ALL SAINTS' COLLEGE

Science Department

Chemistry ATAR - Year 12

Acids & Bases Test

Name: ________________________________

Instructions to Students:

1. 50 minutes permitted
2. Attempt all questions
3. Write in the spaces provided
4. Show all working when required
5. All answers to be in blue or black pen, diagrams in pencil.

Multiple Choice	Short Answer	TOTAL
/10	/40	/50

Final Percentage

Year 12 Chemistry ATAR

Acids & Bases Test

Multiple Choice Section:

1. A Brönsted-Lowry acid is defined as a substance that

   a. accepts a proton
   b. accepts an electron
   c. donates a proton
   d. donates an electron

2. Given the following equation: $HF + HCO_3^- \leftrightharpoons F^- + H_2CO_3$

   Identify the two bases in the reaction.

   a. F^- and H_2CO_3
   b. HF and H_2CO_3
   c F^- and HCO_3^-
   d. HF and F^-

3. The value of K_w at 25°C is

   a. 1.0×10^{-14}
   b. 1.0×10^{-7}
   c. 7.00
   d. 14.00

4. What volume of 0.1 mol.L^{-1} of hydrochloric acid is needed to react completely with 40.0 mL of 0.20 mol.L^{-1} barium hydroxide?

   a. 20 mL
   b. 40 mL
   c. 80 mL
   d. 160 mL

5. A chemist added 20.0 mL of 0.0010 $mol.L^{-1}$ hydrochloric acid to 100.0 mL of 0.100 $mol.L^{-1}$ potassium chloride solution. Which one of the following is the correct pH of the resulting solution?

a. 2.6
b. 3.0
c. 3.8
d. 5.2

6. Which of the following is both a strong electrolyte and a weak acid?

a. Na_2CO_3
b. NH_4NO_3
c. CH_3COOH
d. HCl

7. Which of the following could function as an amphiprotic species in water solution?

a. HCl
b. Al_2O_3
c. HSO_4^-
d. NH_4^+

8. Which of the following pairs of compounds could be used to prepare a buffer solution?

a. HCl and KCl
b. NH_3 and NH_4Cl
c. H_2S and Na_2SO_4
d. Na_2CO_3 and $NaOH$

9. When the pH of a 0.01 $mol.L^{-1}$ solution of sulfuric acid is measured it is found to be significantly lower than the pH of a 0.01 $mol.L^{-1}$ solution of phosphoric acid. What is the reason for this?

a. Phosphoric acid is a triprotic acid, while sulfuric acid is only diprotic, therefore the concentration of hydrogen ions is higher in the phosphoric acid solution than in the sulfuric acid solution.

b. Phosphoric acid is a stronger acid than sulfuric acid, so the phosphoric acid is more likely to produce hydrogen ions in solution than the sulfuric acid.

c. Sulfuric acid is a stronger acid than phosphoric acid, so there are more hydrogen ions in the sulfuric acid solution than the phosphoric acid solution.

d. The sulfuric acid solution is more concentrated than the phosphoric acid solution, therefore there will be more hydrogen ions in the sulfuric acid solution than the phosphoric acid solution.

10. Each of the following salts is dissolved in water. Which answer correctly classifies the salts as acidic, basic or neutral?

	$Na_2CO_{3(aq)}$	$NH_4Cl_{(aq)}$	$K_3PO_{4(aq)}$
a.	neutral	acidic	basic
b.	acidic	basic	neutral
c.	basic	acidic	basic
d.	basic	basic	acidic

End of Multiple Choice Section

Short Answer Questions

1. Rewrite the following equations and show how each of the species are acting either as a Lowry-Bronsted acid or base. State the conjugate acid/base and base/acid pairs for each reaction.

a) $HF + H_2O \rightleftharpoons H_3O^+ + F^-$

1

$HF + H_2O \rightleftharpoons H_3O^+ + F^-$

Conjugate acid/base pair: ___HF/F^-__________________

1

Conjugate base/acid pair: ___H_2O/H_3O^+__________________

b) $H_3O^+ + SO_4^{2-} \rightleftharpoons HSO_4^- + H_2O$

1

$H_3O^+ + SO_4^{2-} \rightleftharpoons HSO_4^- + H_2O$

1

Conjugate acid/base pair: ___ H_3O^+/H_2O__________________

Conjugate base/acid pair: ____SO_4^{2-}/HSO_4^-__________________

[4 marks]

2. Write equations to show that in aqueous solution:

a) CH_3COOH is an **acid**.

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

1

b) Na_2S is **basic**.

c)

$S^{2-} + H_2O \rightleftharpoons HS^- + OH^-$

1

d) Carbonate ions are **basic**.

1

$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$

[3 marks]

3. a) Write two equations to show how bicarbonate ions and acetate ions could be considered basic in aqueous solution.

i. $HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$ 1

ii. $CH_3COO^- + H_2O \rightleftarrows CH_3COOH + OH^-$ 1

b) Write the K_b expression for these two ions.

i. $K_b = [H_2CO_3] \times [OH^-] / [HCO_3^-]$ 1
ii.
iii. $K_b = [CH_3COOH] \times [OH^-] / [CH_3COO^-]$ 1

c) The K values for these two equations are given in the table below:

Base	K_b @ 25°C
HCO_3^{-1}	4.2×10^{-7}
CH_3COO^{-1}	5.6×10^{-10}

For the two solutions 0.01 mol.L^{-1} sodium bicarbonate and 0.01 mol.L^{-1} sodium acetate solution, which will have the highest pH (closest to 14)? Justify your answer.

1

[6 marks]

The highest pH will be the most basic. They are both the same concentration, so the ion with the highest (largest) K_b will have the highest pH. Therefore HCO_3^-. 1

4. Write ionic equations (with phases) to show the reaction between:

a) Magnesium and hydrochloric acid.

$Mg_{(s)} + 2H^{+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$ $\boxed{1}$

b) Sodium sulfite solid and hydrochloric acid.

$Na_2SO_{3(s)} + 2H^{+}_{(aq)} \rightarrow SO_{2(g)} + H_2O_{(l)} + 2Na^{+}_{(aq)}$ $\boxed{1}$

c) Ammonium Chloride solution and potassium hydroxide solution.

$NH_4^{+}{}_{(aq)} + OH^{-}_{(aq)} \rightarrow NH_{3(g)} + H_2O_{(l)}$ $\boxed{1}$

d) Calcium bicarbonate solution and nitric acid.

$HCO_3^{-}{}_{(aq)} + H^{+}_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ $\boxed{1}$

e) Ammonia solution and hydrochloric acid.

$NH_{3(aq)} + H^{+}_{(aq)} \rightarrow NH_4^{+}{}_{(aq)}$ $\boxed{1}$

[5 marks]

5. Calculate the pH of:

a) A solution of 1.575×10^{-2} g of HNO_3 in 250 mL of water.

$\underline{HNO_3}$

m = 1.575×10^{-2} g

M = 63.0 g/mol

n = m/M = $1.575 \times 10^{-2}/63.0 = 2.50 \times 10^{-4}$ mol $\boxed{0.5}$

$[HNO_3]$ = n/V = 0.00025/0.250 = 0.001 M $\boxed{0.5}$

$[H^+] = [HNO_3]$

pH = $-\log_{10}[H^+] = -\log_{10}(0.001) = \underline{3.00}$ $\boxed{1}$

b) A solution of 0.2 g of NaOH in 500 mL of water.

NB: You must show all working in this question.

<u>NaOH</u>

m = 0.2 g

M = 40.0 g/mol

n = m/M = 0.2/40.0 = 5.00×10^{-3} mol $\boxed{0.5}$

[NaOH] = n/V = 0.005/0.5 = 0.01 M $\boxed{0.5}$

$[H^+] = 10^{-14}/[OH^-] = 10^{-14}/0.01 = 10^{-12}$ M

pH = $-\log_{10}[H^+] = -\log_{10}(10^{-12}) = \underline{12.0}$ $\boxed{1}$

[4 marks]

6. Gastric juice is approximately 0.15 $mol.L^{-1}$ HCl. Calculate the volume of gastric juice that would be neutralised by an antacid tablet containing 750mg of $CaCO_3$.

[3 marks]

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

<u>$CaCO_3$</u>

m = 0.750g   n = m/M = 0.750/100.09 = 7.49×10^{-3} mol $\boxed{1}$

M = 100.09 g/mol

n(HCl) = 2/1 x ($CaCO_3$) = 2 x 7.49 x 10^{-3} = 0.0150 mol $\boxed{1}$

V = n/c = 0.0150/0.15 = 0.0999L = <u>99.9mL</u> $\boxed{1}$

7. State whether the following solutions of salts will be acid, basic or neutral. In each case that a solution is not neutral give a one line **hydrolysis** equation to justify its acid or base nature.

a) $Mg(NO_3)_2$

neutral $\boxed{1}$

c) LiCl

neutral $\boxed{1}$

c) $KHSO_3$

basic – $HSO_3^- + H_2O \leftrightharpoons H_2SO_3 + OH^-$ $\boxed{1}$

d) NH_4HSO_4

[4 marks]

Acidic – $NH_4^+ + H_2O \leftrightharpoons NH_3 + H_3O^+$ $\boxed{1}$

8. Give an example of any

a) Acidic oxide — SO_2, CO_2, any non-metal oxide 1

b) Basic hydroxide — NaOH, KOH, any metal hydroxide 1

c) Amphiprotic substance (Something that can act as an acid or as a base)

Any valid amphiprotic, H_2O, HCO_3^- etc 1

[3 marks]

10. Explain in a paragraph what happens to the pH of water when there is an increase in temperature beyond 25˚C. Be sure to state the effect of the increase in temperature, and the cause.

Water autoionises according to the following equation:

$$H_2O \leftrightharpoons H^+ + OH^-$$ 1

This is an endothermic process whereby equal concentrations of H^+ and OH^- are created. At 25°C the concentration of each is 10^{-7} M. This equates to a pH of 7. **As the temperature is increased, the forward reaction is favoured, producing more H^+ and OH^- ions.** 1 Due to this increase, the pH goes **DOWN below 7,** yet the solution is still neutral, as equal amounts of H^+ and OH^- are present. 1

[3 marks]

11. a) Explain in a few sentences why a mixture of Ethanoic Acid and Sodium Ethanoate can act as a buffer, but a mixture of hydrochloric acid and sodium chloride solution cannot.

To be effective as a buffer the combination of species must be of a weak acid and its conjugate base, capable of responding to changes in an equilibrium as predicted by Le Chateliers principle. 1

Ethanoic acid and sodium acetate are such a pairing, setting up the following equilibrium:

$$CH_3COOH \leftrightharpoons CH_3COO^- + H^+$$ 1

Hydrochloric acid and sodium chloride could not act in this way as $HCl_{(aq)}$ is a strong acid with no tendency to reform once ionised, thus would be unable to respond to any imposed change. 1

$$HCl \rightarrow H^+ + Cl^-$$

b) Write equations to show what happens to a buffer solution containing equimolar amounts of HCO_3^{-1} and CO_3^{-2} when we add small amounts of:

i) $OH^{-1}_{(aq)}$

$HCO_3^- + OH- \leftrightharpoons CO_3^{2-} + H_2O$ $\boxed{1}$

ii) $H_3O^+_{(aq)}$

$CO_3^{2-} + H_3O^+ \leftrightharpoons HCO_3^- + H_2O$ $\boxed{1}$

[5 marks]