Acid, Base & Salts Past Papers

1. The Brønsted-Lowry definition of a base is a substance which acts as a

   A proton donor to form a conjugate acid
   B proton donor to form a conjugate base
   C proton acceptor to form a conjugate acid
   D proton acceptor to form a conjugate base.

2. Under certain conditions liquid ammonia ionises as shown:

   $$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$$

   Which line in the table shows the correct conjugate acid and conjugate base for this ionisation?

	Conjugate acid	Conjugate base
A	NH_3	NH_4^+
B	NH_4^+	NH_3
C	NH_2^-	NH_4^+
D	NH_4^+	NH_2^-

3. $HCN(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$

   In the above equation HCN(aq) is acting as

   A an acid
   B a conjugate acid
   C a base
   D a conjugate base.

4. $H_2CO_3(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + HCO_3^-(aq)$

   Which line in the table correctly describes $H_2CO_3(aq)$ and HCN(aq) in the above reaction?

	$H_2CO_3(aq)$	HCN(aq)
A	base	conjugate base
B	base	conjugate acid
C	acid	conjugate base
D	acid	conjugate acid

5. Which of the following salts forms an alkaline solution in water?

   A Sodium sulfate
   B Lithium chloride
   C Ammonium nitrate
   D Potassium propanoate

6. Which of the following salts will form a solution with the lowest pH?

   A Potassium chloride
   B Potassium ethanoate
   C Ammonium chloride
   D Ammonium ethanoate

7. Which salt solution would have the lowest pH?

   A NaCl
   B Na_2CO_3
   C Na_2SO_3
   D CH_3COONa

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8. Excess calcium carbonate was added to 100 cm^3 of 1 mol l^{-1} hydrochloric acid.

The experiment was repeated using the same mass of calcium carbonate and 100 cm^3 of 1 mol l^{-1} methanoic acid.

Which of the following was the same for both experiments?

A The mass of unreacted calcium carbonate at the end of the reaction.
B The time taken for the reaction to be completed.
C The pH of the mixture at the end of the reaction.
D The initial rate of the reaction.

9. An acid is a substance which

A donates a proton leaving a conjugate acid
B donates a proton leaving a conjugate base
C accepts a proton leaving a conjugate acid
D accepts a proton leaving a conjugate base.

10. Zinc oxide reacts as shown.

$$ZnO(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(\ell)$$
$$ZnO(s) + 2NaOH(aq) + H_2O(\ell) \rightarrow Na_2Zn(OH)_4(aq)$$

This shows that zinc oxide is

A basic
B acidic
C neutral
D amphoteric.

11. Which of the following, when dissolved in distilled water, gives rise to a solution with a pH value greater than 7?

A Lithium chloride
B Potassium ethanoate
C Sodium sulphate
D Ammonium nitrate

12. Which of the following 0·01 mol l^{-1} aqueous solutions has the highest pH value?

A Sodium fluoride
B Sodium benzoate
C Sodium propanoate
D Sodium methanoate

13 Which of the following is most acidic?

A Methanoic acid
B Methanol
C Phenol
D Propanoic acid

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14

Substance	K_a
X	$1{\cdot}85 \times 10^{-11}$
Y	$1{\cdot}57 \times 10^{-10}$
Z	$1{\cdot}61 \times 10^{-5}$

Based on information in the table,

A X is less basic than Y
B X is more acidic than Z
C Y is more basic than Z
D Y is less acidic than X.

15 Which of the following decreases when an aqueous solution of ethanoic acid is diluted?

A pH
B pKa
C $[H^+]$
D The degree of dissociation

16 Which of the following is true for a neutral solution at 325 K?

A pH = 7.00
B $K_w = 1.01 \times 10^{-14}$
C $[H_3O^+] = [OH^-]$
D $[H_3O^+] = 1.00 \times 10^{-7}$

17 The pH of a solution of benzoic acid with concentration 0·01 mol l^{-1} is

A 1·1
B 2·0
C 3·1
D 5·2.

18 What is the concentration of hydroxide ions, in mol l^{-1}, in a solution with a pH of 8·5?

A $8{\cdot}5 \times 10^{-6}$
B $3{\cdot}2 \times 10^{-6}$
C $8{\cdot}5 \times 10^{-9}$
D $3{\cdot}2 \times 10^{-9}$

19 The pH of 0·002 mol l^{-1} calcium hydroxide solution is

A 2·4
B 2·7
C 11·3
D 11·6.

20 **What is the concentration of hydroxide ions, in mol l^{-1}, in an aqueous solution of pH 14?**

A 10^{-14}
B 10^{0}
C 10^{1}
D 10^{14}

21 Which of the following statements is **not** always true for aqueous solutions at 298 K?

A $Kw = 10^{-14}$
B $pH = -\log_{10}[H^+]$
C $[H^+]\,[OH^-] = 10^{-14}$
D $[H^+] = [OH^-] = 10^{-7}$ mol l^{-1}

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22 The ionic product of water, K_w, is 5.48×10^{-14} at 50 °C.

The pH of water at 50 °C is

A 5.48

B 6.63

C 7.00

D 13.3

23 Solution **X** has a pH of 4·38. When it is diluted tenfold the pH changes to 4·88.

X is likely to be

A a partly soluble acid

B a buffered acid

C a strong acid

D a weak acid.

24 5·0 cm^3 of a solution of hydrochloric acid was diluted to exactly 250 cm^3 with water. The pH of this diluted solution was 2·00.

The concentration of the original undiluted solution, in mol l^{-1}, was

A $2{\cdot}0 \times 10^{-2}$

B $4{\cdot}0 \times 10^{-2}$

C $4{\cdot}0 \times 10^{-1}$

D $5{\cdot}0 \times 10^{-1}$.

25 500 cm^3 of 0·022 mol l^{-1} hydrochloric acid is added to 500 cm^3 of 0·020 mol l^{-1} sodium hydroxide solution. The pH of the resulting solution will be

A 2

B 3

C 4

D 5.

26 The equilibrium constant for the dissociation of a base is given by K_b.

20 cm^3 of 0·1 mol l^{-1} solutions of each of the bases in the table below were neutralised by 20 cm^3 of 0·1 mol l^{-1} hydrochloric acid and the pH of the resulting salt solutions measured.

Which base would have given the salt solution with the highest pH?

	Base	K_b
A	Ammonia	$1{\cdot}8 \times 10^{-5}$
B	Methylamine	$4{\cdot}5 \times 10^{-4}$
C	Phenylamine	$4{\cdot}3 \times 10^{-10}$
D	Phenylmethylamine	$2{\cdot}4 \times 10^{-5}$

Acid, Base & Salts Past Papers

1. . Phenols are weak acids.

The table shows the pK_a values of different phenols at 298 K.

Name of phenol	pK_a
phenol	9.99
3-hydroxyphenol	9.15
3,5-dihydroxyphenol	8.45
2-methylphenol	10.29
4-methylphenol	10.26
2-ethylphenol	10.20
4-ethylphenol	10.00

Calculate the concentration of hydronium ions, H_3O^+, in mol l^{-1}, in a 0.150 mol l^{-1} aqueous solution of 2-methylphenol. **3**

2 . In an aqueous solution of hexaaquairon(II) ions, $[Fe(OH_2)_6]^{2+}$, the following equilibrium exists.

$$[Fe(OH_2)_6]^{2+} + H_2O \rightleftharpoons [FeOH(OH_2)_5]^{+} + H_3O^+$$

This equation shows that water is amphoteric.

Explain, with reference to the equation, why water can be described as amphoteric. **1**

3 . A sample of milk was found to have a lactic acid concentration of 1.12×10^{-5} mol l^{-1}.

Calculate the pH of a solution of lactic acid ($K_a = 1.38 \times 10^{-4}$) with a concentration of 1.12×10^{-5} mol l^{-1}. **2**

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4. Carbonic acid, $H_2CO_3(aq)$, dissociates as shown.

$$H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq) \qquad pK_a = 6.35$$

(i) Explain how the strength of carbonic acid compares with that of ethanoic acid.

(ii) State the role of H_2O in the above equilibrium. **1**

5. The impure precipitate of benzoic acid is produced by acidifying the alkaline sodium benzoate solution.

Explain fully why an aqueous solution of sodium benzoate is alkaline. **2**

6. The average pH of pre-industrial ocean surface water is recorded to be 8.2. The increased CO_2 dissolved in the oceans has already reduced the pH of surface water and by the year 2100 the pH is predicted to be 7.9.

(i) Calculate the concentration, in mol l^{-1}, of hydronium ions, H_3O^+, in surface water with a pH of 8.2. **1**

(ii) Calculate the percentage increase in hydronium ion concentration between water with a pH of 8.2 and water with a pH of 7.9. **2**

Acid, Base & Salts Past Papers

7 Hydrofluoric acid, HF, is a weak acid.

$$HF(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + F^-(aq)$$

(a) State what is meant by a weak acid. **1**

(b) 3.75 mol l^{-1} hydrofluoric acid solution can be used to engrave glass.

(i) Calculate the pH of this hydrofluoric acid solution. **2**

(ii) The concentration of commercially available hydrofluoric acid solution is expressed in terms of percentage by mass.

Calculate the percentage by mass of a 3.75 mol l^{-1} hydrofluoric acid solution. **2**

8. There are different definitions for acids and bases.

(a) One definition for acids and bases was proposed by Johannes Brønsted and Thomas Lowry.

(i) State the Brønsted-Lowry definition for a base. **1**

(ii) A solution of hydrogen peroxide consists of two acid-conjugate base pairs.

$$H_2O_2(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HO_2^-(aq)$$

Complete the table to identify one of the acid-conjugate base pairs. **1**

Acid	
Conjugate base	

(b) Another definition for acids and bases was proposed by Gilbert Lewis. A Lewis acid is a substance that can accept a pair of non-bonding electrons. A Lewis base is a substance that can donate a pair of non-bonding electrons.

An example of a Lewis acid-base reaction is shown.

$$B(OH)_3(aq) + 2H_2O(\ell) \rightleftharpoons [B(OH)_4]^-(aq) + H_3O^+(aq)$$

Explain why this is a Lewis acid-base reaction. **1**

8 (c) Acids can be classified as strong or weak. The table contains information about four acids.

Name of acid	Formula	K_a at 298 K
ethanoic	CH_3COOH	$1{\cdot}7 \times 10^{-5}$
chloroethanoic	$CH_2ClCOOH$	$1{\cdot}6 \times 10^{-3}$
dichloroethanoic	$CHCl_2COOH$	$5{\cdot}0 \times 10^{-2}$
trichloroethanoic	CCl_3COOH	$2{\cdot}3 \times 10^{-1}$

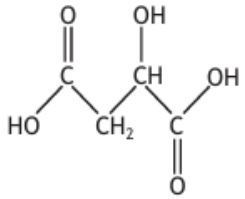
(i) Describe the relationship between the number of chlorine atoms in an acid molecule and the strength of the acid. **1**

(ii) 1·89 g of chloroethanoic acid was dissolved in deionised water and the solution was made up to 250 cm^3 in a volumetric flask.

(A) Calculate the concentration, in mol l^{-1}, of the chloroethanoic acid solution. **1**

(B) Using your answer to (A) calculate the pH of the chloroethanoic acid solution. **2**

9. . Apple jam contains malic acid.



malic acid

(a) Malic acid dissociates in two stages. The equation for the first stage dissociation of malic acid is

$HOOCCH_2CH(OH)COOH(aq) + H_2O(\ell) \rightleftharpoons HOOCCH_2CH(OH)COO^-(aq) + H_3O^+(aq)$

(i) Write an expression for the first stage dissociation constant, K_a, for malic acid. **1**

(ii) Complete the equation to show the second stage dissociation of malic acid. **1**

$HOOCCH_2CH(OH)COO^-(aq) + H_2O(\ell) \rightleftharpoons$

(b) While making apple jam, the jam will only thicken if the pH is between 2·7 and 3·3.

(i) The pH of the apple jam is determined by the first stage dissociation of malic acid ($K_a = 3{\cdot}2 \times 10^{-4}$).

The concentration of malic acid in the jam is 0·0051 mol l^{-1}.

Show by calculation that the jam will thicken at this concentration of malic acid. **3**

10 Zinc ethanoate can also be used to treat Wilson's disease.

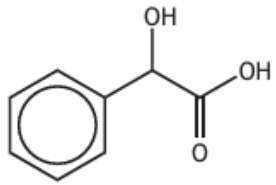
(i) Zinc ethanoate can be prepared from zinc hydroxide and ethanoic acid.

Name this type of reaction. **1**

(ii) Zinc ethanoate is a salt of a weak acid.

State what is meant by a weak acid. **1**

11. Mandelic acid, 2-hydroxy-2-phenylethanoic acid, is a component of skin care products.



mandelic acid

(a) Mandelic acid is a weak acid.

$C_6H_5CH(OH)COOH(aq) + H_2O(\ell) \rightleftharpoons C_6H_5CH(OH)COO^-(aq) + H_3O^+(aq)$

Write the expression for the dissociation constant, K_a, for mandelic acid. **1**

(b) A 100 cm^3 sample of skin care product contained 10·0 g of mandelic acid. The K_a of mandelic acid is $1{\cdot}78 \times 10^{-4}$.

(i) Calculate the concentration of the mandelic acid, in mol l^{-1}, present in the skin care product. **2**

(ii) Using your answer to (b)(i), calculate the pH of a solution of mandelic acid of this concentration. **3**

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12 Explain fully why a solution of the salt sodium 4-hydroxybenzoate has a pH greater than 7. **2**

13 When ethanoic acid is added to water the following equilibrium is established.

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$$

Identify the conjugate base of CH_3COOH. **1**

14. Balsamic vinegar is a dark brown liquid containing ethanoic acid. The pH of a sample of balsamic vinegar was 2·5.

a). Write the formula for the conjugate base of ethanoic acid. **1**

b) Calculate the concentration of ethanoic acid in the sample of balsamic vinegar. **2**

15 Hypochlorous acid is a weak acid which dissociates in water as shown.

$$HClO(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$$

(*a*) What is the conjugate base of hypochlorous acid?

(*b*) Write the expression for the dissociation constant, K_a, of hypochlorous acid.

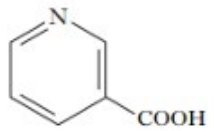
(*c*) Given that the K_a for hypochlorous acid is $3{\cdot}98 \times 10^{-8}$ and that the solution has a pH of 5·4, calculate the following ratio.

$$\frac{[ClO^-(aq)]}{[HClO(aq)]}$$

2

(4)

16 Nicotinic acid is used in the treatment of high cholesterol levels. A structural formula for nicotinic acid is



(*a*) Write an equation to show the dissociation of nicotinic acid in water. **1**

(*b*) The K_a value of nicotinic acid is $1{\cdot}4 \times 10^{-5}$.

Calculate the concentration of a nicotinic acid solution which has a pH of 3·77. **3**

Acid, Base & Salts Past Papers

17 When an ant bites, it injects methanoic acid (HCOOH).

(*a*) Methanoic acid is a weak acid.

$$HCOOH(aq) + H_2O(\ell) \rightleftharpoons HCOO^-(aq) + H_3O^+(aq)$$

(i) What is the conjugate base of methanoic acid? **1**

(ii) Write the expression for the dissociation constant, K_a, of methanoic acid. **1**

When an ant bites, it injects methanoic acid (HCOOH).

(*b*) (i) In a typical bite, an ant injects $3{\cdot}6 \times 10^{-3}$ g of methanoic acid.
Assuming that the methanoic acid dissolves in $1{\cdot}0\,cm^3$ of water in the body, calculate the concentration of the methanoic acid solution in $mol\,l^{-1}$. **2**

(ii) Calculate the pH of this methanoic acid solution. **2**

18 Solutions of NaH_2PO_4 are acidic because the $H_2PO_4^-$ ion partially dissociates.

$$H_2PO_4^-(aq) \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq) \quad pK_a = 7{\cdot}2$$

(*a*) Write the expression for the acid dissociation constant, K_a. **1**

(*b*) Calculate the pH of 0·1 $mol\,l^{-1}$ NaH_2PO_4 solution. **2**

(*c*) NaH_2PO_4 is used with $NaHCO_3$ in baking powders, to produce carbon dioxide.

$$H_2PO_4^-(aq) + HCO_3^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H_2O(\ell) + CO_2(g)$$

Explain how HCO_3^- acts as a base in this reaction. **1**

19. Fizzy drinks contain carbon dioxide dissolved in water which dissociates, as shown, to produce carbonic acid.

$$H_2O(\ell) + CO_2(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \quad pK_a = 6{\cdot}4$$

(*a*) What is the Bronsted-Lowry definition of an acid? **1**

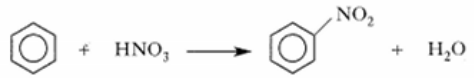
(*b*) Write the formula for the conjugate base in this reaction. **1**

Fizzy drinks contain carbon dioxide dissolved in water which dissociates, as shown, to produce carbonic acid.

$$H_2O(\ell) + CO_2(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \quad pK_a = 6{\cdot}4$$

(*c*) Calculate the pH of a 0·1 $mol\,l^{-1}$ solution of carbonic acid. **2**

20. Benzene can be nitrated by reaction with concentrated nitric acid.



The nitration of benzene is normally achieved using a mixture of concentrated nitric and sulphuric acids. The latter react in the following way:

$$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$$

Give the formula of the acid and its conjugate base in this reaction. **1**

21. Propanoic acid is a weak acid. Sodium propanoate is a salt which can be formed from it. Both propanoic acid and sodium propanoate can be used as mould inhibitors.

Calculate the pH of 0·10 $mol\,l^{-1}$ propanoic acid solution. **2**

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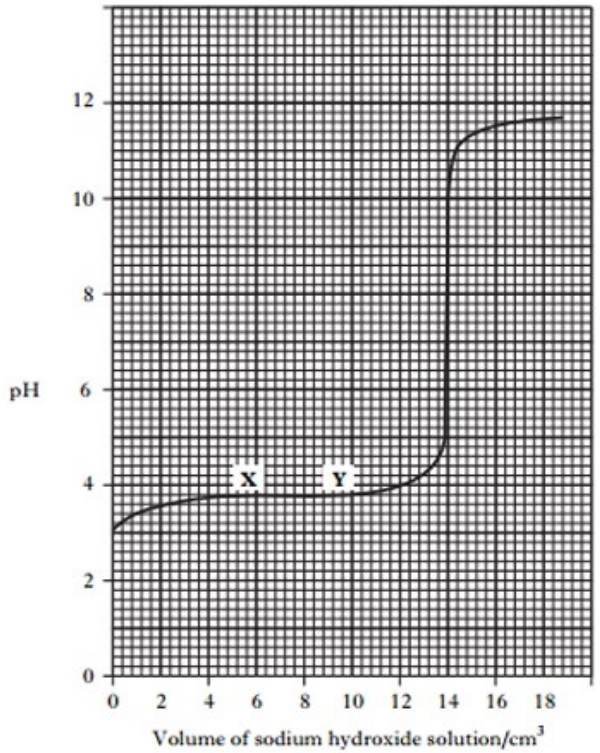
22 Hydrofluoric acid, HF, is a weak acid.

$$HF(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + F^-(aq)$$

A student neutralised 25 cm^3 of hydrofluoric acid solution with sodium hydroxide solution and followed the reaction by measuring the pH.

The graph obtained for this reaction is shown below.



(*a*) Write the expression for the dissociation constant, K_a, of hydrofluoric acid. 1

(*b*) When exactly half the acid has been neutralised, $pK_a = pH$.
Using only information from the graph, deduce pK_a and thus calculate K_a for hydrofluoric acid. 2

23. Butanoic acid can be synthesised from 1-bromopropane by a two stage process.

$$CH_3CH_2CH_2Br \xrightarrow[KCN(aq)]{\text{stage 1}} \mathbf{Y} \xrightarrow{\text{stage 2}} CH_3CH_2CH_2COOH$$

Using information from the Data Booklet, calculate the pH of 0·010 mol l^{-1} aqueous butanoic acid. 2

24. Octanoic acid is a weak acid with a dissociation constant, $K_a = 1{\cdot}27 \times 10^{-5}$ and $pK_a = 4{\cdot}9$.
One litre of 0·20 mol l^{-1} octanoic acid solution was prepared.

Calculate the pH of the solution.

25. The equilibrium in water can be represented by the equation

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

The ionic product for water (K_w) is $1{\cdot}00 \times 10^{-14}$ $mol^2 l^{-2}$ at 297 K.
As shown in the table below, K_w is temperature dependent.

Temperature/K	$K_w/mol^2 l^{-2}$
273	$1{\cdot}14 \times 10^{-15}$
283	$2{\cdot}93 \times 10^{-15}$
298	$1{\cdot}01 \times 10^{-14}$
323	$5{\cdot}48 \times 10^{-14}$
373	$5{\cdot}13 \times 10^{-13}$

(*a*) Write the expression for K_w. 1

(*b*) Give a reason for the variation of K_w with temperature. 1

(*c*) Calculate the pH of water at 323 K. 2

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1. C
2. D
3. A
4. D
5. D
6. C
7. A
8. D
9. B
10. D
11. B
12. B The **weaker the parent acid**, the **stronger its conjugate base**, and the **higher the pH**.
13. A
14. C
15. C
16. C
17. C $\boxed{\text{pH} \approx \frac{1}{2}(pK_a - \log c)}$ $\text{pH} = \frac{1}{2}(4.2 - (-2)) = 3.1$
18. B

$$\text{pOH} = 14 - 8.5 = 5.5$$
$$[\text{OH}^-] = 10^{-5.5}$$
$$= 3.2 \times 10^{-6}$$

19. D $\text{Ca(OH)}_2 \rightarrow \text{Ca}^{2+} + 2\text{OH}^-$

$$[\text{OH}^-] = 2 \times 0.002 = 0.004 \text{ mol l}^{-1}$$
$$\text{pOH} = -\log(0.004) \approx 2.4$$
$$\text{pH} = 14 - 2.4 = 11.6$$

20. B

$$\text{pOH} = 14 - 14 = 0$$
$$[\text{OH}^-] = 10^0 = 1 \text{ mol l}^{-1}$$

21. D
22. B

$$[\text{H}^+] = [\text{OH}^-] = \sqrt{K_w}$$
$$[\text{H}^+] = \sqrt{5.48 \times 10^{-14}} = 2.34 \times 10^{-7}$$
$$\text{pH} = -\log(2.34 \times 10^{-7}) \approx 6.63$$

23. D
24. D

$$[\text{H}^+] = 10^{-2} \text{ mol l}^{-1}$$
$$\frac{250}{5} = 50$$
$$50 \times 10^{-2} = 0.50 = 5.0 \times 10^{-1}$$

25. B

HCl:
$0.5 \times 0.022 = 0.011$

NaOH:
$0.5 \times 0.020 = 0.010$

Excess acid
$0.011 - 0.010 = 0.001$ mol

Total volume = 1.0 L
$[\text{H}^+] = 0.001 \Rightarrow \text{pH} = 3$

26. B

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1. 2.77×10^{-6}

$$\begin{array}{rcccl} pH & = & \frac{1}{2}pK_a & - & \frac{1}{2}\log_{10}c \\ pH & = & \frac{1}{2}x(10.29) & - & \frac{1}{2}\log_{10}(0.150) \\ pH & = & 5.145 & - & \frac{1}{2}x(-0.824) \\ pH & = & 5.145 & - & (-0.412) \\ pH & = & 5.56 & & \end{array}$$

$$\begin{array}{rcl} pH & = & 5.56 \\ -\log_{10}[H^+] & = & 5.56 \\ \log_{10}[H^+] & = & -5.56 \\ [H^+] & = & 10^{-5.56} \\ [H^+] & = & 2.77 \times 10^{-6} \text{ mol } l^{-1} \end{array}$$

2.

3. 4.41

$$\begin{array}{rcccl} pH & = & \frac{1}{2}pK_a & - & \frac{1}{2}\log_{10}c \\ pH & = & \frac{1}{2}x - \log_{10}(1.38 \times 10^{-4}) & - & \frac{1}{2}\log_{10}(1.12 \times 10^{-5}) \\ pH & = & \frac{1}{2}x - (-3.86) & - & \frac{1}{2}x(-4.95) \\ pH & = & 1.930 & - & (-2.475) \\ pH & = & 4.405 & & \end{array}$$

4. (i) (Carbonic acid is a) weaker acid as it has a higher pK_a/lower K_a

OR

Ethanoic acid is a stronger acid as it has a lower pK_a/higher K_a

(ii) Base

5. The (benzoate) ion from the salt removes/reacts with H^+ from the water

This results in the water equilibrium shifting to the right hand side OR this results in excess OH^- ions from the water equilibrium. **(1)**

6 (i) 6.31×10^{-9}

$$\begin{array}{rcl} pH & = & 8.2 \\ -\log_{10}[H_3O^+] & = & 8.2 \\ \log_{10}[H_3O^+] & = & -8.2 \\ [H_3O^+] & = & 10^{-8.2} \\ [H_3O^+] & = & 6.31 \times 10^{-9} \text{ mol } l^{-1} \end{array}$$

(ii) 99.7%

$$\begin{array}{rcl} pH & = & 7.9 \\ -\log_{10}[H_3O^+] & = & 7.9 \\ \log_{10}[H_3O^+] & = & -7.9 \\ [H_3O^+] & = & 10^{-7.9} \\ [H_3O^+] & = & 1.26 \times 10^{-8} \text{ mol } l^{-1} \end{array}$$

7. a) Partially dissociated into ions in aqueous solution.

b (i) 1.298

$$\begin{array}{rcccl} pH & = & \frac{1}{2}pK_a & - & \frac{1}{2}\log_{10}c \\ pH & = & \frac{1}{2}(3.17) & - & \frac{1}{2}\log_{10}(3.75) \\ pH & = & 1.585 & - & \frac{1}{2}(0.574) \\ pH & = & 1.585 & - & 0.287 \\ pH & = & 1.298 & & \end{array}$$

(ii) 7.5%

gfm HF = (1x1)+(1x19) = 1+19 = 20g

3.75mol of HF in 1litre of solution ∴ **mass** = **no.** of mol x **gfm** = 3.75 x 20 = 75g

1 litre of HF solution would have approx. mass of 1000g $\frac{75g}{1000g} \times 100 = 7.5\%$

$$\% \text{ Increase} = \frac{1.26 \times 10^{-8} - 6.31 \times 10^{-9}}{6.31 \times 10^{-9}} \times 100$$

8a (i) A proton/hydrogen ion/H^+ acceptor

(ii)

Acid	H_2O_2
Conjugate base	HO_2^-

OR

Acid	H_3O^+
Conjugate base	H_2O

8b $B(OH)_3$ accepts (a pair of non-bonding) electrons and water donates (a pair of non-bonding) electrons

OR

$B(OH)_3$ accepts (a pair of non-bonding) electrons from water

OR

Water donates (a pair of non-bonding) electrons to $B(OH)_3$

8c (i) As the number of chlorine (atoms) increase the strength of the acid increases.

OR

As the number of chlorine (atoms) decreases the strength of the acid decreases.

(ii) A $0{\cdot}08$ (mol l^{-1})

(ii) B 2

pH	=	$\frac{1}{2}$ pK_a	-	$\frac{1}{2}$log c
pH	=	$\frac{1}{2}$ x -log$_{10}K_a$	-	$\frac{1}{2}$ log$_{10}$ c
pH	=	$-\frac{1}{2}$ x log$_{10}$ (1.3×10^{-3})	-	$\frac{1}{2}$ log$_{10}$ (0.08)
pH	=	$-\frac{1}{2}$ x (-2.89)	-	$\frac{1}{2}$ x (-1.10)
pH	=	1.44	-	(-0.55)
pH	=	1.99		

9 a (i) $$K = \frac{[H_3O^+(aq)][HOOCCH_2CH(OH)COO^-(aq)]}{[HOOCCH_2CH(OH)COOH(aq)]}$$

9a (ii) $HOOCCH_2CH(OH)COO^-(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + {}^-OOCCH_2CH(OH)COO^-(aq)$

9b 2.90

pH	=	$\frac{1}{2}$pK_a	-	$\frac{1}{2}$log$_{10}$ c
	=	$-\frac{1}{2}$log$_{10}K_a$	-	$\frac{1}{2}$log$_{10}$ c
	=	$-\frac{1}{2}$log$_{10}$(3.2×10^{-4})	-	$\frac{1}{2}$ x log$_{10}$(0.0051)
	=	($-\frac{1}{2}$ x -3.49)	-	($\frac{1}{2}$ x -2.29)
	=	1.75	-	(-1.15)
	=	2.90		

10 (i) Neutralisation

(ii) Partially dissociated (into ions) in solution.

11 a) $$K_a = \frac{[C_6H_5CH(OH)COO^-]\,[H_3O^+]}{[C_6H_5CH(OH)COOH]}$$

11 b (i) 0.658

1mol $C_6H_5CH(OH)COOH$ = (8x12)+(8x1)+(3x16) = 96+8+48 = 152g

$$\text{no. of mol} = \frac{\text{mass}}{\text{gfm}} = \frac{10\text{g}}{152\text{ g mol}^{-1}} = 0.0658\text{ mol}$$

$$\text{concentration} = \frac{\text{no. of mol}}{\text{volume}} = \frac{0.0658\text{mol}}{0.1\text{ litres}} = 0.658\text{ mol l}^{-1}$$

(ii) 1.97

pH	=	$\frac{1}{2}$pK_a	-	$\frac{1}{2}$log$_{10}$ c
	=	$\frac{1}{2}$(-log$_{10}K_a$)	-	$\frac{1}{2}$log$_{10}$ c
	=	$\frac{1}{2}$(-log$_{10}1.78\times10^{-4}$)	-	$\frac{1}{2}$ x log$_{10}$(0.658)
	=	$\frac{1}{2}$(3.750)	-	$\frac{1}{2}$(0.182)
	=	1.875	-	(-0.0909)
	=	1.97		

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12) The (4-hydroxybenzoate) ion from the salt removes/ reacts with H^+ from the water **(1)**

This results in the water equilibrium shifting to the right hand side

OR

This results in the water equilibrium producing an excess of OH^- ions. **(1)**

13. CH_3COO^-

14. a) $0.575 \text{ mol } l^{-1}$

$$\begin{aligned} pH &= \tfrac{1}{2}pK_a - \tfrac{1}{2}\log c \\ 2.5 &= \tfrac{1}{2} \times 4.76 - \tfrac{1}{2}\log c \\ 2.5 &= 2.38 - \tfrac{1}{2}\log c \\ \tfrac{1}{2}\log c &= 2.38 - 2.5 \\ \tfrac{1}{2}\log c &= -0.12 \\ \log c &= -0.24 \\ c &= 10^{-0.24} \\ &= 0.575 \end{aligned}$$

b) CH_3COO^- or $C_2H_3O_2^-$

15. a) ClO^-

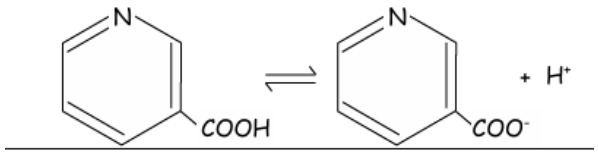
b) $K_a = \dfrac{[H_3O^+]\,[ClO^-]}{[HClO]}$

c) 0.01

$pH = -\log_{10}[H^+] = 5.4 \therefore \log_{10}[H^+] = -5.4 \therefore [H^+] = 10^{-5.4} = 3.98\times10^{-6}$

$K_a = \dfrac{[H_3O^+]\,[ClO^-]}{[HClO]} \therefore \dfrac{[ClO^-]}{[HClO]} = \dfrac{K_a}{[H_3O^+]} = \dfrac{3.98\times10^{-8}}{3.98\times10^{-6}} = 0.01$

16 a)



b) $0.0020 \text{ mol } l^{-1}$

$pK_a = -\log_{10}K_a = -\log_{10}(1.4\times10^{-5}) = -(-4.85) = 4.85$

$$\begin{aligned} pH &= \tfrac{1}{2}pK_a - \tfrac{1}{2}\log_{10} c \\ \tfrac{1}{2}\log_{10} c &= \tfrac{1}{2}pK_a - pH \\ &= (\tfrac{1}{2} \times 4.85) - 3.77 \\ &= 2.425 - 3.77 \\ &= -1.34 \\ \log_{10} c &= -2.68 \\ c &= 0.0020 \text{mol } l^{-1} \end{aligned}$$

17 a (i) methanoate ion

$HCOO^-$

(ii) $K_a = \dfrac{[HCOO^-][\,H_3O^+]}{[HCOOH]}$

B (i) $0.0783 \text{ mol } l^{-1}$

gfm $HCOOH = (2\times1) + (1\times12) + (2\times16) = 2 + 12 + 32 = 46 \text{g mol}^{-1}$

$\text{no. of mol} = \dfrac{\text{mass}}{\text{gfm}} = \dfrac{3.6\times10^{-3}\text{g}}{46\text{g mol}^{-1}} = 7.83\times10^{-5}\text{ mol}$

$\text{concentration} = \dfrac{\text{no. of mol}}{\text{volume}} = \dfrac{7.83\times10^{-5}\text{ mol}}{0.001\text{ litres}} = 0.0783 \text{ mol } l^{-1}$

(ii) 2.43

$$\begin{aligned} pH &= \tfrac{1}{2}pK_a - \tfrac{1}{2}\log_{10} c \\ &= (\tfrac{1}{2} \times 3.75) - \tfrac{1}{2} \times \log_{10}(0.0783) \\ &= 1.875 - (-0.553) \\ &= 2.428 \end{aligned}$$

18 a) $K_a = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$

b) 4.1

$pH = \frac{1}{2}pK_a - \frac{1}{2}\log_{10}c$
$= (\frac{1}{2}\times 7.2) - \frac{1}{2}\log_{10}(0.1)$
$= 3.6 - (-0.5)$
$= 4.1$

c) Accepts a H^+ ion

19 a) Donates H^+/proton

b) HCO_3^-

c) 3.7

$pH = \frac{1}{2}pK_a - \frac{1}{2}\log_{10}c$
$= (\frac{1}{2}\times 6.4) - \frac{1}{2}\times\log_{10}(0.1)$
$= 3.2 - (-0.5)$
$= 3.7$

20.

Acid	H_2SO_4
Conjugate base	HSO_4^-

21. 2.935

$pH = \frac{1}{2}pK_a - \frac{1}{2}\log_{10}c$
$= (\frac{1}{2}\times 4.87) - \frac{1}{2}\times\log_{10}(0.1)$
$= 2.435 - (-0.5)$
$= 2.935$

22a) $K_a = \frac{[H_3O^+][F^-]}{[HF]}$

b). 1.58×10^{-4}

Acid is completely neutralised at 14cm^3 NaOH added
Half of Acid has been neutralised at 7cm^3 NaOH added
∴pH of solution at 7cm^3 NaOH added = 3.8 = pK_a
∴pK_a= pH = 3.8

$pK_a = -\log_{10}K_a = 3.8$
$\log_{10}K_a = -3.8$
$K_a = 10^{-3.8} = 1.58\times10^{-4}$

23. 3.4

$pH = \frac{1}{2}pK_a - \frac{1}{2}\log_{10}c$
$= (\frac{1}{2}\times 4.83) - \frac{1}{2}\times\log_{10}(0.01)$
$= 2.415 - \frac{1}{2}\times(-2)$
$= 2.415 - (-1)$
$= 3.415$

24. 2.80

$pH = \frac{1}{2}pK_a - \frac{1}{2}\log_{10}c$
$= \frac{1}{2}(4.9) - \frac{1}{2}\log_{10}(0.2)$
$= 2.45 - (-0.35)$
$= 2.80$

25. a) $K_w = [H^+][OH^-]$

b) K_w increases as water dissociates more as temp increases

c) 6.6

$K_w = [H^+][OH^-] = [H^+]^2 = 5.48\times10^{-14}$ NB $[H^+] = [OH^-]$
$[H^+] = \sqrt{(5.48\times10^{-14})} = 2.34\times10^{-7}$ mol l^{-1}
$\log_{10}[H^+] = -6.6$
$-\log_{10}[H^+] = 6.6$
$pH = 6.6$