



## Chemistry ATAR 3+4

### Acids & Bases Test : **SOLUTIONS : 54 MARKS**

#### **DO NOT MARK THIS PAPER**

- Q1. Which of the following volumes of a  $0.040 \text{ mol L}^{-1}$  potassium hydroxide solution is required to react exactly with  $20.0 \text{ mL}$  of a  $0.010 \text{ mol L}^{-1}$  diprotic acid?
- A.  $1.0 \text{ mL}$
  - B.  $5.0 \text{ mL}$
  - C.  $10.0 \text{ mL}$
  - D.  $20.0 \text{ mL}$
- Q2. Which of these salts will give a basic solution when added to water?
- A.  $\text{NH}_4\text{NO}_3$
  - B.  $\text{NH}_4\text{CH}_3\text{COO}$
  - C.  $\text{Ca}(\text{NO}_3)_2$
  - D.  $\text{CaS}$
- Q3. Which of the following is most **UNLIKELY** to act as both a Brønsted - Lowry acid or base?
- A.  $\text{OH}^-$
  - B.  $\text{HPO}_4^{2-}$
  - C.  $\text{HS}^-$
  - D.  $\text{NH}_4^+$
- Q4. Which statement best describes the equivalence point in a titration between a strong acid and a strong base?
- A. The point at which the first sign of a colour change occurs
  - B. The point at which equal moles of acid and base have been added together
  - C. The point at which equal moles of  $\text{H}^+$  ions and  $\text{OH}^-$  ions have been added together
  - D. The point at which the rate of the forward reaction equals the rate of the reverse reaction
- Q5. All the following are amphoteric except:
- A.  $\text{HSO}_4^{1-}$

- B.  $\text{HPO}_4^{2-}$
- C.  $\text{H}_2\text{PO}_4^{1-}$
- D.  $\text{PO}_4^{3-}$

- Q6. Sulfuric acid ( $\text{H}_2\text{SO}_4$ ) and nitric acid ( $\text{HNO}_3$ ) are both strong acids. Ethanoic acid ( $\text{CH}_3\text{COOH}$ ) is a weak acid.  
20.00 mL solutions of 0.10 M concentration of each of these three acids were separately titrated with a 0.10 M solution of sodium hydroxide ( $\text{NaOH}$ ).  
In order to react completely
- all three acids would require the same amount of  $\text{NaOH}$ .
  - $\text{HNO}_3$  would require more  $\text{NaOH}$  than  $\text{CH}_3\text{COOH}$  but less than  $\text{H}_2\text{SO}_4$ .
  - $\text{H}_2\text{SO}_4$  and  $\text{HNO}_3$  would require the same amount of  $\text{NaOH}$  but  $\text{CH}_3\text{COOH}$  would require less.
  - $\text{CH}_3\text{COOH}$  and  $\text{HNO}_3$  would require the same amount of  $\text{NaOH}$  but  $\text{H}_2\text{SO}_4$  would require more.

Q7. Which of the following examples represents an acid-base reaction?

- $\text{NH}_4^+_{(\text{aq})} + \text{OH}^-_{(\text{aq})} \rightarrow \text{NH}_{3(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$
- $2\text{NO}_3^-_{(\text{aq})} + 2\text{H}^+_{(\text{aq})} + 3\text{H}_2\text{O}_{2(\text{aq})} \rightarrow 2\text{NO}_{(\text{g})} + 3\text{O}_{2(\text{g})} + 4\text{H}_2\text{O}_{(\text{l})}$
- $2\text{K}_{(\text{s})} + 2\text{H}_2\text{O}_{(\text{l})} \rightarrow 2\text{K}^+_{(\text{aq})} + 2\text{OH}^-_{(\text{aq})} + \text{H}_{2(\text{g})}$
- $\text{Ca}^{2+}_{(\text{aq})} + \text{CO}_3^{2-}_{(\text{aq})} \rightarrow \text{CaCO}_{3(\text{s})}$

Q8. Methanoic acid and azoic acid are both weak acids with the following acidity constants (equilibrium constants).

Ka in M at 25°C		
methanoic acid	( $\text{HCOOH}$ )	$1.82 \times 10^{-4}$
azoic acid	( $\text{HN}_3$ )	$1.91 \times 10^{-5}$

Two separate solutions were prepared, one of 0.1 M methanoic acid and the other of 0.1 M azoic acid.

Which one of the following would be present in the highest concentration at 25°C?

- $\text{HN}_3$  in the azoic acid solution
- $\text{N}_3^-$  in the azoic acid solution
- $\text{HCOOH}$  in the methanoic acid solution
- $\text{HCOO}^-$  in the methanoic acid solution

Q9. Acid X is  $0.1 \text{ mol L}^{-1}$  hydrochloric acid. Acid Y is  $1.0 \text{ mol L}^{-1}$  ethanoic acid.  
How does acid X compare with acid Y?

- X is weaker and more dilute than Y.
- X is stronger and more dilute than Y.
- X is weaker and more concentrated than Y.
- X is stronger and more concentrated than Y.

Q10. Pure water undergoes self-ionisation. The equilibrium constant for the reaction at 95°C is  $4.8 \times 10^{-13}$ . This corresponds to a pH of 6.2. Which of the following statements is true?

- A. At 95°C the water is acidic.
- B. At 95°C the water is neutral.
- C. At 95°C the water is basic.
- D. The pH has been worked out incorrectly.

1. Write net **IONIC** equations for any reaction that occurs in the following making sure to include phases in your answer, Also write **full observations**:

**NB: If no reaction occurs you must state this.**

[12 marks]

1 mark for molecular, 1 mark for net ionic inc states

a) Calcium hydroxide solid and sulphuric acid.



2

*A white solid is added to a clear colourless solution. Upon addition the solid dissolves to leave a clear colourless solution and a white precipitate.*

1 mark

8

b) Strontium oxide powder and phosphoric acid.

2



*A white solid is added to a clear colourless solution. Upon addition the solid dissolves and a white precipitate forms in a clear colourless solution.*

1 mark

c) Nitric acid and copper carbonate solution. Will give solid  $\text{CuSO}_4$



2

*A blue solution is added to a clear colourless solution. Upon addition there is an effervescence of a colourless odourless gas and the solution remains blue.*

1 mark

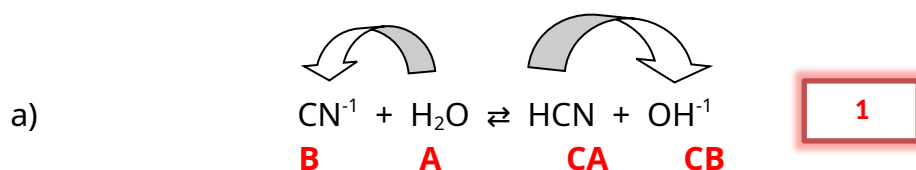
d) Acetic acid solution and magnesium metal.



2

*A silvery metal is added to a clear colourless solution. Upon addition there is an effervescence of a colourless odourless gas and the solution remains clear and colourless. 1 mark*

2. Rewrite the following equations labelling the acids and bases with either an "A" or a "B" and show proton donation and acceptance with an arrow for both the forward and reverse reaction. State the conjugate acid/base pair and conjugate base/acid pair for each reaction:



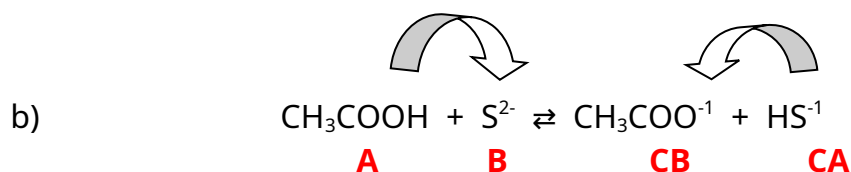
1

Conj. Acid/Base Pair =  $\text{H}_2\text{O} / \text{OH}^{-}$

0.5

Conj. Base/Acid Pair =  $\text{CN}^{-} / \text{HCN}$

0.5



1

Conj. Acid/Base Pair =  $\text{CH}_3\text{COOH} / \text{CH}_3\text{COO}^{-}$

0.5

Conj. Base/Acid Pair =  $\text{S}^{2-} / \text{HS}^{-}$

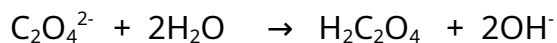
0.5

[4 marks]

3. Is a lithium oxalate solution acid, basic or neutral? Explain with the aid of a hydrolysis equation.

► **BASIC**

1



1

[2 marks]

4. The  $K_a$  values for two acids are given in the table below:

Acid	$K_a$ @ 25°C
$\text{H}_2\text{C}_2\text{O}_4$	$5.4 \times 10^{-5}$
$\text{H}_3\text{PO}_4$	$7.1 \times 10^{-3}$

NB: These are the  $K$  values for the 1<sup>st</sup> ionisation only! i.e.  $K_{a1}$

- a) Of the two acids which is the strongest? Justify your answer using the  $K_a$  values.

►  **$\text{H}_3\text{PO}_4$  is the strongest of these two weak acids, as its  $K_a$  value is higher indicating a greater extent of ionisation.**

2

- b) Write equations to represent the first ionisation of each acid.



1



1

[4 marks]

5. Calculate the pH of (assume 25°C):

- a) A solution of 0.320 grams of HCl in 250mL of water.

HCl

$n(\text{HCl}) = \underline{m}$

$$\begin{aligned}
 &1.008 \\
 &+ \underline{35.45} \\
 &36.458 \text{ g.mol}^{-1}
 \end{aligned}
 \qquad
 \begin{aligned}
 &\text{M} \\
 &= \underline{0.320} \\
 &36.458 \\
 &= \underline{0.008777 \text{ mol}}
 \end{aligned}$$

$$\begin{aligned}
 [\text{H}^+] &= [\text{HCl}] = \frac{n}{V} \\
 &= \frac{0.008777}{0.250} \\
 &= \underline{0.03511 \text{ M}}
 \end{aligned}$$

3

$$\begin{aligned}
 \text{pH} &= -\log_{10} [\text{H}^+] \\
 &= -\log_{10} 0.03511 \\
 &= \underline{1.45}
 \end{aligned}$$

b) 75 mL of 0.15M NaOH is mixed with 2.5g of powdered Ba(OH)<sub>2</sub>

$$\begin{aligned}
 n(\text{NaOH}) &= CV \\
 &= 0.15 \times 0.075 \\
 &= 0.01125 \text{ mol}
 \end{aligned}$$

1

$$\begin{aligned}
 n(\text{Ba(OH)}_2) &= m/M_r \\
 &= 2.5 / (137.3 + 34) \\
 &= 0.01459 \text{ mol}
 \end{aligned}$$

1

$$\begin{aligned}
 \text{But as there 2 OH} &\times 2 \\
 &= 0.02919 \text{ mol}
 \end{aligned}$$

1

$$\text{Total OH}^- = 0.01125 + 0.02919 = 0.0404 \text{ mol}$$

1

$$\begin{aligned}
 n(\text{OH}^-) &= CV \\
 0.0404 &= C \times 0.075 \\
 &= 0.538 \text{ molL}^{-1}
 \end{aligned}$$

$$[\text{H}^+] = \frac{1 \times 10^{-14}}{[\text{OH}^-]}$$

1

$$= \frac{1 \times 10^{-14}}{0.538}$$

$$= \underline{1.862 \times 10^{-14}}$$

$$\begin{aligned}
 \text{pH} &= -\log_{10} [\text{H}^+] \\
 &= -\log_{10} (1.862 \times 10^{-14})
 \end{aligned}$$

1

$$= \underline{13.7}$$

[6 marks]

6. A 4.65g sample of pure  $\text{NaOH}_{(s)}$  is dissolved in 200mL of distilled water and added to 626mL of  $0.15 \text{ mol.L}^{-1} \text{ H}_2\text{SO}_{4(aq)}$ . Determine the pH of the mixture when the reaction is complete. Also state the limiting reagent.

$$\begin{aligned} n(\text{NaOH}) &= \frac{m}{M} \\ &= \frac{4.65}{40} \\ &= \underline{0.1163 \text{ mol}} \end{aligned}$$

$$\begin{aligned} n(\text{H}_2\text{SO}_4) &= C \times V \\ &= 0.15 \times 0.626 \\ &= \underline{0.0939 \text{ mol}} \end{aligned}$$

1



So  $n(\text{NaOH}) = 2 \times n(\text{H}_2\text{SO}_4) \quad n(\text{H}_2\text{SO}_4) = 2 \times 0.0939 = 0.1878 \text{ mol}$

2

\* We only have 0.1163 mol of NaOH

$\therefore$  NaOH is the LIMITING REACTANT!

1

7

$$\begin{aligned} \therefore n(\text{H}^+) \text{ remaining} &= \text{TOTAL} - n(\text{NaOH neutralised}) \\ &= 0.1878 - 0.1163 \\ &= \underline{0.07155 \text{ mol}} \end{aligned}$$

1

$$\begin{aligned} [\text{H}^+] &= \frac{n}{V} \\ &= \frac{0.07155}{0.826} \\ &= \underline{0.0866 \text{ M}} \end{aligned}$$

1

$$\begin{aligned} \text{pH} &= -\log_{10} [\text{H}^+] \\ &= -\log_{10} (0.0866) \\ &= \underline{1.06} \end{aligned}$$

1



[7 marks]

7. Titrations are a very important analytical technique in Chemistry. Unfortunately, acids, bases and salts are generally all clear and colourless in solution, so the end point of a titration cannot be signified by a colour change as in a redox titration. We need to select an indicator which changes colour for us. However, the selection of the correct indicator is based on a few factors. In each case the acid is in the conical flask.

- a) On your answer sheet, write down the missing entries *a* to *f* from the table below.

	Strong Base	Weak Base
Strong Acid	1. pH at end point = <i>a</i> Indicator = <i>b</i>	3. pH at end point = <i>e</i> Indicator = <i>f</i>
Weak Acid	2. pH at end point = <i>c</i> Indicator = <i>d</i>	

- **a = 7**  
**b = LITMUS or BROMOTHYMOLO BLUE**  
**c = 9**  
**d = PHENOLPHTHALEIN**  
**e = 5**  
**f = METHYL ORANGE or METHYL RED**

6

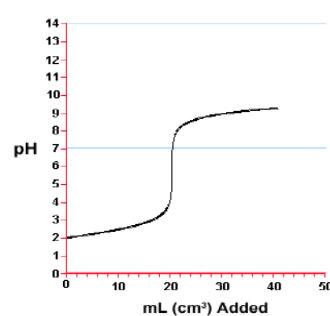
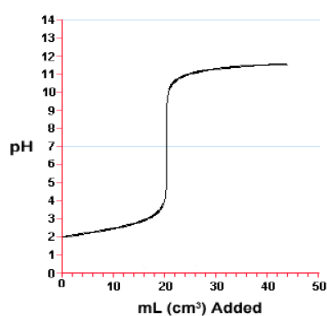
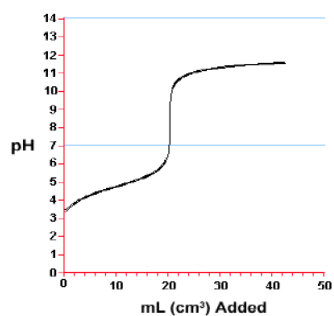
6 x 0.5 = 3

- b) The following titration curves are drawn for titrations 1,2 and 3 above. Match the titration to the correct curve. Write your answer in the form "1A" or "1B" etc.

A

B

C



► "1 B" = STRONG ACID v STRONG BASE

► "2 A" = WEAK ACID v STRONG BASE

► "3 C" = STRONG ACID v WEAK BASE

3

[6 marks]

END of PAPER

TOTAL MARKS = 54 Marks