IB Chemistry – HL

Topic 8 Questions

1. The K_a value for an acid is 1.0×10^{-2}. What is the K_b value for its conjugate base?

A. 1.0×10^{-2}

B. 1.0×10^{-6}

C. 1.0×10^{-10}

D. 1.0×10^{-12}

2. Separate 20.0 cm^3 solutions of a weak acid and a strong acid of the same concentration are titrated with NaOH solution. Which will be the same for these two titrations?

I. Initial pH

II. pH at equivalence point

III. Volume of NaOH required to reach the equivalence point

A. I only

B. III only

C. I and II only

D. II and III only

3. When the following 1.0 mol dm^{-3} aqueous solutions are arranged in order of **increasing** pH, which is the correct order?

I. Ammonium chloride

II. Ammonium ethanoate

III. Sodium ethanoate

A. I, II, III

B. II, I, III

C. III, I, II

D. III, II, I

4. An acid-base indicator, HIn, dissociates according to the following equation.

$$HIn(aq) \rightleftharpoons H^+(aq) + In^-(aq)$$

colour A colour B

Which statement about this indicator is correct?

I. In a strongly acidic solution colour B would be seen.

II. In a neutral solution the concentrations of HIn(aq) and $In^-(aq)$ must be equal.

III. It is suitable for use in titrations involving weak acids and weak bases.

A. I only

B. II only

C. III only

D. None of the above

5. What is the concentration of OH^- ions (in mol dm^{-3}) in an aqueous solution in which $[H^+] = 2.0\times10^{-3}$ mol dm^{-3}? ($K_w = 1.0\times10^{-14}$ mol^2 dm^{-6})

A. 2.0×10^{-3}

B. 4.0×10^{-6}

C. 5.0×10^{-12}

D. 2.0×10^{-17}

6. What is the relationship between K_a and pK_a?

A. $pK_a = -\log K_a$

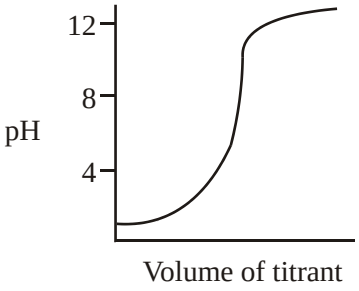
B. $pK_a = \frac{1.0\times10^{-14}}{K_a}$

C. $pK_a = \log K_a$

D. $pK_a = \frac{1.0}{K_a}$

7. Which curve is produced by the titration of a 0.1 mol dm^{-3} weak base with 0.1 mol dm^{-3} strong acid?

A.



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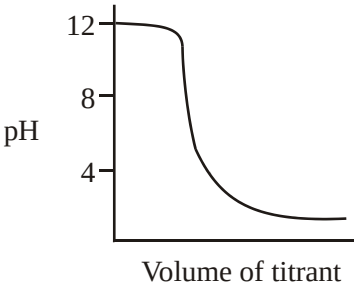

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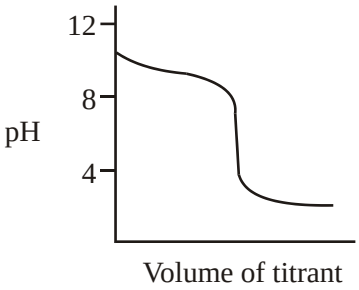

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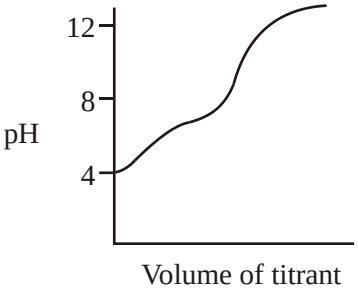


8. The acid dissociation constant of a weak acid HA has a value of 1.0×10^{-5} mol dm^{-3}. What is the pH of a 0.10 mol dm^{-3} aqueous solution of HA?

A. 2

B. 3

C. 5

D. 6

9. Which mixture would produce a buffer solution when dissolved in 1.0 dm^3 of water?

A. 0.50 mol of CH_3COOH and 0.50 mol of NaOH

B. 0.50 mol of CH_3COOH and 0.25 mol of NaOH

C. 0.50 mol of CH_3COOH and 1.00 mol of NaOH

D. 0.50 mol of CH_3COOH and 0.25 mol of $Ba(OH)_2$

10. Which compound, when dissolved in aqueous solution, has the highest pH?

A. NaCl

B. Na_2CO_3

C. NH_4Cl

D. NH_4NO_3

11. Which values are correct for a solution of NaOH of concentration 0.010 mol dm^{-3} at 298 K?

($K_w = 1.0\times10^{-14}$ mol dm^{-6} at 298 K)

A. $[H^+] = 1.0\times10^{-2}$ mol dm^{-3} and pH = 2.00

B. $[OH^-] = 1.0\times10^{-2}$ mol dm^{-3} and pH = 12.00

C. $[H^+] = 1.0\times10^{-12}$ mol dm^{-3} and pOH = 12.00

D. $[OH^-] = 1.0\times10^{-12}$ mol dm^{-3} and pOH = 2.00

12. Which solution, of concentration 0.10 mol dm^{-3}, has the highest pH value?

A. HCl(aq)

B. $MgCl_2$(aq)

C. NaCl(aq)

D. $AlCl_3$(aq)

13. Which statement about indicators is **always** correct?

A. The mid-point of an indicator's colour change is at pH = 7.

B. The pH range is greater for indicators with higher pK_4 values.

C. The colour red indicates an acidic solution.

D. The pK_a value of the indicator is within its pH range.

14. Which compound will dissolve in water to give a solution with a pH greater than 7?

A. sodium chloride

B. potassium carbonate

C. ammonium nitrate

D. lithium sulfate

15. An aqueous solution has a pH of 10. Which concentrations are correct for the ions below?

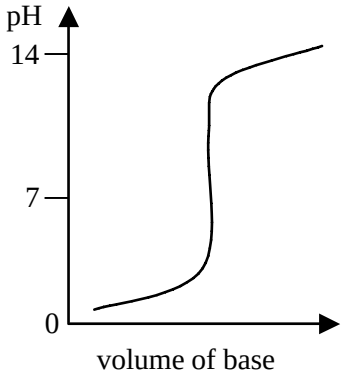
	$[H^+(aq)]$ mol dm^{-3}	$[OH^-(aq)]$ mol dm^{-3}
A.	10^4	10^{-10}
B.	10^{-4}	10^{-10}
C.	10^{-10}	10^{-4}

D.

10^{-10}	10^{-5}

16. Which graph shows how the pH changes when a weak base is added to a strong acid?

A



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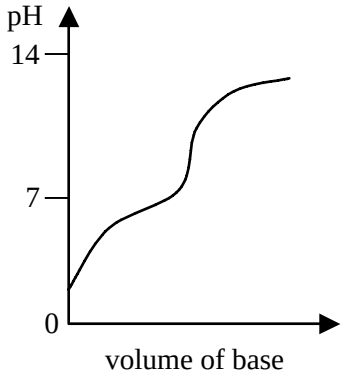

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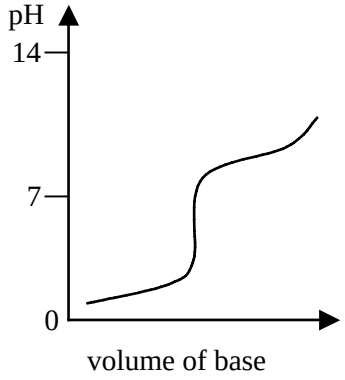

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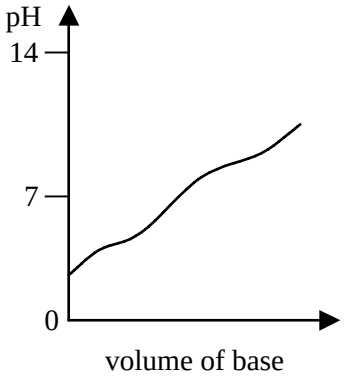

17. When the following acids are listed in decreasing order of acid strength (strongest first), what is the correct order?

	K_a
benzoic	6.31×10^{-5}
chloroethanoic	1.38×10^{-3}
ethanoic	1.74×10^{-5}

A. chloroethanoic > benzoic > ethanoic

B. benzoic > ethanoic > chloroethanoic

C. chloroethanoic > ethanoic > benzoic

D. ethanoic > benzoic > chloroethanoic

18. The strengths of organic acids can be compared using K_a and pK_a values. Which acid is the strongest?

A.

Acid A	pK_a = 6

B.	Acid B	pK_a = 3
C.	Acid C	$K_a = 1\times10^{-5}$
D.	Acid D	$K_a = 1\times10^{-4}$

19. Which is the correct statement about the pH and pOH values of an aqueous solution at 25°C?

A. pH + pOH =14.0

B. pH + pOH =1.0 $\times10^{-14}$

C. pH × pOH =14.0

D. pH × pOH =1.0 $\times10^{-14}$

20. Which salt, when dissolved in water to form a 1.0 mol dm^{-3} solution, produces the lowest pH value?

A. Ammonium chloride

B. Ammonium ethanoate

C. Sodium ethanoate

D. Sodium chloride

21. Which solution has the lowest pH value?

A. Aluminium sulfate

B. Sodium nitrate

C. Potassium chloride

D. Sodium ethanoate

22. Which neutralization reaction could use phenolphthalein (pK_a = 9.3) and not methyl orange (pK_a = 3.7) as an indicator?

A. NaOH(aq) and HNO_3(aq)

B. NH_3(aq) and CH_3COOH(aq)

C. NaOH(aq) and CH_3COOH(aq)

D. NH_3(aq) and HNO_3(aq)

23. Water dissociates according to the equation

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \qquad \Delta H = +56 \text{ kJ}$$

At 25°C water has a pH of 7. Which of the following occurs when water is heated to 30°C?

A. It remains neutral and its pH decreases.

B. It becomes acidic and its pH decreases.

C. It remains neutral and its pH increases.

D. It becomes acidic and its pH increases.

24. Which mixture would produce a buffer solution when dissolved in 1.0 dm^3 of water?

A. 0.30 mol of $NH_3(aq)$ and 0.30 mol of HCl(aq)

B. 0.30 mol of $NH_3(aq)$ and 0.15 mol of HCl(aq)

C. 0.30 mol of $NH_3(aq)$ and 0.60 mol of HCl(aq)

D. 0.30 mol of $NH_3(aq)$ and 0.15 mol of $H_2SO_4(aq)$

25. Ammonia (NH_3) is a weak base in aqueous solution with an ionization constant K_b. What expression is equal to the ionization constant for the following reaction?

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

A. $\frac{K_w}{K_a}$

B. $\frac{K_a}{K_w}$

C. $\frac{K_w}{K_b}$

D. $\frac{K_b}{K_w}$

26. The pK_a values of four acids are as follows.

W	4.87
X	4.82
Y	4.86
Z	4.85

What is the correct order when these acids are arranged in order of **increasing** acid strength?

A. X, Z, Y, W

B. X, Y, Z, W

C. W, Z, Y, X

D. W, Y, Z, X

27. 10 cm^3 of 0.01 mol dm^{-3} nitric acid (HNO_3) is diluted with 90 cm^3 of water. What is the pH of the resulting solution?

A. 1

B. 2

C. 3

D. 4

28. A base of concentration 0.10 mol dm^{-3} is titrated with 25 cm^3 of an acid of concentration 0.10 mol dm^{-3}. Which base-acid pair would have the highest pH at the equivalence point?

A. NaOH(aq) and CH_3COOH(aq)

B. NaOH(aq) and HNO_3(aq)

C. NH_3(aq) and HNO_3(aq)

D. NH_3(aq) and CH_3COOH(aq)

29. What is the value of $[H^+]$ in a buffer solution in which $[CH_3COOH]$ = 2.0 mol dm^{-3} and $[CH_3COO^-]$ 1.0 mol dm^{-3}? For CH_3COOH, $K_a = 1.8\times10^{-5}$ mol dm^{-3}.

A. 6.0×10^{-3}

B. 3.6×10^{-5}

C. 1.8×10^{-5}

D. 9.1×10^{-6}

30. Which salt forms the most acidic solution when added to water?

A. NaCl

B. $MgSO_4$

C. $Al(NO_3)_3$

D. $KHCO_3$

31. An acid-base indicator has a pK_a value of 4.0. At what pH will this indicator change colour?

A. 2.0

B. 4.0

C. 8.0

D. 12.0

32. Which values are correct for a 0.010 mol dm^{-3} solution of NaOH(aq) at 298 K? ($K_w = 1.0\times10^{-14}$ mol^2 dm^{-6} at 298 K)

A. $[H^+] = 1.0\times10^{-12}$ mol dm^{-3} and pH = 12.00

B. $[OH^-] = 1.0\times10^{-12}$ mol dm^{-3} and pH = 12.00

C. $[H^+] = 1.0\times10^{-12}$ mol dm^{-3} and pOH = 12.00

D. $[OH^-] = 1.0\times10^{-12}$ mol dm^{-3} and pOH = 12.00

33. At 25°C, K_a for an acid is 1.0×10^{-2}. What is the value of K_b for its conjugate base?

A. 1.0×10^{2}

B. 1.0×10^{-2}

C. 1.0×10^{12}

D. 1.0×10^{-12}

34. Which statement about indicators is **always** correct?

A. The mid-point of the pH range of an indicator is 7.

B. The pH range is greater for indicators with higher pK_a values.

C. The colour red indicates an acidic solution.

D. The pK_a value of the indicator is within its pH range.

35. (a) (i) Calculate the K_a value of methanoic acid, HCOOH, using table 21 in the Data Booklet.

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(1)

(ii) Based on its K_a value, state and explain whether methanoic acid is a strong or weak acid.

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(2)

(iii) Calculate the hydrogen ion concentration and the pH of a 0.010 mol dm^{-3} methanoic acid solution. State **one** assumption made in arriving at your answer.

(4)

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(b) Explain how you would prepare a buffer solution of pH 3.75 starting with methanoic acid.

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(3)
(Total 10 marks)

36. The indicator bromophenol blue, HIn(aq), has a form that is yellow and an In^-(aq) form that is blue.

(a) Write an equation to show how bromophenol blue acts as an indicator.

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(1)

(b) State and explain the colour of bromophenol blue

(i) on the addition of a strong acid.

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(ii) at the equivalence point of a titration.

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(3)
(Total 4 marks)

37. (a) The dissociation of water takes place as follows:

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

(i) State the expression for the ionic product constant of water, K_w.

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(1)

(ii) The value of K_w is 2.4×10^{-14} mol^2 dm^{-6} at 310 K. Calculate the $[H^+]$ at 310 K.

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(1)

(b) Lactic acid $CH_3CH(OH)COOH$ is a weak monoprotic acid ($pK_a = 3.85$ and $K_a = 1.4\times10^{-4}$ mol dm^{-3}).

(i) Write an equation for the reaction of lactic acid with water.

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(1)

(ii) State the ionization constant expression, K_a, for lactic acid.

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(1)

(iii) Calculate the pH of a 0.20 mol dm^{-3} solution of lactic acid.

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(2)

(iv) Determine the pH of a solution containing 0.10 mol dm^{-3} of lactic acid and 0.10 mol dm^{-3} of sodium lactate.

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(1)
(Total 7 marks)

38. (a) (i) Write the equation for the reaction of ammonia with water.

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(1)

(ii) Derive the expression for K_b for this reaction.

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(1)

(b) Using information from Table 16 in the Data Booklet, determine the pOH of a 0.20 mol dm^{-3} solution of ammonia.

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(3)
(Total 5 marks)

39. Benzoic acid, C_6H_5COOH, is a weak acid.

(a) Deduce the equation for the ionization of benzoic acid in water.

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(1)

(b) Use information from Table 16 in the Data Booklet to calculate a value for the dissociation constant, K_a, for benzoic acid.

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(1)

(c) Derive the ionization constant expression for benzoic acid and use it to determine the pH of a 0.20 mol dm^{-3} aqueous solution of benzoic acid.

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(3)
(Total 5 marks)

40. The hydrogen ion concentration in pure water varies with temperature. At a particular temperature $[H^+] = 1.7 \times 10^{-7}$ mol dm^{-3}.

(a) State the expression for the ionic product constant of water, K_w, and calculate the value of K_w at this temperature.

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(2)

(b) Calculate the pH of water at this temperature.

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(1)

(c) State and explain whether water at this temperature is acidic, neutral or alkaline.

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(2)
(Total 5 marks)

41. Predict whether each of the following solutions would be acidic, alkaline or neutral. In each case explain your reasoning.

(i) 0.1 mol dm^{-3} $FeCl_3(aq)$

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(ii) 0.1 mol dm^{-3} $NaNO_3(aq)$

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(iii) 0.1 mol dm^{-3} $Na_2CO_3(aq)$

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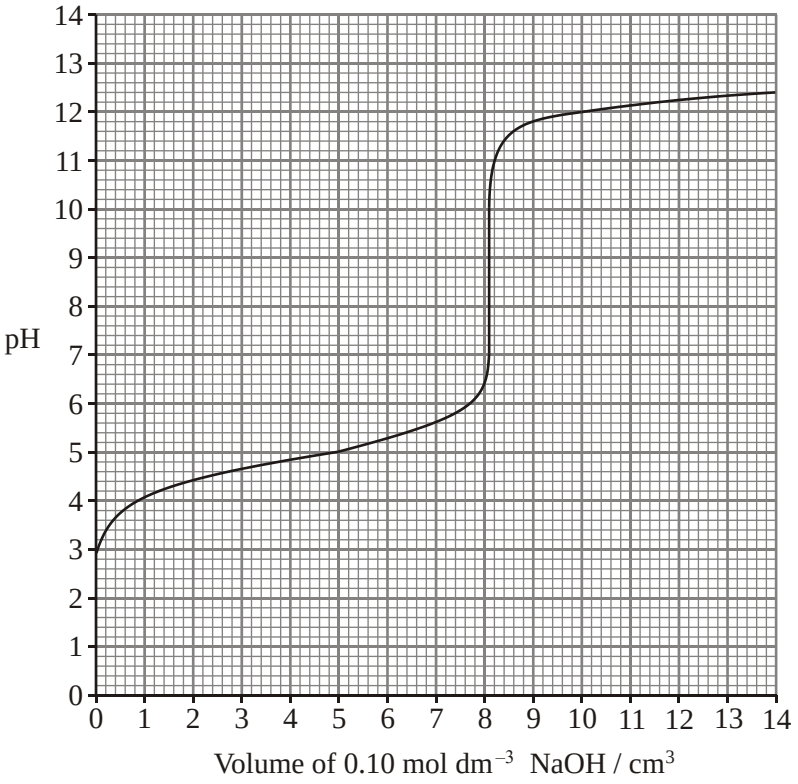
(Total 6 marks)

42. The following graph shows how the pH changes during the titration of 10 cm^3 of a solution of a weak acid (HA) with 0.10 mol dm^{-3} NaOH.



(i) State the pH at the equivalence point and explain why the pH changes rapidly in this region.

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(2)

(ii) Calculate the initial concentration of the acid (HA).

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(3)

(iii) Calculate the $[H^+]$ of the acid before any sodium hydroxide is added. Use this value to determine the K_a value and the pK_a value of the acid.

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(5)
(Total 10 marks)

43. A buffer solution can be made by dissolving 0.25 g of sodium ethanoate in 200 cm^3 of 0.10 mol dm^{-3} ethanoic acid. Assume that the change in volume is negligible.

(i) Define the term *buffer solution.*

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(2)

(ii) Calculate the concentration of the sodium ethanoate in mol dm^{-3}.

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(3)

(iii) Calculate the pH of the resulting buffer solution by using information from Table 16 of the Data Booklet.

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(3)
(Total 8 marks)

44. An experiment was carried out to determine the concentration of an aqueous solution of ammonia by titrating it with a solution of sulfuric acid of concentration 0.150 mol dm^{-3}. It was found that 25.0 cm^3 of the ammonia solution required 20.1 cm^3 of the sulfuric acid solution for neutralization.

(a) Write the equation for the reaction and calculate the concentration, in mol dm^{-3}, of the ammonia solution.

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(4)

(b) Several acid-base indicators are listed in Table 17 of the Data Booklet. State and explain which one of the following indicators should be used for this experiment: bromocresol green, phenol red or phenolphthalein.

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(3)

(c) Determine the pOH of a solution with an ammonia concentration of 0.121 mol dm^{-3}. (pK_b of ammonia is 4.75.)

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(4)

(Total 11 marks)

45. (i) State what is meant by the term *buffer solution*, and describe the composition of an acid buffer solution in general terms.

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(3)

(ii) Calculate the pH of a mixture of 50 cm^3 of ammonia solution of concentration 0.10 mol dm^{-3} and 50 cm^3 of hydrochloric acid solution of concentration 0.050 mol dm^{-3}.

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(4)

(Total 7 marks)

46. The pH of a solution is 4.8. Using information from Table 17 of the Data Booklet, deduce and explain the colours of the indicators bromophenol blue and phenol red in this solution.

(Total 3 marks)

47. Calculate the pH of a buffer solution containing 0.0500 mol dm^{-3} of ethanoic acid ($K_a = 1.74\times10^{-5}$) and 0.100 mol^{-3} of sodium ethanoate.

(Total 3 marks)

48. Describe the composition and behaviour of a buffer solution.

(Total 3 marks)

49. (i) Define the term pH.

(1)

(ii) A 25.0 cm^3 sample of 0.100 mol dm^{-3} hydrochloric acid was placed in a conical flask, and 0.100 mol dm^{-3} sodium hydroxide is added until a total of 50.0 cm^3 had been added. Sketch a graph of pH against volume of NaOH(aq) added, clearly showing the volume of NaOH(aq) needed for complete reaction and the pH values at the start, the equivalence point and finish.

(4)

(iii) The experiment in (ii) was repeated, but with a 25.0 cm^3 sample of 0.100 mol dm^{-3} ethanoic acid in the conical flask instead of the hydrochloric acid. Use information from Table 16 of the Data Booklet to calculate the pH at the start of the experiment. State the approximate pH value at the equivalence point.

(5)
(Total 10 marks)

50. (i) Describe how an indicator, HIn, works.

(3)

(ii) Name a suitable indicator for the reaction between ethanoic acid and sodium hydroxide. Use information from Table 17 in the Data Booklet to explain your choice.

(2)
(Total 5 marks)

51. (i) Identify **two** substances that can be added to water to form a basic buffer solution.

(1)

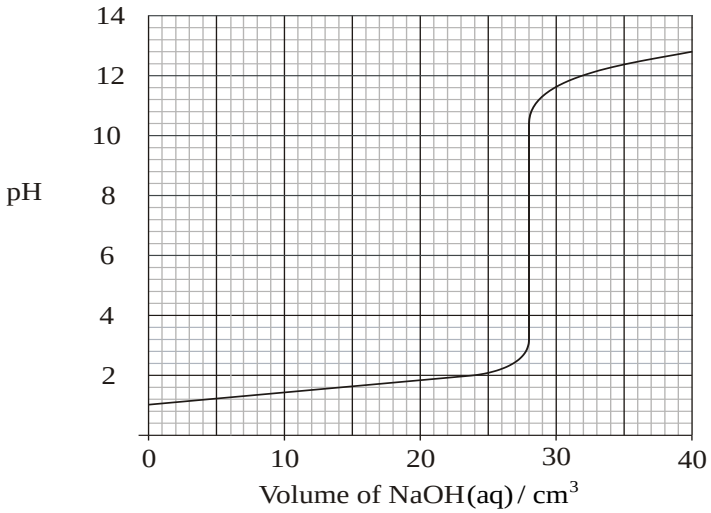
(ii) Describe what happens when a small amount of acid solution is added to the buffer solution prepared in (i). Use an equation to support your explanation.

(2)
(Total 3 marks)

52. Predict and explain whether an aqueous solution of 0.10 mol dm^{-3} $AlCl_3$ will be acidic, alkaline or neutral.

(Total 2 marks)

53. A titration was carried out to determine the concentration of 25.0 cm^3 of an aqueous solution of nitric acid. The pH value of the liquid in the flask was measured as 0.100 mol dm^{-3}, aqueous sodium hydroxide was added. The results are shown on the graph below.



(i) Use the graph to determine the value of $[H^+]$ of the nitric acid solution.

(1)

(ii) Determine the pH value when the value of $[H^+]$ has decreased to 1×10^{-3} mol dm^{-3}.

(1)

(iii) Use the graph to determine the volume of 0.100 mol dm^{-3} aqueous sodium hydroxide solution needed to exactly neutralize the nitric acid.

(1)

(iv) Calculate the concentration, in mol dm^{-3}, of the nitric acid.

(2)
(Total 5 marks)

54. In aqueous solution at 298 K, ammonia is a weak base with a pK_b value of 4.75 and a K_b value of 1.7×10^{-5} mol dm^{-3}.

(a) Write an equation for the reaction of ammonia with water.

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(1)

(b) State the ionization constant expression, K_b, for ammonia.

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(1)

(c) Calculate the pH of a 0.25 mol dm^{-3} solution of ammonia.

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(3)
(Total 5 marks)

55. Nitric acid and ammonia may be used to make a buffer solution.

(i) Describe the behaviour of a buffer solution.

(2)

(ii) Describe how you could prepare a buffer solution using 0.100 mol dm^{-3} solutions of nitric acid and ammonia.

(3)
(Total 5 marks)

56. With reference to Table 16 in the Data Booklet, determine the pH of a 0.100 mol dm^{-3} solution

of propanoic acid.

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(Total 3 marks)

57. 0.100 mol dm^{-3} hydrochloric acid solution is added to 25.0 cm^3 0.100 mol dm^{-3} ammonia solution and the pH is recorded until a total of 35.0 cm^3 hydrochloric acid has been added.

(i) Sketch a graph to show how the pH changes as hydrochloric acid is added to the ammonia solution. Use a pH scale of 0–14, and an acid volume scale of 0–35 cm^3. Explain the shape of the curve.

(6)

(ii) Use table 17 of the Data Booklet to suggest an indicator that could be used in the titration, explaining your choice.

(2)

(Total 8 marks)

58. (i) State the composition of an acidic buffer solution.

(1)

(ii) Suggest the identity of an acid and its amount that could be added to a solution containing 0.10 mol ammonia in order to prepare a buffer.

(2)

(iii) Explain how the solution you prepare in (ii) can act as a buffer solution when a strong acid and a strong base are added to separate portions of it. Write an equation to illustrate the buffer action in **each** case.

(4)

(iv) Write an equation for the reaction of ammonia with water, and write its K_b expression.

(2)

(Total 9 marks)

59. (a) Predict and explain, using equations where appropriate, whether the following solutions are acidic, alkaline or neutral.

(i) 0.1 mol dm^{-3} $FeCl_3(aq)$

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(1)

(ii) 0.1 mol dm^{-3} $NaNO_3(aq)$

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(1)

(iii) 0.1 mol dm^{-3} $Na_2CO_3(aq)$

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(1)

(b) Acidic gases can be released into the atmosphere that have an environmental impact when they are deposited as acid rain. State **two** elements that form the acidic gases and describe **two** impacts they have on the natural environment.

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(3)

(Total 6 marks)

60. An experiment was carried out to determine the concentration of aqueous ammonia by titrating it with a 0.150 mol dm^{-3} sulfuric acid solution. It was found that 25.0 cm^3 of the aqueous ammonia required 20.1 cm^3 of the sulfuric acid solution for neutralization.

(a) Write the equation for the reaction and calculate the concentration, in mol dm^{-3}, of the aqueous ammonia.

(4)

(b) Several acid-base indicators are listed in Table 16 of the Data Booklet. Identify **one** indicator that could be used for this experiment. Explain your answer.

(3)

(c) (i) Determine the pOH of 0.121 mol dm^{-3} aqueous ammonia (pK_b = 4.75).

(4)

(ii) State what is meant by the term *buffer solution*, and describe the composition of an acid buffer solution in general terms.

(3)

(iii) Calculate the pH of a mixture of 50.0 cm^3 of 0.100 mol dm^{-3} aqueous ammonia and 50.0 cm^3 of 0.0500 mol dm^{-3} hydrochloric acid solution.

(4)

(Total 18 marks)