Trinity College

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 mol L^{-1} potassium hydroxide solution is required to react exactly with 20.0 mL of a 0.010 mol L^{-1} diprotic acid?

A. 1.0 mL
B. 5.0 mL
C. 10.0 mL
D. 20.0 mL

Q2. Which of these salts will give a basic solution when added to water?

A. NH_4NO_3
B. NH_4CH_3COO
C. $Ca(NO_3)_2$
D. CaS

Q3. Which of the following is most **UNLIKELY** to act as both a Brönsted - Lowry acid or base?

A. OH^-
B. HPO_4^{2-}
C. HS^-
D. 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 H^+ ions and 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. HSO_4^{1-}

B. HPO_4^{2-}
C. $H_2PO_4^{1-}$
D. PO_4^{3-}

Q6. Sulfuric acid (H_2SO_4) and nitric acid (HNO_3) are both strong acids. Ethanoic acid (CH_3COOH) 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 (NaOH).
In order to react completely

A. all three acids would require the same amount of NaOH.
B. HNO_3 would require more NaOH than CH_3COOH but less than H_2SO_4.
C. H_2SO_4 and HNO_3 would require the same amount of NaOH but CH_3COOH would require less.
D. CH_3COOH and HNO_3 would require the same amount of NaOH but H_2SO_4 would require more.

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

A. $NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \rightarrow NH_{3(aq)} + H_2O_{(l)}$
B. $2NO_3^-{}_{(aq)} + 2H^+{}_{(aq)} + 3H_2O_{2(aq)} \rightarrow 2NO_{(g)} + 3O_{2(g)} + 4H_2O_{(l)}$
C. $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2K^+{}_{(aq)} + 2OH^-{}_{aq} + H_{2(g)}$
D. $Ca^{2+}{}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow CaCO_{3\,(s)}$

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

		***K*a in M at 25^{0}C**
methanoic acid	(HCOOH)	1.82×10^{-4}
azoic acid	(HN_3)	1.91×10^{-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?

A. HN_3 in the azoic acid solution
B. N_3^- in the azoic acid solution
C. HCOOH in the methanoic acid solution
D. $HCOO^-$ in the methanoic acid solution

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

A. *X* is weaker and more dilute than *Y*.
B. *X* is stronger and more dilute than *Y*.
C. *X* is weaker and more concentrated than *Y*.
D. *X* is stronger and more concentrated than *Y*.

Q10. Pure water undergoes self-ionisation. The equilibrium constant for the reaction at 95°C is 4.8×10^{-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.

► $Ca(OH)_{2\,(s)} + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow CaSO_{4(s)} + 2H_2O_{(l)}$ 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

$$3SrO_{(s)} + 2H_3PO_{4(aq)} \rightarrow Sr_3(PO_4)_{2(s)} + 3H_2O_{(l)}$$

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 $CuSO_4$

► $2H^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow H_2O_{(l)} + CO_{2\,(g)}$ 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.

► $2CH_3COOH_{(aq)} + Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2CH_3COO^-_{(aq)} + H_{2(g)}$ 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:

a) $CN^{-1} + H_2O \rightleftarrows HCN + OH^{-1}$ 1

B A CA CB

Conj. Acid/Base Pair = H_2O / OH^- 0.5

Conj. Base/Acid Pair = CN^- / HCN 0.5

b) $CH_3COOH + S^{2-} \rightleftarrows CH_3COO^{-1} + HS^{-1}$ 1

A B CB CA

Conj. Acid/Base Pair = CH_3COOH / CH_3COO^- 0.5

Conj. Base/Acid Pair = S^{2-} / 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

$C_2O_4^{2-} + 2H_2O \rightarrow H_2C_2O_4 + 2OH^-$ 1

[2 marks]

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

Acid	K_a @ 25°C
$H_2C_2O_4$	5.4×10^{-5}
H_3PO_4	7.1×10^{-3}

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

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

► H_3PO_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.

► **$H_2C_2O_4 + H_2O \rightleftarrows H_3O^+ + HC_2O_4^-$** 1

► **$H_3PO_4 + H_2O \rightleftarrows H_3O^+ + H_2PO_4^-$** 1

[4 marks]

5. Calculate the pH of (assume 25^0C):

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

HCl **n (HCl) = m**

1.008
+ 35.45
36.458 g.mol^{-1}

M
= 0.320
36.458
= 0.008777 mol

$[H^+] = [HCl] = \frac{n}{V}$

= 0.008777
0.250
= 0.03511 M

3

pH = - log $_{10}$ $[H^+]$
= - log $_{10}$ 0.03511
= 1.45

b) 75 mL of 0.15M NaOH is mixed with 2.5g of powdered $Ba(OH)_2$

n(NaOH) = CV
= 0.15x0.075
= 0.01125 mol

1

n($Ba(OH)_2$) =m/Mr
=2.5/(137.3+34)
=0.01459 mol

1

But as there 2 OH x 2
=0.02919 mol

1

Total OH^- = 0.01125+0.02919 = 0.0404 mol

1

$n(OH^-)$ = CV
0.0404 = C x 0.075
= 0.538 molL^{-1}

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

1

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

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

pH = - log $_{10}$ $[H^+]$
= - log $_{10}$ (1.862×10^{-14})

1

= **13.7**

[6 marks]

6. A 4.65g sample of pure $NaOH_{(s)}$ is dissolved in 200mL of distilled water and added to 626mL of 0.15 $mol.L^{-1}$ $H_2SO_{4(aq)}$. Determine the pH of the mixture when the reaction is complete. Also state the limiting reagent.

$n(NaOH) = \frac{m}{M}$

$= \frac{4.65}{40}$

$= 0.1163$ mol

$n(H_2SO_4) = C \times V$

$= 0.15 \times 0.626$

$= 0.0939$ mol

1

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

So $n(NaOH) = 2 \times H_2SO_4$ $n(H_2SO_4) = 2 \times 0.0939 = 0.1878$ mol

2

1

* We only have 0.1163 mol of NaOH

∴ NaOH is the LIMITING REACTANT!

7

∴ $n(H^+)$ remaining = TOTAL - n(NaOH neutralised

= 0.1878 - 0.1163

= 0.07155 mol

1

$[H^+] = = \frac{n}{V}$

$= \frac{0.07155}{0.826}$

$= 0.0866$ M

1

$pH = -\log_{10}[H^+]$

$= -\log_{10}(0.0866)$

$= 1.06$

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 = *a* Indicator = *b*	3. pH at end point = *e* Indicator = *f*
Weak Acid	2. pH at end point = *c* Indicator = *d*	

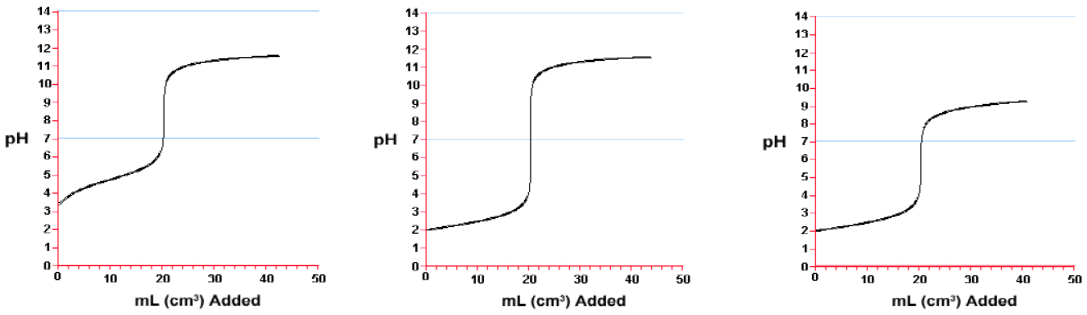
► **a = 7**
b = LITMUS or BROMOTHYMOL BLUE
c = 9
d = PHENOLPHTHALEIN
e = 5
f = METHYL ORANGE or METHYL RED

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

► **"3 C" = STRONG ACID v WEAK BASE**

[6 marks]

END of PAPER

TOTAL MARKS = 54 Marks