Practice Questions on Topic 18

Questions 1 to 18 must be answered without the aid of a calculator. The calculation questions involve the type of mental arithmetic that you must be able to perform on Paper 1.

1. A 0.10 mol dm^{-3} solution of a weak base has a pH of 11. What is the concentration of hydroxide ions, OH^-, in mol dm^{-3}?

   A 11
   B 0.10
   C 10^{-3}
   D 10^{-11}

2. Which species is the strongest acid in the following reaction?

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

   A NH_3
   B H_2O
   C NH_4^+
   D OH^-

3. The value for the acid dissociation constant, K_a, for the strong acid $HClO_4$ is estimated to be 10^7 mol dm^{-3}. What is the value of pK_b for the ClO_4^- ion and what is the strength of the ClO_4^- ion as a base?

	pK_b	strength as base
A	7	strong
B	7	weak
C	10^{-7}	weak
D	21	weak

4. The concentration of H^+ (aq) ions in a solution is 6 x 10^{-5} mol dm^{-3}. What is the approximate pH of the solution?

   A 6
   B 5.2
   C 5
   D 4.2

5. Which of the following indicators would **not** be suitable for the titration of a strong acid with a weak base?

   A phenolphthalein, $pK_a = 9.3$
   B methyl red, $pK_a = 5.1$
   C bromophenol blue, $pK_a = 4.0$
   D methyl orange, $pK_a = 3.7$

6. What is the pH value of a 0.01 mol dm^{-3} solution of the strong NaOH?

   A 2
   B 12
   C 13
   D 14

7. A weak acid buffer is made by mixing 100 cm^3 of a 0.10 mol dm^{-3} solution of a weak acid HA with 10 cm^3 of a 0.10 mol dm^{-3} solution of its sodium salt NaA. What is the pH of the buffer solution? (K_a for HA = 10^{-5} mol dm^{-3})

   A 3
   B 4
   C 5
   D 6

8. Which of the following combinations form a buffer solution when mixed together?

   I 20 cm^3 of 0.10 mol dm^{-3} CH_3COOH (aq) + 10 cm^3 of 0.10 mol dm^{-3} NaOH (aq)
   II 10 cm^3 of 0.10 mol dm^{-3} CH_3COOH (aq) + 10 cm^3 of 0.10 mol dm^{-3} NaOH (aq)
   III 10 cm^3 of 0.10 mol dm^{-3} CH_3COOH (aq) + 20 cm^3 of 0.10 mol dm^{-3} NaOH (aq)

   A **I** only
   B **I** and **II**
   C **II** and **III**
   D **I**, **II** and **III**

9. Which salt produces an alkaline solution when dissolved in water?

   A NaCl
   B $(NH_4)_2SO_4$
   C $MgCl_2$
   D CH_3COOK

10. 10 cm^3 of an alkaline solution with a pH of 12 was mixed with 90 cm^3 of pure water. What is the pH of the resulting mixture?

    A 1.2
    B 11
    C 12
    D 13

11. What is the pH of a 0.01 mol dm^{-3} solution of a weak acid HA? (K_a for HA = 10^{-4} mol dm^{-3})

    A 3
    B 4
    C 5
    D 6

12. What are the concentrations in mol dm^{-3} of H_3O^+ (aq) and OH^- (aq) ions in an acidic solution of pH 2?

	$[H_3O^+ (aq)]$	$[OH^- (aq)]$
A	10^{-2}	10^{-12}
B	10^{-2}	10^{-2}
C	10^{-2}	10^{-7}
D	2	12

13. In a titration exercise, a sodium hydroxide solution of unknown concentration is added dropwise from a burette to a flask containing 25.0 cm^3 of a 0.1 mol dm^{-3} solution of a strong acid. The titration is then repeated with the same sodium hydroxide solution in the burette but this time with 25.0 cm^3 of a 0.1 mol dm^{-3} solution of a weak acid in the flask. Which of the following is the same in the two titrations?

    I The volume of NaOH needed to reach the equivalence point.
    II The pH at the start of the titration.
    III The pH at the equivalence point

    A **I** only
    B **I** and **II**
    C **II** and **III**
    D **I**, **II** and **III**

14. A 0.10 mol dm^{-3} solution of the weak acid HA has a pH of 5. What is the value of the acid dissociation constant, K_a, for HA in mol dm^{-3}?

    A 10^{-6}
    B 10^{-9}
    C 10^{-10}
    D 10^{-11}

15. What is the pH of a 5 x 10^{-3} mol dm^{-3} solution of the strong base barium hydroxide, $Ba(OH)_2$?

    A 2
    B 3
    C 11
    D 12

16. What is the pH of the 0.10 mol dm^{-3} solution of a weak base B? (K_b = 10^{-7} mol dm^{-3})

    A 8
    B 10
    C 11
    D 14

17. The pH of pure water at 25 ^oC is 7.00 and at 100 ^oC it is 6.14. Which of the following statements is correct?

    I Water is more dissociated into ions at 100 ^oC than at room temperature.
    II The concentration of H^+ (aq) ions in water is greater than the concentration of OH^- (aq) ions at 100 ^oC.
    III Water is more acidic at 100 ^oC than at room temperature.

    A **I** only
    B **I** and **II**
    C **II** and **III**
    D **I**, **II** and **III**

18. Which of the following is the strongest acid?

    A Acid A with K_a = 2 x 10^{-3} mol dm^{-3}
    B Acid B with K_a = 5 x 10^{-5} mol dm^{-3}
    C Acid C with pK_a = 3
    D Acid D with pK_a = 6

19. (a) When ethanoic acid is dissolved in water, the following equilibrium is established:

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

(i) Ethanoic acid is described as being a "weak acid". By referring to this equation, explain what is meant by the term weak acid. *(1)*

(ii) State the conjugate base of CH_3COOH. *(1)*

(iii) State the strongest acid of the four species written in the equation. *(1)*

(b) The value of the acid dissociation constant, K_a, for ethanoic acid is 1.74×10^{-5} mol dm^{-3} at 25 °C and for methanoic acid, HCOOH, it is 1.60×10^{-4} mol dm^{-3} at the same temperature.

(i) Determine which of the two acids is more ionised in aqueous solution. *(1)*

(ii) Write an expression for K_a for ethanoic acid. *(1)*

(iii) Calculate the pH of a 0.100 mol dm^{-3} solution of ethanoic acid at 25 °C. State any approximations you make in your calculation. *(4)*

(iv) Predict how the pH of a solution of ethanoic acid varies with increasing temperature. Explain your reasoning. *(3)*

20. (a) Define:

(i) pH

(ii) K_w *(2)*

(b) Calculate the pH of a 0.10 mol dm^{-3} solution of sodium hydroxide at 25 °C (the value of K_w at this temperature is 10^{-14} mol^2 dm^{-6}). *(2)*

(c) (i) Define what is meant by the term "buffer solution". *(2)*

(ii) A buffer solution can be prepared by mixing 150 cm^3 of 0.10 mol dm^{-3} sodium propanoate solution and 100 cm^3 of a 0.20 mol dm^{-3} solution of propanoic acid, CH_3CH_2COOH. Calculate the pH of this buffer solution at 25 °C (the value of K_a for propanoic acid = 1.60×10^{-4} mol dm^{-3} at this temperature). *(4)*

(iii) Explain what happens when a few drops of hydrochloric acid are added to this buffer solution. Write an equation to illustrate your answer. *(2)*

21. Phenol red is used as an acid-base indicator. It can be represented by the formula HIn. Phenol red is a weak acid. It is partially ionised in aqueous solution with a pK_{In} value of 7.9. The unionised molecule HIn and the ion In^- have different colours:

$$HIn\ (aq) + H_2O\ (l) \rightleftharpoons In^-\ (aq) + H_3O^+\ (aq)$$

yellow red

(a) Define pK_{In}. *(1)*

(b) Predict the colour of phenol red when a few drops of the indicator are added separately to solutions of:

(i) pH 3

(ii) pH 7.9

Use the equilibrium reaction to explain your answer in each case. *(4)*

(c) Calculate the pH of a 1.00 mol dm^{-3} solution of hydrochloric acid, HCl, at 298 K. *(1)*

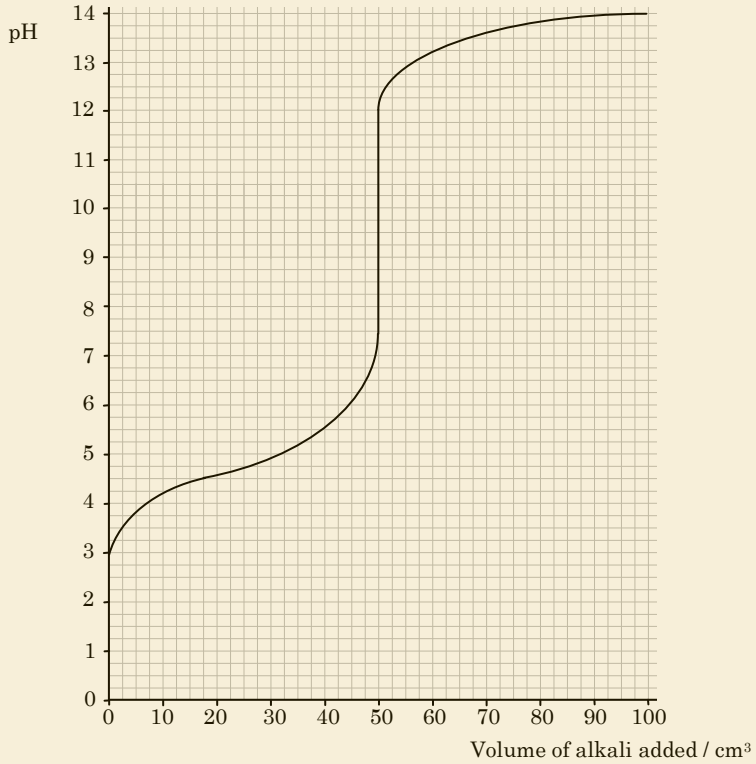
(d) The following graph shows how the pH varies when sodium hydroxide solution, NaOH, is added from a burette to 25.0 cm^3 of a 1.00 mol dm^{-3} solution of ethanoic acid, CH_3COOH.

(i) Write a balanced chemical equation for the reaction between sodium hydroxide and ethanoic acid. *(1)*

(ii) Estimate the concentration of the sodium hydroxide solution. *(1)*

(iii) The pH of the reaction mixture rises when the first few drops of sodium hydroxide solution are added from the burette. However, between approximately 10 and 40 cm^3 of added sodium hydroxide the pH does not change as quickly. Explain why the pH of the reaction mixture does not change significantly during this period. *(2)*

(iv) Use the graph to estimate the value of the acid dissociation constant, K_a, for ethanoic acid. Show how you arrived at your answer. *(3)*



(e) Using the data in the table below, select a suitable indicator to determine the endpoint for the titration between the 1.00 mol dm^{-3} solution of ethanoic acid and the sodium hydroxide solution. Outline the reason for your choice. *(2)*

Indicator	pH range
Methyl orange	3.1 – 4.4
Phenol red	6.8 – 8.4
Phenolphthalein	8.3 – 10.0

(f) On the graph, sketch the pH curve for the titration using the same sodium hydroxide solution but now with 25.0 cm^3 a 1.0 mol dm^{-3} hydrochloric acid in place of the ethanoic acid solution. Label this line **X**. *(3)*