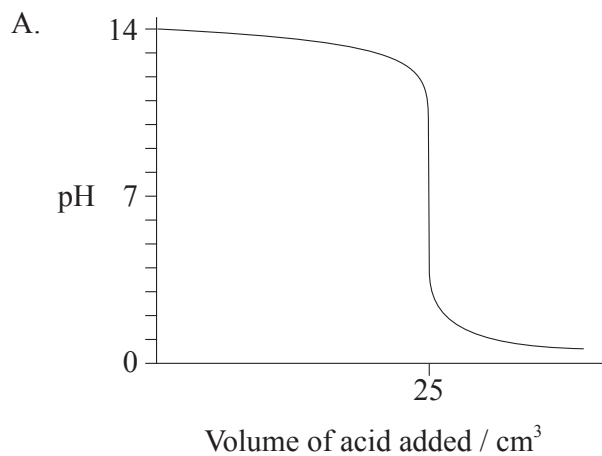
30. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. Which mixtures are buffer solutions?

- I. $\text{KHSO}_4(\text{aq})$ and $\text{H}_2\text{SO}_4(\text{aq})$
 - II. $\text{CH}_3\text{COONa}(\text{aq})$ and $\text{CH}_3\text{COOH}(\text{aq})$
 - III. $\text{HCOOK}(\text{aq})$ and $\text{HCOOH}(\text{aq})$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
-

31. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. Which titration curve is produced by the titration of 25 cm^3 of 1.00 mol dm^{-3} NaOH with 1.00 mol dm^{-3} CH_3COOH ?



32. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

24. Which are conjugate acid/base pairs according to the Brønsted–Lowry theory?

- I. $\text{NH}_4^+/\text{NH}_3$
 - II. $\text{HCOOH}/\text{HCOO}^-$
 - III. $\text{H}_2\text{SO}_4/\text{SO}_4^{2-}$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

33. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. Which is correct for a weak acid, HA, with concentration 0.01 mol dm^{-3} at 298K?

- A. $[\text{H}^+] < 1 \times 10^{-2}$
- B. $\text{pH} < 2$
- C. $[\text{OH}^-] < 1 \times 10^{-12}$
- D. $\text{pOH} > 12$

34. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. Which salt has the lowest pH when dissolved in water?

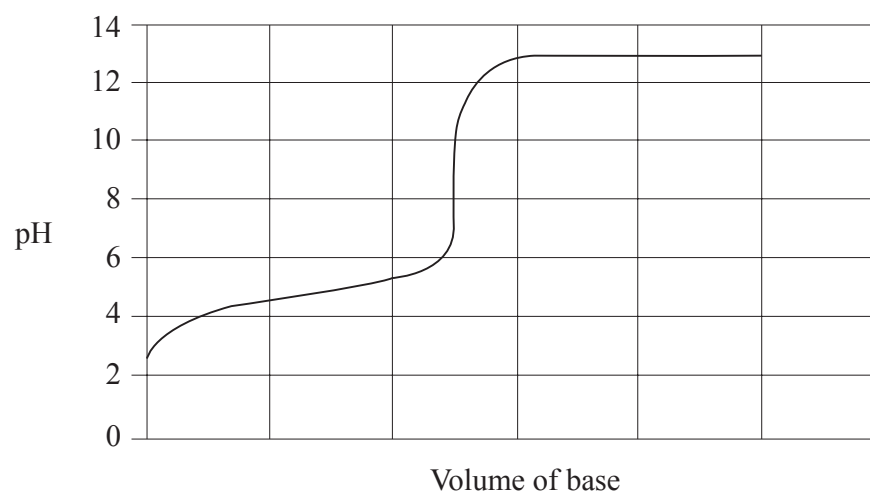
- A. KNO_3
 - B. CH_3COONa
 - C. Na_2CO_3
 - D. $[\text{Fe}(\text{H}_2\text{O})_6]\text{Cl}_3$
-

35. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX | Original Q28

28. Which of the following mixtures would result in the pK_a of the acid being obtained from a direct pH measurement of the resulting solution?
- A. $25\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{HCl}$ and $25\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{NaCl}$
 - B. $25\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{NaOH}$ and $25\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{CH}_3\text{COOH}$
 - C. $12.5\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{CH}_3\text{COOH}$ and $25\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{NaOH}$
 - D. $12.5\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{NaOH}$ and $25\text{ cm}^3\ 0.1\text{ mol dm}^{-3}\ \text{CH}_3\text{COOH}$

36. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX | Original Q29

29. An aqueous solution of a weak acid containing an indicator is titrated with a strong base, resulting in the following titration curve.

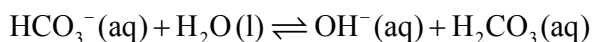


At which pH does the buffer region occur?

- A. Between 4.5 and 5.5
- B. Between 7.5 and 9.5
- C. At 9.5
- D. At 12

37. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. What are the conjugate acid–base pairs in the following reaction?



	Brønsted–Lowry acid	Brønsted–Lowry base	Conjugate acid	Conjugate base
A.	$\text{HCO}_3^-(\text{aq})$	$\text{H}_2\text{O}(\text{l})$	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{OH}^-(\text{aq})$
B.	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{OH}^-(\text{aq})$	$\text{HCO}_3^-(\text{aq})$	$\text{H}_2\text{O}(\text{l})$
C.	$\text{H}_2\text{O}(\text{l})$	$\text{HCO}_3^-(\text{aq})$	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{OH}^-(\text{aq})$
D.	$\text{H}_2\text{O}(\text{l})$	$\text{HCO}_3^-(\text{aq})$	$\text{OH}^-(\text{aq})$	$\text{H}_2\text{CO}_3(\text{aq})$

8813-6101

38. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. Which group of three compounds contains only weak acids and bases?

A.	$\text{Ba}(\text{OH})_2$	CH_3NH_2	CH_3COOH
B.	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$	$\text{CH}_3\text{CH}_2\text{NH}_2$	HCOOH
C.	NH_3	HNO_3	$\text{CH}_3\text{CH}_2\text{COOH}$
D.	NH_3	NaOH	H_2CO_3

39. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. What is the relationship between $\text{p}K_{\text{a}}$, $\text{p}K_{\text{b}}$ and $\text{p}K_{\text{w}}$ for a conjugate acid–base pair?

- A. $\text{p}K_{\text{a}} = \text{p}K_{\text{w}} + \text{p}K_{\text{b}}$
- B. $\text{p}K_{\text{a}} = \text{p}K_{\text{w}} - \text{p}K_{\text{b}}$
- C. $\text{p}K_{\text{a}} \times \text{p}K_{\text{b}} = \text{p}K_{\text{w}}$
- D. $\frac{\text{p}K_{\text{a}}}{\text{p}K_{\text{b}}} = \text{p}K_{\text{w}}$

40. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. The table below shows data for the K_a and pK_b values for some acids and bases at 298 K.

Acid	K_a	Base	pK_b
HClO	2.9×10^{-8}	NH ₃	4.75
C ₆ H ₅ CH ₂ COOH	4.9×10^{-5}	C ₆ H ₅ NH ₂	9.13

Which two formulas represent the weakest acid and the weakest base in the table?

- A. HClO and C₆H₅NH₂
- B. C₆H₅CH₂COOH and NH₃
- C. C₆H₅CH₂COOH and C₆H₅NH₂
- D. HClO and NH₃

8813-6101

Turn over**41. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29**

29. Which pair of compounds could be used to make a buffer solution (assuming appropriate molar ratios)?

- A. KCl and HCl
- B. NaCl and HCl
- C. KHSO₄ and H₂SO₄
- D. CH₃COONa and CH₃COOH

42. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX | Original Q30

30. Which salts form acidic solutions when dissolved in water?

- I. NH_4Cl
 - II. $\text{Cr}(\text{NO}_3)_3$
 - III. CH_3COONa
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

43. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. Which of the following is an example of a Lewis acid–base reaction, but not a Brønsted–Lowry acid–base reaction?

- A. $2\text{CrO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- B. $\text{Co}(\text{H}_2\text{O})_6^{2+}(\text{aq}) + 4\text{HCl}(\text{aq}) \rightarrow \text{CoCl}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$
- C. $\text{NH}_3(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow \text{NH}_4^+(\text{aq})$
- D. $\text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CH}_3\text{COOH}(\text{aq}) + \text{OH}^-(\text{aq})$

44. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. Which list contains only strong bases?

- A. ammonia, sodium hydroxide, ethylamine
- B. potassium hydroxide, ammonia, sodium hydroxide
- C. lithium hydroxide, potassium hydroxide, barium hydroxide
- D. ammonia, ethylamine, barium hydroxide

45. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX | Original Q28

28. The pK_b value of ammonia is 4.75 at 298 K. What is the pK_a value of the ammonium ion?

A. $\frac{10^{-14}}{4.75}$

B. $\frac{14.00}{4.75}$

C. $14.00 - 4.75$

D. $\frac{10^{-14}}{10^{-4.75}}$

46. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX | Original Q29

29. The K_a values of four weak acids W, X, Y and Z are listed below.

W $K_a = 1.35 \times 10^{-3}$

X $K_a = 4.47 \times 10^{-2}$

Y $K_a = 9.33 \times 10^{-6}$

Z $K_a = 1.47 \times 10^{-5}$

What is the correct order of **increasing** strength as acids?

A. $X < W < Z < Y$

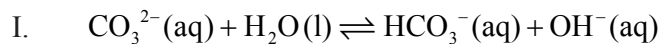
B. $W < Z < X < Y$

C. $Y < X < Z < W$

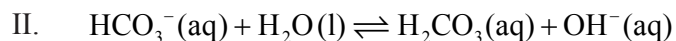
D. $Y < Z < W < X$

47. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

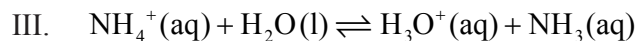
24. In which equilibria are the conjugate acid–base pairs correctly labelled?



Base 1 Acid 2 Acid 1 Base 2



Base 1 Acid 2 Acid 1 Base 2



Acid 1 Base 2 Acid 2 Base 1

- A. I and II only
B. I and III only
C. II and III only
D. I, II and III

2213-6107

48. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX | Original Q25

25. A solution of acid HX has a $\text{pH} = 1$ and a solution of acid HY has a $\text{pH} = 3$. Which statement **must** be correct?

- A. HX is a stronger acid than HY.
B. HY is a stronger acid than HX.
C. The $[\text{H}^{+}]$ in the solution of HX is 100 times greater than the $[\text{H}^{+}]$ in the solution of HY.
D. The $[\text{H}^{+}]$ in the solution of HY is 100 times greater than the $[\text{H}^{+}]$ in the solution of HX.

49. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. The values of K_w , the ionic product constant of water, are:

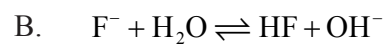
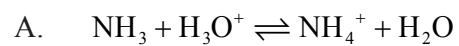
K_w	T / °C
6.4×10^{-15}	18
1.0×10^{-14}	25

Which statements are correct?

- I. The $[\text{OH}^-]$ in water is less than the $[\text{H}^+]$ at 18 °C .
 - II. The ionization of water is an endothermic process.
 - III. The pH of water is lower at 25 °C than at 18 °C .
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

50. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. For which equilibrium can an expression for a base dissociation constant, K_b , for the forward reaction be written?



51. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX | Original Q28

28. Which of the following mixtures, in an aqueous solution, will produce a buffer solution?

- I. 50 cm^3 of 0.1 mol dm^{-3} CH_3COONa and 50 cm^3 of 0.1 mol dm^{-3} CH_3COOH
 - II. 50 cm^3 of 0.1 mol dm^{-3} NH_3 and 50 cm^3 of 0.1 mol dm^{-3} NH_4Cl
 - III. 50 cm^3 of 0.1 mol dm^{-3} NaOH and 50 cm^3 of 0.2 mol dm^{-3} CH_3COOH
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

52. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX | Original Q29

29. The colours of three indicators are shown in the table below.

Indicator	Colour at low pH	Colour at high pH	pH range at which colour change takes place
methyl orange	red	yellow	3.2–4.4
bromothymol blue	yellow	blue	6.0–7.6
phenolphthalein	colourless	pink	8.2–10.0

Equal volumes of these three indicators were mixed and the mixture was added to a solution of pH = 5.0. What colour would be seen?

- A. Yellow
- B. Orange
- C. Green
- D. Blue

53. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX | Original Q24

24. Which definition of a base is correct?

- A. A Lewis base accepts a proton.
- B. A Brønsted–Lowry base accepts an electron pair.
- C. A Brønsted–Lowry base donates an electron pair.
- D. A Lewis base donates an electron pair.

54. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. A student adds 0.3 g of magnesium metal to equal volumes of hydrochloric acid and ethanoic acid of the same concentrations in separate flasks. Which statement is correct?
- A. Hydrochloric acid reacts more rapidly as it has a higher pH than ethanoic acid.
 - B. A greater total volume of H_2 gas is produced with hydrochloric acid than with ethanoic acid.
 - C. The same total volume of H_2 gas is produced with both hydrochloric acid and ethanoic acid.
 - D. Ethanoic acid reacts more slowly because it has a lower pH than hydrochloric acid.
-

55. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. Which compound will produce an aqueous solution which has a pH greater than 7?
- A. CuSO_4
 - B. FeCl_3
 - C. Na_2CO_3
 - D. NH_4NO_3
-

56. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Methylamine acts as a weak base when it reacts with water. For a diluted aqueous solution, what is the K_b expression for this reaction?

A. $K_b = \frac{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}{[\text{CH}_3\text{NH}_2]}$

B. $K_b = \frac{[\text{CH}_3\text{NH}_2][\text{H}_2\text{O}]}{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}$

C. $K_b = \frac{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}{[\text{CH}_3\text{NH}_2][\text{H}_2\text{O}]}$

D. $K_b = \frac{[\text{CH}_3\text{NH}_2]}{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}$

8814-6101

Turn over**57. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28**

28. A buffer solution is formed by mixing equal volumes of 1.00mol dm^{-3} propanoic acid and 0.500mol dm^{-3} potassium propanoate.

What is the concentration, in mol dm^{-3} , of $[\text{H}^+(\text{aq})]$ in this buffer solution? (K_a for propanoic acid is 1.30×10^{-5} .)

A. 2.60×10^{-5}

B. 1.95×10^{-5}

C. 1.30×10^{-5}

D. 0.650×10^{-5}

58. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. The acid–base indicator phenol red, HIn, changes colour from yellow to red over a pH range of 6.6–8.2. Which statement is correct?
- A. In a strongly acidic solution $[\text{HIn}] < [\text{In}^-]$.
 - B. The $\text{p}K_{\text{a}}$ of phenol red is between 6.6 and 8.2.
 - C. The In^- ions are yellow.
 - D. Phenol red would be a suitable indicator for the titration of a strong acid and a weak base.
-

59. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. What is the conjugate base of phenol, $\text{C}_6\text{H}_5\text{OH}$?
- A. $\text{C}_6\text{H}_4^- \text{— OH}$
 - B. $\text{C}_6\text{H}_5 \text{— } \overset{+}{\text{O}}\text{H}_2$
 - C. $\text{C}_6\text{H}_5 \text{— O}^-$
 - D. $\text{C}_6\text{H}_6^+ \text{— OH}$
-

60. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. Which compounds can be mixed together as aqueous solutions of equal volume and concentration to form an acidic buffer solution?
- A. Sodium hydrogensulfate and sulfuric acid
 - B. Sodium propanoate and propanoic acid
 - C. Ammonium chloride and ammonia solution
 - D. Sodium chloride and hydrochloric acid
-

61. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX | Original Q28

28. Which statements about an acid–base indicator are correct?

- I. It can be a weak acid.
 - II. It is a substance in which the conjugate acid/base pair are different colours.
 - III. It can be a weak base.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

2214-6113

Turn over

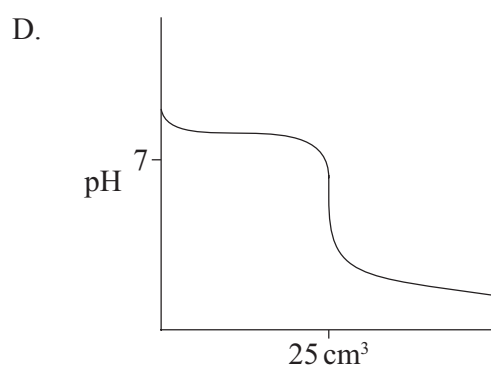
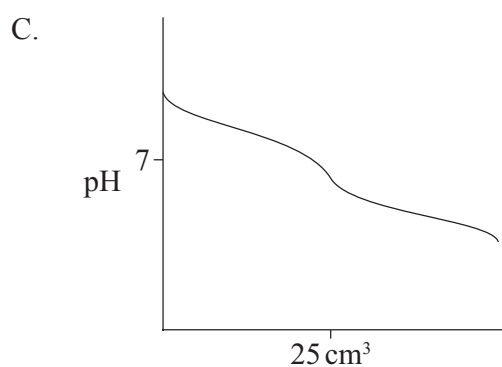
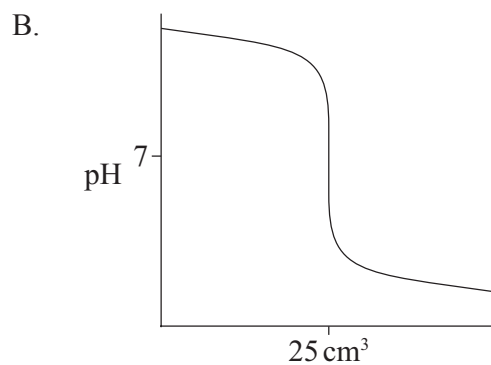
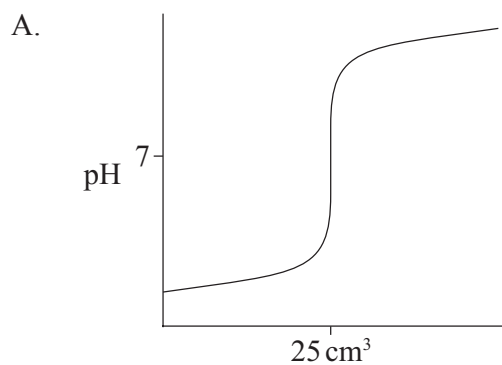
62. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX | Original Q29

29. What is the expression for the ionic product constant of water, K_w ?

- A. $K_w = K_a \times K_b$
 - B. $K_w = K_a + K_b$
 - C. $K_w = \frac{K_a}{K_b}$
 - D. $K_w = K_a - K_b$
-

63. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX | Original Q30

30. Which graph would be obtained by adding $0.10\text{ mol dm}^{-3}\text{HCl(aq)}$ to 25 cm^3 of $0.10\text{ mol dm}^{-3}\text{NaOH(aq)}$?



64. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

24. In which reaction does H_2O act as a Lewis base but **not** as a Brønsted–Lowry base.

- A. $\text{H}_2\text{O} + \text{NH}_4^+ \rightarrow \text{H}_3\text{O}^+ + \text{NH}_3$
- B. $\text{H}_2\text{O} + \text{CaO} \rightarrow \text{Ca}^{2+} + 2\text{OH}^-$
- C. $\text{H}_2\text{O} + [\text{Fe}(\text{H}_2\text{O})_6]^{3+} \rightarrow \text{Fe}[(\text{OH})(\text{H}_2\text{O})_5]^{2+} + \text{H}_3\text{O}^+$
- D. $6\text{H}_2\text{O} + [\text{Ni}(\text{NH}_3)_6]^{2+} \rightarrow 6\text{NH}_3 + [\text{Ni}(\text{H}_2\text{O})_6]^{2+}$

65. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX | Original Q25

25. A solution of 50 cm^3 hydrochloric acid has a pH of 4. What is the final pH if 450 cm^3 of water is added?

- A. 3
- B. 4
- C. 5
- D. 6

66. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. The $\text{p}K_{\text{b}}$ of HS^- is 7.08. What is its conjugate acid and what is the K_{a} value of the acid?

	Conjugate acid	K_{a}
A.	H_2S	$10^{-6.92}$
B.	H_2S	6.92
C.	S^{2-}	$10^{-6.92}$
D.	S^{2-}	6.92

67. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. Which mixture of solutions can be used to prepare a buffer solution?

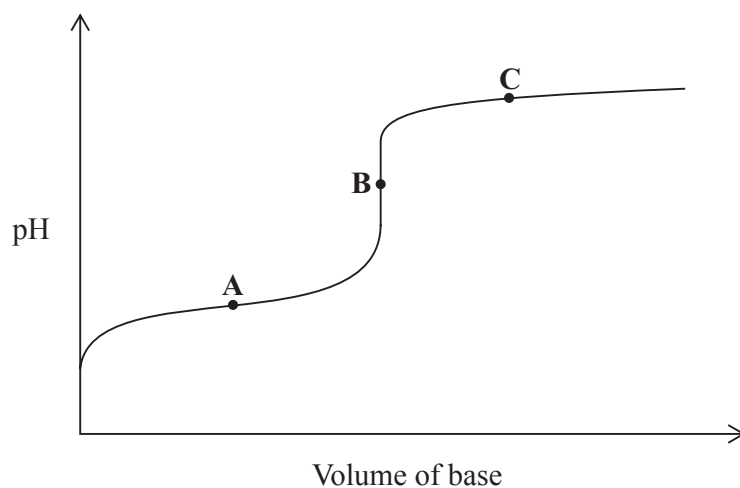
- A. 50.0 cm^3 0.100 mol dm^{-3} HCl and 100.0 cm^3 0.100 mol dm^{-3} NH_3
- B. 50.0 cm^3 0.100 mol dm^{-3} HCl and 50.0 cm^3 0.100 mol dm^{-3} NH_3
- C. 50.0 cm^3 0.100 mol dm^{-3} HCl and 100.0 cm^3 0.100 mol dm^{-3} NH_4Cl
- D. 50.0 cm^3 0.100 mol dm^{-3} HCl and 50.0 cm^3 0.100 mol dm^{-3} NH_4Cl

2214-6107

Turn over

68. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX | Original Q28

28. A weak acid is titrated with a strong base. Which statement is true for the titration curve?



- A. **A** is the equivalence point.
- B. The pH at **A** equals the pK_a of the acid.
- C. The pH at **B** equals 7.
- D. **C** is in the buffer region.

69. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX | Original Q29

29. Methyl orange is an indicator which changes its colour from red to yellow in a pH range of 3.2 – 4.4. For which titration would methyl orange be a suitable indicator?
- A. Iodine and sodium thiosulfate solution
 - B. Hydrochloric acid and ammonia solution
 - C. Ethanoic acid and sodium hydroxide solution
 - D. Ethanoic acid and ammonia solution

2214-6107

70. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX | Original Q24

24. Which of the following molecules can act as a Lewis acid but not as a Brønsted–Lowry acid?
- A. BF_3
 - B. PCl_3
 - C. NH_3
 - D. H_2O
-

71. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. Which is a $0.001 \text{ mol dm}^{-3}$ solution of a weak acid?

	Conductivity	pH
A.	poor	5
B.	good	7
C.	poor	10
D.	good	3

72. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. What is the order of increasing acid strength? Approximate K_a and pK_a values at 298 K are given.

	K_a		pK_a
ClCH_2COOH	1×10^{-3}	$\text{C}_6\text{H}_5\text{OH}$	10.0
$\text{CH}_3\text{CH}_2\text{COOH}$	1×10^{-5}	$\text{C}_6\text{H}_5\text{NH}_3^+$	4.6

- A. $\text{ClCH}_2\text{COOH} < \text{CH}_3\text{CH}_2\text{COOH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{C}_6\text{H}_5\text{OH}$
- B. $\text{C}_6\text{H}_5\text{OH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{ClCH}_2\text{COOH} < \text{CH}_3\text{CH}_2\text{COOH}$
- C. $\text{C}_6\text{H}_5\text{OH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{CH}_3\text{CH}_2\text{COOH} < \text{ClCH}_2\text{COOH}$
- D. $\text{C}_6\text{H}_5\text{OH} < \text{CH}_3\text{CH}_2\text{COOH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{ClCH}_2\text{COOH}$

73. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Which solutions, mixed in equal concentrations and volumes, form an acid buffer solution?

- A. $\text{HCl(aq)} + \text{NaCl(aq)}$
- B. $\text{CH}_3\text{CO}_2\text{H(aq)} + \text{CH}_3\text{CO}_2\text{Na(aq)}$
- C. $\text{CH}_3\text{CO}_2\text{H(aq)} + \text{NaOH(aq)}$
- D. $\text{CH}_3\text{CO}_2\text{H(aq)} + \text{CH}_3\text{CH}_2\text{CO}_2\text{H(aq)}$

74. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

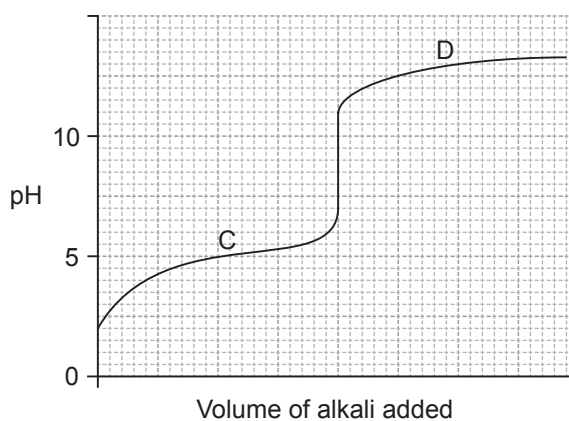
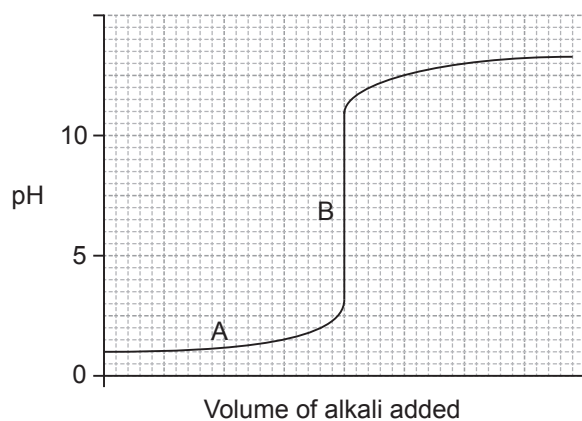
28. Which salt forms the most acidic solution when dissolved in water?

	Salt	Ionic radius of cation / 10^{-12} m
A.	CrCl_3	63
B.	FeCl_2	76
C.	MgCl_2	65
D.	NaCl	98

Turn over

75. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. What is the buffer region in the acid–base titration curves below?



76. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX | Original Q24

24. Which species **cannot** function as a Lewis acid?

- A. BF_3
- B. AlCl_3
- C. CCl_4
- D. H^+

77. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX | Original Q25

25. 10.0 cm^3 of a $1.00 \times 10^{-2}\text{ mol dm}^{-3}$ aqueous solution of sodium hydroxide is added to a volumetric flask and the total volume is made up to 1.00 dm^3 with distilled water. The resulting solution is then thoroughly mixed.

What is the pH of the diluted solution?

- A. 9
- B. 10
- C. 12
- D. 14

Turn over

78. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. The strengths of four acids are:

glycine	$pK_a = 9.87$
chloroethanoic acid	$K_a = 1.38 \times 10^{-3}$
phenol	$K_a = 1.00 \times 10^{-10}$
butanoic acid	$pK_a = 4.82$

What is the order of **increasing** acid strength?

- A. chloroethanoic acid < butanoic acid < phenol < glycine
 - B. glycine < phenol < chloroethanoic acid < butanoic acid
 - C. phenol < chloroethanoic acid < butanoic acid < glycine
 - D. phenol < glycine < butanoic acid < chloroethanoic acid
-

79. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. The pK_a of ethanoic acid is 4.8 at 298 K. Which combination will produce a buffer solution with a pH of 4.8 at 298 K?

- A. 20.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{CH}_3\text{COOH}$ and 10.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{NaOH}$
 - B. 20.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{CH}_3\text{COOH}$ and 20.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{NaOH}$
 - C. 10.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{CH}_3\text{COOH}$ and 20.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{NaOH}$
 - D. 14.8 cm^3 of $1.0 \text{ mol dm}^{-3} \text{CH}_3\text{COOH}$ and 10.0 cm^3 of $1.0 \text{ mol dm}^{-3} \text{NaOH}$
-

80. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX | Original Q28

28. Which compound forms an acidic solution when dissolved in water?

- A. FeCl_3
- B. CH_3NH_2
- C. NaNO_3
- D. Na_2CO_3

81. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX | Original Q29

29. For which titration can the end point **not** be determined accurately by using an acid-base indicator?

- A. $\text{NH}_3(\text{aq}) + \text{CH}_3\text{COOH}(\text{aq})$
- B. $\text{NaOH}(\text{aq}) + \text{HNO}_3(\text{aq})$
- C. $\text{NH}_3(\text{aq}) + \text{HNO}_3(\text{aq})$
- D. $\text{NaOH}(\text{aq}) + \text{CH}_3\text{COOH}(\text{aq})$

82. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

24. Which gas in the atmosphere causes the pH of unpolluted rain to be approximately 6?

- A. Carbon dioxide
 - B. Sulfur dioxide
 - C. Oxygen
 - D. Nitrogen
-

83. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX | Original Q25

25. Which compound is a strong acid?

- A. NH_3
- B. HNO_3
- C. H_2CO_3
- D. CH_3COOH

84. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. The forward reaction of this equilibrium is endothermic.



What is correct about water at 50°C ?

- A. $[\text{H}^+] > [\text{OH}^-]$
- B. $[\text{H}^+] < [\text{OH}^-]$
- C. $\text{pH} < 7.0$
- D. $\text{pH} = 7.0$

85. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. Which equation represents a reaction for which a base dissociation constant expression, K_b , can be written?

- A. $\text{CH}_3\text{COOH}(\text{aq}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{CH}_3\text{COO}^-(\text{aq}) + \text{NH}_4^+(\text{aq})$
 - B. $\text{HF}(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{F}^-(\text{aq})$
 - C. $\text{HCN}(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{CN}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 - D. $\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$
-

86. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX | Original Q28

28. An equal amount of each of the following salts is added separately to the same volume of water. Which salt will have the greatest effect on the pH of water?

- A. $\text{Al}(\text{NO}_3)_3$
- B. Na_2SO_4
- C. RbCl
- D. KBr

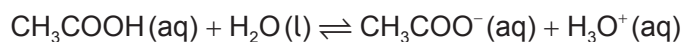
87. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX | Original Q29

29. Which mixture will form a buffer in aqueous solution?

- A. $0.10 \text{ mol NH}_3 + 0.20 \text{ mol HCl}$
- B. $0.10 \text{ mol NH}_3 + 0.20 \text{ mol NaOH}$
- C. $0.10 \text{ mol NaOH} + 0.20 \text{ mol KCl}$
- D. $0.20 \text{ mol NH}_3 + 0.10 \text{ mol HCl}$

88. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. Which is a conjugate Brønsted–Lowry acid-base pair?



- A. $\text{CH}_3\text{COO}^- / \text{H}_3\text{O}^+$
 - B. $\text{H}_2\text{O} / \text{CH}_3\text{COO}^-$
 - C. $\text{H}_2\text{O} / \text{H}_3\text{O}^+$
 - D. $\text{CH}_3\text{COOH} / \text{H}_2\text{O}$
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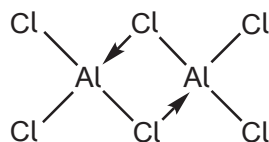
89. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Aqueous solutions of a weak acid and a strong acid of equal concentration are compared. Which statements are correct?

- I. The weak acid is less dissociated than the strong acid.
 - II. The strong acid reacts with a metal oxide but the weak acid does not.
 - III. The strong acid has greater conductivity than the weak acid.
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III
-

90. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. The diagram represents the bonding in aluminium chloride.

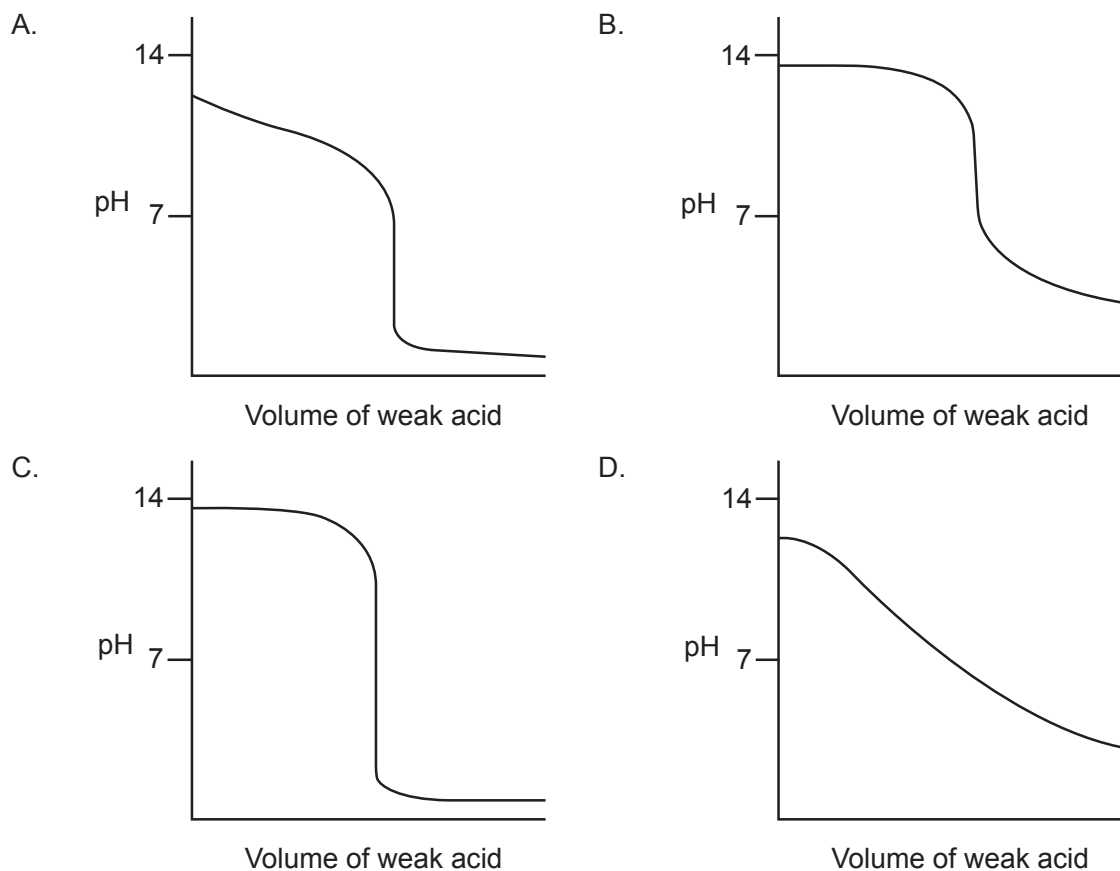


Which statement is correct?

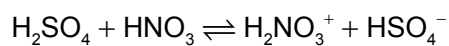
- A. The aluminium atoms behave as Lewis acids.
- B. The aluminium atoms behave as Lewis bases.
- C. One aluminium atom is a Lewis base and the other a Lewis acid.
- D. One chlorine atom is a Lewis base and the other a Lewis acid.
-

91. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. Which titration curve would occur when a weak acid is added to a strong base?

**92. November 2016 - N16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26**

26. Which species behave as Brønsted–Lowry bases in the following reaction?



- A. HNO_3 and HSO_4^-
- B. HNO_3 and H_2NO_3^+
- C. H_2SO_4 and HSO_4^-
- D. H_2NO_3^+ and HSO_4^-

93. November 2016 - N16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. Which mixture is a buffer solution?

- A. 25 cm³ of 0.10 mol dm⁻³ NH₃(aq) and 50 cm³ of 0.10 mol dm⁻³ HCl(aq)
 - B. 50 cm³ of 0.10 mol dm⁻³ NH₃(aq) and 25 cm³ of 0.10 mol dm⁻³ HCl(aq)
 - C. 25 cm³ of 0.10 mol dm⁻³ NaOH(aq) and 25 cm³ of 0.10 mol dm⁻³ HCl(aq)
 - D. 50 cm³ of 0.10 mol dm⁻³ NaOH(aq) and 25 cm³ of 0.10 mol dm⁻³ HCl(aq)
-

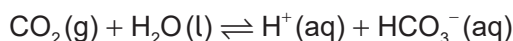
94. November 2016 - N16/4/CHEMI/HPM/ENG/TZ0/XX | Original Q29

29. Which salt solution has the highest pH?

- A. NH₄Cl
 - B. Ca(NO₃)₂
 - C. Na₂CO₃
 - D. K₂SO₄
-

95. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX | Original Q24

24. What will happen if the pressure is increased in the following reaction mixture at equilibrium?



- A. The equilibrium will shift to the right and pH will decrease.
 - B. The equilibrium will shift to the right and pH will increase.
 - C. The equilibrium will shift to the left and pH will increase.
 - D. The equilibrium will shift to the left and pH will decrease.
-

96. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. 10.0 cm³ of an aqueous solution of sodium hydroxide of pH = 10 is mixed with 990.0 cm³ of distilled water. What is the pH of the resulting solution?

- A. 8
 - B. 9
 - C. 11
 - D. 12
-

97. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

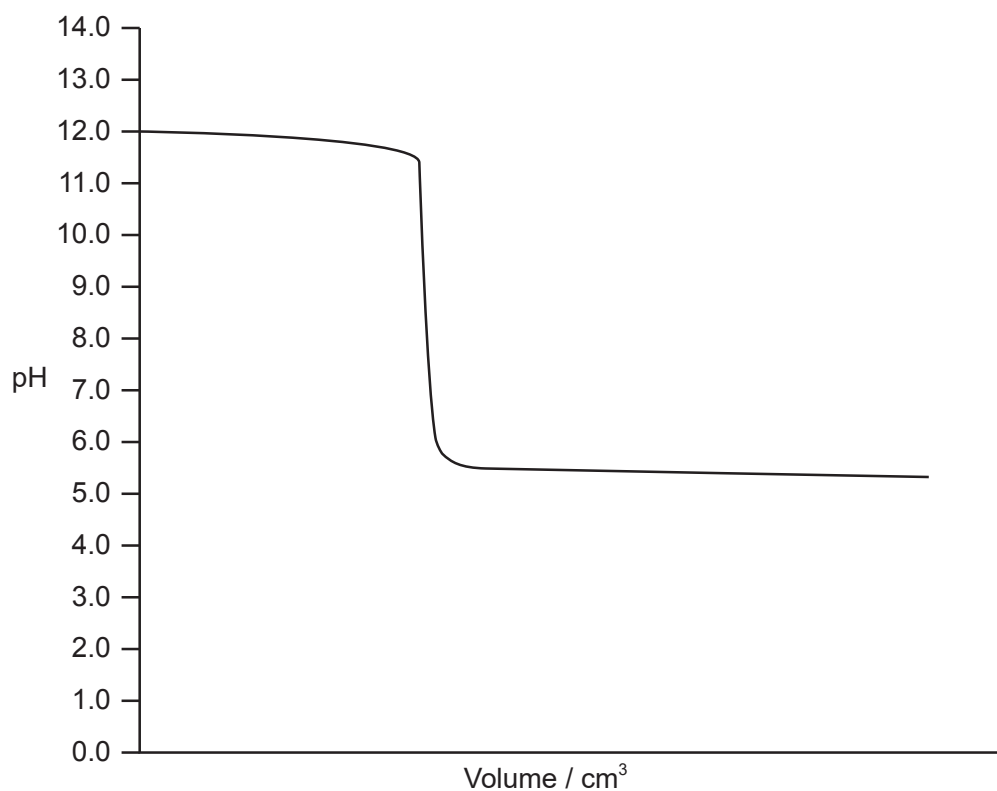
26. Which of the following will form a buffer solution if combined in appropriate molar ratios?

- A. HCl and NaCl
- B. NaOH and HCOONa
- C. NH_4Cl and HCl
- D. HCl and NH_3

Turn over

98. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Which indicator is appropriate for the acid-base titration shown below?



- A. Thymol blue ($pK_a = 1.5$)
- B. Methyl orange ($pK_a = 3.7$)
- C. Bromophenol blue ($pK_a = 4.2$)
- D. Phenolphthalein ($pK_a = 9.6$)

99. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. Which statement is **incorrect** for a 0.10 mol dm^{-3} HCOOH solution?

- A. $\text{pH} = 1$
- B. $[\text{H}^+] \ll 0.10 \text{ mol dm}^{-3}$
- C. $[\text{HCOO}^-]$ is approximately equal to $[\text{H}^+]$
- D. HCOOH is partially ionized

100. May 2017 - M17/4/CHEMI/HPM/ENG/TZ2/XX | Original Q25

25. Which of the following is correct?

- A. A weak acid is a proton donor and its aqueous solution shows good conductivity.
 - B. A weak acid is a proton donor and its aqueous solution shows poor conductivity.
 - C. A weak acid is a proton acceptor and its aqueous solution shows good conductivity.
 - D. A weak acid is a proton acceptor and its aqueous solution shows poor conductivity.
-

101. May 2017 - M17/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. Which type of bond is formed when a Lewis acid reacts with a Lewis base?

- A. Covalent
- B. Dipole-dipole
- C. Double
- D. Hydrogen

Turn over

102. May 2017 - M17/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. What is the order of increasing acidity of the following acids?

Acid	K_a	Acid	pK_a
chloroethanoic	1.3×10^{-3}	hydrogen fluoride	3.3
ethanoic	1.7×10^{-5}	hydrogen cyanide	9.3

- A. chloroethanoic < ethanoic < hydrogen fluoride < hydrogen cyanide
- B. ethanoic < chloroethanoic < hydrogen fluoride < hydrogen cyanide
- C. chloroethanoic < ethanoic < hydrogen cyanide < hydrogen fluoride
- D. hydrogen cyanide < ethanoic < hydrogen fluoride < chloroethanoic

103. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

24. Which species produced by the successive dissociations of phosphoric acid, H_3PO_4 , are amphiprotic?
- A. HPO_4^{2-} and PO_4^{3-}
- B. H_2PO_4^- and HPO_4^{2-}
- C. H_2PO_4^- and PO_4^{3-}
- D. HPO_4^{2-} only
-

104. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX | Original Q25

25. What is the pH of $1.0 \times 10^{-3} \text{ mol dm}^{-3}$ sodium hydroxide, NaOH(aq) ?

$$K_w = 1.0 \times 10^{-14}$$

- A. 3
- B. 4
- C. 10
- D. 11
-

Turn over

105. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. Which species acts as a Lewis and Brønsted–Lowry base?
- A. $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$
- B. BF_3
- C. NH_4^+
- D. OH^-
-

106. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

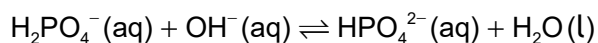
27. A buffer is produced by mixing 20.0 cm³ of 0.10 mol dm⁻³ ethanoic acid, CH₃COOH(aq), with 0.10 mol dm⁻³ sodium hydroxide, NaOH(aq).

What is the volume of NaOH required and the pH of the buffer?

	Volume of NaOH / cm ³	pH of buffer
A.	40.0	9.2
B.	40.0	4.8
C.	10.0	9.2
D.	10.0	4.8

107. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX | Original Q24

24. Which two species act as Brønsted–Lowry acids in the reaction?



- A. $\text{HPO}_4^{2-}(\text{aq})$ and $\text{OH}^-(\text{aq})$
B. $\text{H}_2\text{PO}_4^-(\text{aq})$ and $\text{HPO}_4^{2-}(\text{aq})$
C. $\text{HPO}_4^{2-}(\text{aq})$ and $\text{H}_2\text{O}(\text{l})$
D. $\text{H}_2\text{PO}_4^-(\text{aq})$ and $\text{H}_2\text{O}(\text{l})$

108. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. What is the order of increasing pH for the following solutions of the same concentration?

- A. $\text{NaCl} < \text{NH}_4\text{Cl} < \text{Na}_2\text{CO}_3 < \text{CH}_3\text{COONa}$
B. $\text{CH}_3\text{COONa} < \text{NH}_4\text{Cl} < \text{NaCl} < \text{Na}_2\text{CO}_3$
C. $\text{NH}_4\text{Cl} < \text{NaCl} < \text{CH}_3\text{COONa} < \text{Na}_2\text{CO}_3$
D. $\text{Na}_2\text{CO}_3 < \text{CH}_3\text{COONa} < \text{NaCl} < \text{NH}_4\text{Cl}$

109. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

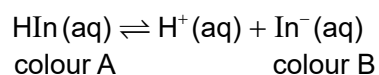
26. Which species is **not** a Lewis base?

- A. OH^-
- B. NH_4^+
- C. H_2O
- D. PH_3

Turn over

110. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. An indicator, HIn, has a $\text{p}K_{\text{a}}$ of 5.1.



Which statement is correct?

- A. At $\text{pH} = 7$, colour B would be observed
 - B. At $\text{pH} = 3$, colour B would be observed
 - C. At $\text{pH} = 7$, $[\text{HIn}] = [\text{In}^-]$
 - D. At $\text{pH} = 3$, $[\text{HIn}] < [\text{In}^-]$
-

111. May 2018 - M18/4/CHEMI/HPM/ENG/TZ2/XX | Original Q25

25. Which statement is correct?

- A. A strong acid is a good proton donor and has a strong conjugate base.
- B. A weak acid is a poor proton acceptor and has a strong conjugate base.
- C. A strong acid is a good proton donor and has a weak conjugate base.
- D. A strong base is a good proton donor and has a weak conjugate acid.

112. May 2018 - M18/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. What is the order of increasing acidity?

Acid	pK_a
HClO	7.4
HIO ₃	0.8

Acid	K_a
HF	5.6×10^{-4}
CH ₃ CH ₂ COOH	1.3×10^{-5}

- A. HClO < CH₃CH₂COOH < HF < HIO₃
 - B. HClO < HF < CH₃CH₂COOH < HIO₃
 - C. HIO₃ < HF < CH₃CH₂COOH < HClO
 - D. HIO₃ < CH₃CH₂COOH < HF < HClO
-

113. May 2018 - M18/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

24. What describes HPO_4^{2-} ?
- A. Amphiprotic but not amphoteric
 - B. Amphoteric but not amphiprotic
 - C. Amphiprotic and amphoteric
 - D. Neither amphiprotic nor amphoteric

Turn over

114. May 2018 - M18/4/CHEMI/HPM/ENG/TZ1/XX | Original Q25

25. What is the pH of a solution in which the hydroxide ion concentration is $1 \times 10^{-11} \text{ mol dm}^{-3}$ at 298 K?

$$K_w = 1 \times 10^{-14} \text{ at } 298 \text{ K}$$

- A. 3
- B. 7
- C. 11
- D. 14

115. May 2018 - M18/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. Which combination of acid and base is most likely to have a pH of 8.5 at the equivalence point in a titration?
- A. Hydrochloric acid and sodium hydroxide
 - B. Hydrochloric acid and ammonia
 - C. Nitric acid and ammonia
 - D. Methanoic acid and sodium hydroxide
-

116. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX | Original Q25

25. What is the difference between a conjugate Brønsted–Lowry acid–base pair?
- A. Electron pair
 - B. Positive charge
 - C. Proton
 - D. Hydrogen atom
-

117. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX | Original Q26

26. Which is an example of an amphoteric species?
- A. Al_2O_3
 - B. CO_3^{2-}
 - C. P_4O_{10}
 - D. HPO_4^{2-}
-

118. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX | Original Q27

27. Which can act as a Lewis acid but not a Brønsted–Lowry acid?
- A. BF_3
 - B. H_2O
 - C. NF_3
 - D. NH_3
-

119. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX | Original Q28

28. What is the order, in increasing pH, of the following solutions of equal concentration?

	pKa		Ka
CH ₃ CH ₂ CH ₂ COOH	4.8	CHCl ₂ COOH	5.0×10^{-2}
CH ₃ CH ₂ COOH	4.9	H ₃ BO ₃	5.8×10^{-10}

- A. H₃BO₃ < CH₃CH₂CH₂COOH < CH₃CH₂COOH < CHCl₂COOH
- B. H₃BO₃ < CH₃CH₂CH₂COOH < CHCl₂COOH < CH₃CH₂COOH
- C. CH₃CH₂CH₂COOH < CH₃CH₂COOH < CHCl₂COOH < H₃BO₃
- D. CHCl₂COOH < CH₃CH₂CH₂COOH < CH₃CH₂COOH < H₃BO₃

Turn over

120. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX | Original Q24

24. What is the pH of 0.001 mol dm⁻³ NaOH(aq)?

- A. 1
- B. 3
- C. 11
- D. 13

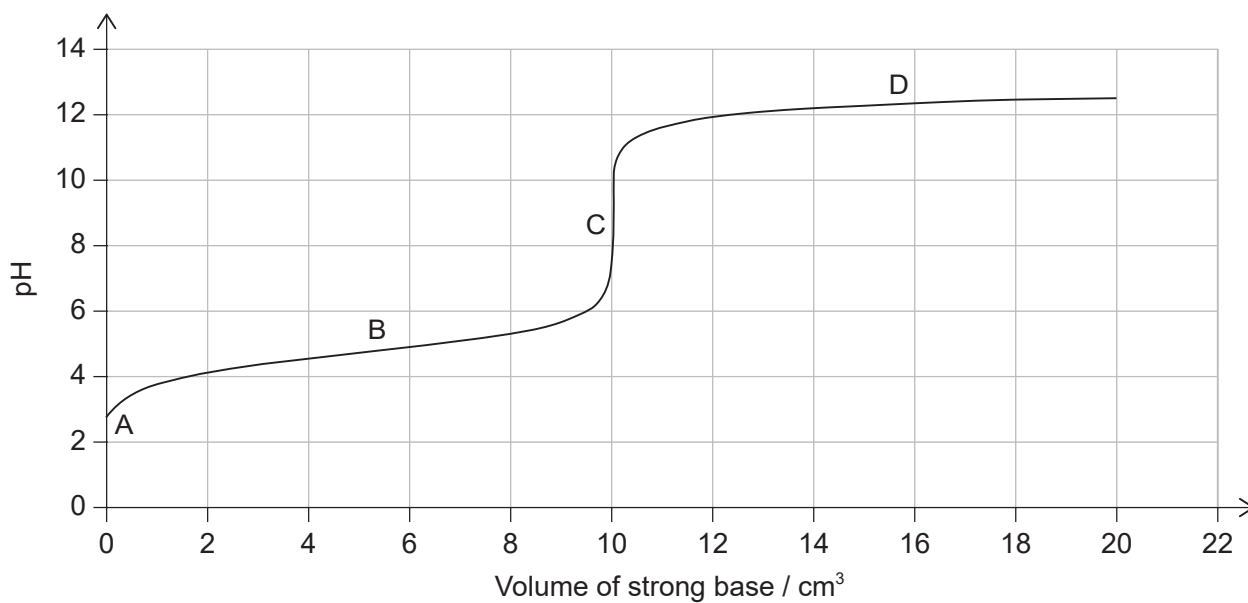
121. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX | Original Q25

25. What is the major reason why the pH of unpolluted rain is less than 7?

- A. methane
- B. carbon dioxide
- C. nitrogen oxides
- D. sulfur dioxide

122. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX | Original Q26

26. Where is the buffer region for the titration of a weak acid with a strong base?



123. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX | Original Q27

27. The following equation represents the dissociation of water at 25 °C.



Which changes occur as the temperature increases?

- A. $[\text{H}_3\text{O}^+]$ increases and pH will decrease.
 - B. $[\text{H}_3\text{O}^+]$ decreases and pH will increase.
 - C. $[\text{H}_3\text{O}^+]$ increases and pH will increase.
 - D. $[\text{H}_3\text{O}^+]$ decreases and pH will decrease.
-

124. May 2019 - M19/4/CHEMI/HPM/ENG/TZ1/XX | Original Q24

24. Which solution is basic at 25 °C?

$$K_w = 1.0 \times 10^{-14}$$

- A. $[\text{H}^+] = 1.0 \times 10^{-3} \text{ mol dm}^{-3}$
 - B. $[\text{OH}^-] = 1.0 \times 10^{-13} \text{ mol dm}^{-3}$
 - C. solution of pH = 4.00
 - D. $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-13} \text{ mol dm}^{-3}$
-

125. May 2019 - M19/4/CHEMI/HPM/ENG/TZ1/XX | Original Q26

26. Which is a Lewis acid but not a Brønsted–Lowry acid?

- A. AlCl_3
 - B. $\text{CH}_3\text{CO}_2\text{H}$
 - C. HF
 - D. CCl_4
-

126. May 2019 - M19/4/CHEMI/HPM/ENG/TZ1/XX | Original Q27

27. Which has the strongest conjugate base?

- A. HCOOH ($K_{\text{a}} = 1.8 \times 10^{-4}$)
- B. HNO_2 ($K_{\text{a}} = 7.2 \times 10^{-4}$)
- C. HCN ($K_{\text{a}} = 6.2 \times 10^{-10}$)
- D. HIO_3 ($K_{\text{a}} = 1.7 \times 10^{-1}$)

127. November 2024 - 8824-9540 | Original Q24

24. The pH of an aqueous solution **Z** is 5 and the pH of an aqueous solution **X** is 10. What is the ratio of their H_3O^+ concentrations?

- A. $[\text{H}_3\text{O}^+]$ is 2 times lower in **X** than in **Z**.
 - B. $[\text{H}_3\text{O}^+]$ is 5 times lower in **X** than in **Z**.
 - C. $[\text{H}_3\text{O}^+]$ is 1×10^2 times lower in **X** than in **Z**.
 - D. $[\text{H}_3\text{O}^+]$ is 1×10^5 times lower in **X** than in **Z**.
-

128. November 2024 - 8824-9540 | Original Q25

25. Using the data provided in the table, which of the conjugate bases is the strongest?

Acid	K_a
HClO	2.9×10^{-8}
$\text{C}_6\text{H}_5\text{COOH}$	6.3×10^{-5}
H_3PO_4	7.3×10^{-3}
H_2SO_3	1.3×10^{-2}

- A. ClO^-
 - B. $\text{C}_6\text{H}_5\text{COO}^-$
 - C. H_2PO_4^-
 - D. HSO_3^-
-

129. November 2024 - 8824-9540 | Original Q26

26. Consider the phosphate buffer system, $\text{Na}_2\text{HPO}_4 / \text{NaH}_2\text{PO}_4$.

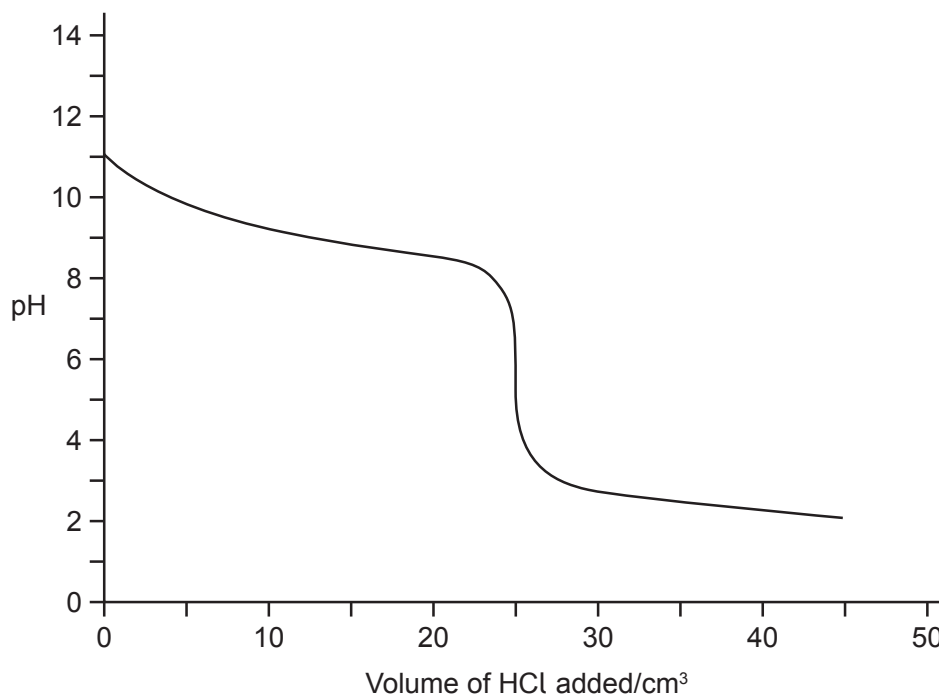
What is correct when a small amount of a strong base is added to the buffer?

- A. OH^- react with Na^+ to form NaOH .
- B. $[\text{H}_2\text{PO}_4^-]$ increases.
- C. $[\text{HPO}_4^{2-}]$ increases.
- D. OH^- react with H_2PO_4^- to form PO_4^{3-} .

Turn over

130. November 2024 - 8824-9540 | Original Q27

27. A 25 cm^3 sample of a weak base was titrated with hydrochloric acid, HCl.



What is the pK_b of the base?

- A. 2
- B. 5
- C. 9
- D. 11

131. May 2024 - 2224-6207 | Original Q27

27. What is the ratio of $[\text{H}^+]$ in ethanoic acid with a $\text{pH} = 3$ to $[\text{H}^+]$ in water at 298 K?

- A. 3:7
- B. 7:3
- C. $1:10^4$
- D. $10^4:1$

132. May 2024 - 2224-6207 | Original Q28

28. What is the conjugate base of OH^- ?

- A. O^{2-}
- B. H_2O
- C. H_3O^+
- D. H^-

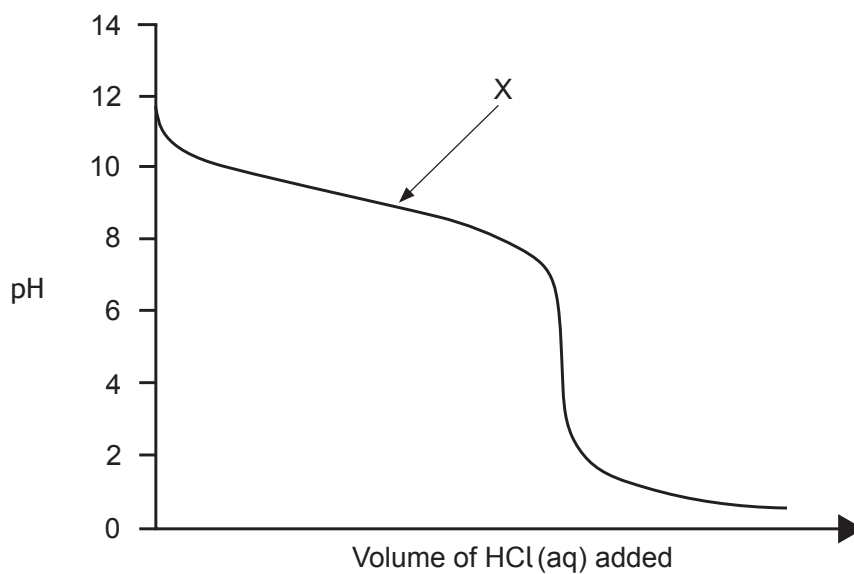
133. May 2024 - 2224-6207 | Original Q29

29. Which combination is correct for a very weak acid and its conjugate base?

	$\text{p}K_{\text{a}}$ of acid	K_{b} of conjugate base
A.	low	low
B.	low	high
C.	high	low
D.	high	high

134. May 2024 - 2224-6207 | Original Q30

30. The pH curve below is produced when aqueous ammonia is titrated with hydrochloric acid.

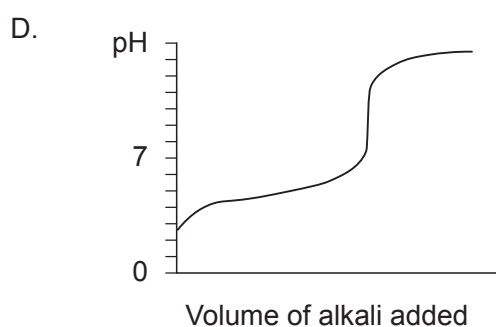
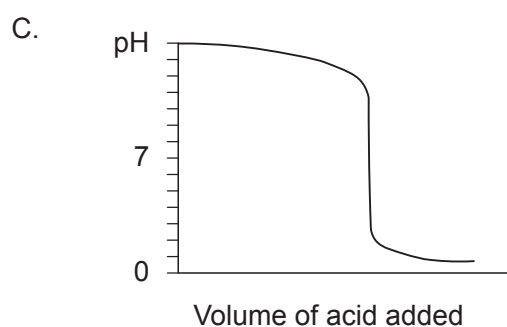
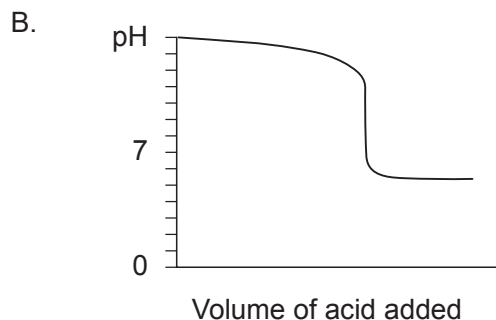
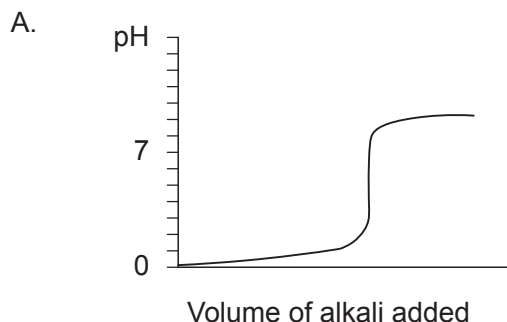


Besides water, which species are the major components of the reaction mixture at point X of the pH curve?

- A. NH_3 only
- B. H^+ only
- C. NH_3 and NH_4^+
- D. H^+ and NH_4^+

135. May 2025 - 2225-6207 | Original Q3

3. Which chart shows the neutralization curve of a strong base with a strong acid?

**136. May 2025 - 2225-6207 | Original Q32**

32. Which two species can be both Brønsted-Lowry acids and Brønsted-Lowry bases?

- A. H_3PO_4 and PO_4^{3-} .
- B. HPO_4^{2-} and H_2PO_4^- .
- C. HPO_4^{2-} and PO_4^{3-} .
- D. PO_4^{3-} and H_2PO_4^- .

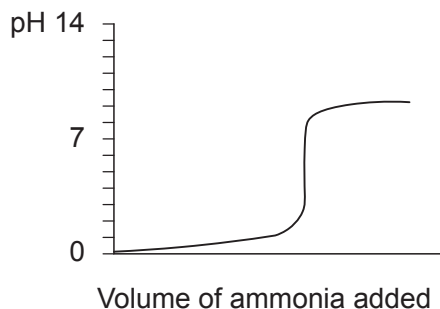
137. May 2025 - 2225-6207 | Original Q33

33. A solution has a pH of 3.0. What is the hydroxide ion concentration, $[\text{OH}^-]$, in the solution?

- A. 11
- B. 10^{-3}
- C. 10
- D. 10^{-11}

138. May 2025 - 2225-6207 | Original Q39

39. When an excess of ammonia was added to hydrochloric acid, the following neutralization curve was obtained.



Which would be the best indicator for this titration?

	Indicator	pK_a
A.	Phenol red	7.9
B.	Bromothymol blue	7.0
C.	Phenolphthalein	9.6
D.	Bromocresol green	4.7

139. May 2025 - 2225-6213 | Original Q31

31. What is required to convert a base into its conjugate acid?

- A. A negative charge
- B. A hydrogen atom
- C. An electron pair
- D. A proton

140. May 2025 - 2225-6213 | Original Q32

32. Which solution has a pH of 9.0?

- A. $10^{-9} \text{ mol dm}^{-3} \text{ NH}_3(\text{aq})$
- B. $10^{-9} \text{ mol dm}^{-3} \text{ NaOH}(\text{aq})$
- C. $10^{-5} \text{ mol dm}^{-3} \text{ NH}_3(\text{aq})$
- D. $10^{-5} \text{ mol dm}^{-3} \text{ NaOH}(\text{aq})$

141. May 2025 - 2225-6213 | Original Q33

- 33.** What is the main reason why sulfuric acid has a lower pH than methanoic acid of the same concentration?
- A. Sulfuric acid is diprotic, whereas methanoic acid is monoprotic.
 - B. Sulfuric acid ionizes more than methanoic acid.
 - C. Sulfuric acid has a stronger conjugate base than methanoic acid.
 - D. Sulfuric acid is more soluble in water than methanoic acid.

142. May 2025 - 2225-6213 | Original Q35

- 35.** What is the best indicator to use in the titration of phenylamine with nitric acid?
- A. Bromophenol blue, $pK_a = 4.2$
 - B. Bromothymol blue, $pK_a = 7.0$
 - C. Phenol red, $pK_a = 7.9$
 - D. Phenolphthalein, $pK_a = 9.6$

Turn over

143. May 2025 - 2225-6219 | Original Q31

31. What is the pH of $0.0010 \text{ mol dm}^{-3} \text{ HCl(aq)}$?

- A. 2.0
- B. 2.5
- C. 3.0
- D. 3.5

Turn over

144. May 2025 - 2225-6219 | Original Q34

34. Which of these bases has the strongest conjugate acid?

Bases	K_b	pK_b
NH_3	1.8×10^{-5}	
CH_3NH_2		3.35
$(\text{CH}_3)_2\text{NH}$	5.9×10^{-4}	
CH_3CONH_2		14.5

- A. NH_3
 - B. CH_3NH_2
 - C. $(\text{CH}_3)_2\text{NH}$
 - D. CH_3CONH_2
-

145. May 2025 - 2225-6219 | Original Q35

- 35.** What is the pH of a buffer solution which contains $0.500 \text{ mol dm}^{-3}$ of methanoic acid and $0.250 \text{ mol dm}^{-3}$ of sodium methanoate?

$$\text{p}K_{\text{a}} (\text{methanoic acid}) = 3.75$$

- A. 3.25
 - B. 3.45
 - C. 3.75
 - D. 4.05
-

ANSWER KEY

Compiled number - session / original question - answer

1. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX / Q24 - B
2. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - C
3. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - A
4. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - C
5. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - C
6. November 2010 - N10/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - C
7. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - B
8. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - D
9. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - B
10. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - C
11. November 2011 - N11/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - C
12. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX / Q25 - C
13. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - A
14. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - A
15. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX / Q28 - B
16. May 2011 - M11/4/CHEMI/HPM/ENG/TZ2/XX / Q29 - C
17. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - C
18. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - C
19. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX / Q28 - D
20. May 2011 - M11/4/CHEMI/HPM/ENG/TZ1/XX / Q29 - D
21. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX / Q24 - C
22. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - A
23. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - B
24. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - A
25. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - A
26. November 2012 - N12/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - D
27. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX / Q23 - D
28. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX / Q24 - B
29. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX / Q25 - D
30. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - C
31. May 2012 - M12/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - C
32. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - A
33. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - A
34. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - D
35. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX / Q28 - D
36. May 2012 - M12/4/CHEMI/HPM/ENG/TZ1/XX / Q29 - A
37. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - C
38. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - B
39. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - B
40. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - A
41. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - D
42. November 2013 - N13/4/CHEMI/HPM/ENG/TZ0/XX / Q30 - A
43. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - B
44. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - C
45. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX / Q28 - C
46. May 2013 - M13/4/CHEMI/HPM/ENG/TZ2/XX / Q29 - D
47. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - D
48. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX / Q25 - C
49. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - C
50. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - B
51. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX / Q28 - D
52. May 2013 - M13/4/CHEMI/HPM/ENG/TZ1/XX / Q29 - A
53. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX / Q24 - D
54. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - C
55. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - C
56. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - A
57. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - A
58. November 2014 - N14/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - B
59. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - C
60. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - B
61. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX / Q28 - D
62. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX / Q29 - A
63. May 2014 - M14/4/CHEMI/HPM/ENG/TZ2/XX / Q30 - B
64. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - D
65. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX / Q25 - C
66. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - A
67. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - A
68. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX / Q28 - B
69. May 2014 - M14/4/CHEMI/HPM/ENG/TZ1/XX / Q29 - B
70. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX / Q24 - A

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71. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - A 106. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - D
72. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - D 107. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX / Q24 - D
73. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - B 108. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - C
74. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - A 109. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - B
75. November 2015 - N15/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - C 110. November 2018 - N18/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - A
76. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX / Q24 - C 111. May 2018 - M18/4/CHEMI/HPM/ENG/TZ2/XX / Q25 - C
77. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX / Q25 - B 112. May 2018 - M18/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - A
78. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - D 113. May 2018 - M18/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - C
79. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - A 114. May 2018 - M18/4/CHEMI/HPM/ENG/TZ1/XX / Q25 - A
80. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX / Q28 - A 115. May 2018 - M18/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - D
81. May 2015 - M15/4/CHEMI/HPM/ENG/TZ2/XX / Q29 - A 116. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - C
82. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - A 117. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - D
83. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX / Q25 - B 118. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - A
84. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - C 119. November 2019 - N19/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - D
85. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - D 120. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX / Q24 - C
86. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX / Q28 - A 121. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX / Q25 - B
87. May 2015 - M15/4/CHEMI/HPM/ENG/TZ1/XX / Q29 - D 122. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - B
88. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - C 123. May 2019 - M19/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - A
89. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - B 124. May 2019 - M19/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - D
90. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - A 125. May 2019 - M19/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - A
91. May 2016 - M16/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - B 126. May 2019 - M19/4/CHEMI/HPM/ENG/TZ1/XX / Q27 - C
92. November 2016 - N16/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - A 127. November 2024 - 8824-9540 / Q24 - D
93. November 2016 - N16/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - B 128. November 2024 - 8824-9540 / Q25 - A
94. November 2016 - N16/4/CHEMI/HPM/ENG/TZ0/XX / Q29 - C 129. November 2024 - 8824-9540 / Q26 - C
95. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX / Q24 - A 130. November 2024 - 8824-9540 / Q27 - B
96. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX / Q25 - A 131. May 2024 - 2224-6207 / Q27 - D
97. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX / Q26 - D 132. May 2024 - 2224-6207 / Q28 - A
98. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX / Q27 - D 133. May 2024 - 2224-6207 / Q29 - D
99. November 2017 - N17/4/CHEMI/HPM/ENG/TZ0/XX / Q28 - A 134. May 2024 - 2224-6207 / Q30 - C
100. May 2017 - M17/4/CHEMI/HPM/ENG/TZ2/XX / Q25 - B 135. May 2025 - 2225-6207 / Q3 - C
101. May 2017 - M17/4/CHEMI/HPM/ENG/TZ2/XX / Q26 - A 136. May 2025 - 2225-6207 / Q32 - B
102. May 2017 - M17/4/CHEMI/HPM/ENG/TZ2/XX / Q27 - D 137. May 2025 - 2225-6207 / Q33 - D
103. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX / Q24 - B 138. May 2025 - 2225-6207 / Q39 - D
104. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX / Q25 - D 139. May 2025 - 2225-6213 / Q31 - D
105. May 2017 - M17/4/CHEMI/HPM/ENG/TZ1/XX / Q26 - D 140. May 2025 - 2225-6213 / Q32 - D

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- 141. May 2025 - 2225-6213 / Q33 - B
- 142. May 2025 - 2225-6213 / Q35 - A
- 143. May 2025 - 2225-6219 / Q31 - C
- 144. May 2025 - 2225-6219 / Q34 - D
- 145. May 2025 - 2225-6219 / Q35 - B