ALL SAINTS' COLLEGE

Science Department

Year 12 Chemistry 2017

Acids & Bas Test

Answers

Name: _____

Tea _____

Instructions to Student

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	Final Percentage
/10	/50	/60	

Section 1: Multiple Choice **10 marks**

Use the multiple Choice grid provided

1. In which of the following equations is the substance in bold type acting as a Brønsted-Lowry base?

a) **NH_4^+**(aq) + OH^-(aq) → NH_3(g) + H_2O(l)

b) **CH_3NH_2**(aq) + CH_3COOH(l) → $CH_3NH_3^+$(aq) + CH_3COO^-(aq)

c) 2 **Na**(s) + 2 H_2O(l) → 2 Na^+(aq) + 2 OH^-(aq) + H_2(g)

d) **$Cr_2O_7^{2-}$**(aq) + 2 OH^-(aq) → 2 CrO_4^{2-}(aq) + H_2O(l)

2. In which one of the following reactions is water behaving as an acid?

a) H_2O(g) + C(s) → H_2(g) + CO(g)

b) H_2O(l) + NH_3(g) → NH_4^+(aq) + OH^-(aq)

c) HCO_3^-(aq) + H_2O(l) → CO_3^{2-}(aq) + H_3O^+(aq)

d) NH_4^+(aq) + H_2O(l) → H_3O^+(aq) + NH_3(aq)

3. What is the conjugate acid of CH_3NH_2?

a) CH_3NH^-

b) CH_3NH^+

c) $CH_3NH_3^+$

d) $CH_3NH_2^-$

4. Which one of the following could be true in an aqueous solution of sodium hydroxide?

a) $[H^+] = [OH^-]$

b) $pH = -\log_{10}[OH^-]$

c) pH= 1.2

d) pH = 12.8

5. Which one of the following is the change in units of pH which occurs when 10.0mL of a 1.0 M solution of a strong monoprotic acid are made up to 1.0 L with water?

a) 1
b) 2
c) 3
d) 5

6. Consider the following equation, which shows the auto-ionisation of water.

$$H_2O(l) + H_2O(l) + \text{heat} \leftrightarrows H_3O^+(aq) + OH^-(aq)$$

If the temperature of this system is decreased, which of the following statements are **true**?

(i) The pH of the water rises
(ii) The water becomes less acidic
(iii) The value of K_w becomes greater
(iv) $[H_3O^+]$ decreases
(v) $[H_3O^+] = [OH^-]$

a) (i), (iv) and (v) only
b) (i), (ii) and (iv) only
c) (ii) and (iii) only
d) (i) and (v) only

7. If equal volumes of the following pairs of 0.1 mol L^{-1} solutions were mixed, which mixture would be the least effective buffer?

a) Na_2HPO_4 and NaH_2PO_4
b) HNO_3 and $Ba(NO_3)_2$
c) CH_3COOH and $NaCH_3COO$
d) H_2CO_3 and $NaHCO_3$

8. Which of the following possibilities describes the pH of a solution of the following compounds dissolved in distilled water?

	Ammonium Nitrate	*Potassium Carbonate*	*Sodium Chloride*	*Sodium Oxide*
a)	Less than 7	Greater than 7	Equals 7	Greater than 7
b)	Less than 7	Equals 7	Less than 7	Greater than 7
c)	Less than 7	Equals 7	Less than 7	Equals 7
d)	Equals 7	Greater than 7	Equals 7	Greater than 7

9. Adding a few drops of concentrated sodium hydroxide to a solution of ethanoic acid:

a) increases [CH_3COO^-]

b) increases [H_3O^+]

c) increases [CH_3COOH]

d) decreases the pH

10. What mass of NaOH is required to prepare 500 mL of a solution with a pH of 12 at 25°C?

a) 2.00 g

b) 0.200 g

c) 0.0400 g

d) 4.00 g

Section 2: Short Answers **50 Marks**

1. Write balanced net ionic equations (including state symbols) for the following reactions: (6)

a) A piece of copper oxide is reacted with dilute sulfuric acid.

Equation: $CuO_{(s)} + 2H^+_{(aq)} \rightarrow Cu^{2+}_{(aq)} + H_2O_{(l)}$

b) Some small pieces of calcium are added to dilute phosphoric acid

Equation: $3\ Ca_{(s)} + 2\ H_3PO_{4\ (aq)} \rightarrow Ca_3(PO_4)_{2\ (s)} + 3\ H_{2\ (g)}$

c) Sodium hydroxide is reacted with a solution of ammonium nitrate

Equation: $NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \rightarrow H_2O_{(l)} + NH_{3\ (aq)}$ (accept g)

Also accept $NH_4^+{}_{(aq)} + NaOH_{(s)} \rightarrow H_2O_{(l)} + NH_{3\ (aq)} + Na^+{}_{(aq)}$

2. Carbonic acid, H_2CO_3, is an example of a polyprotic acid. Using equations, describe what this means. (3)

$H_2CO_3 + H_2O \leftrightarrow HCO_3^- + H_3O^+$ **(1)**

$HCO_3^- + H_2O \leftrightarrow CO_3^{2-} + H_3O^+$ **(1)**

An acid that has more than one ionisable hydrogen **(1)**

3. For each of the following equations: (9)

i) label the acids and bases with either an "A" or "B" on the dotted lines provided

ii) show that the acids are Lowry-Bronsted Acids with an arrow showing proton movement for both the forward and reverse reaction

iii) state the conjugate acid/base pair and conjugate base/acid pair

a) $HSO_4^-{}_{(aq)} + OH^-{}_{(aq)} \leftrightarrow SO_4^{2-}{}_{(aq)} + H2O_{(l)}$

A B CB CA

Acid & Conjugate Base pair 1: **HSO_4^-/SO_4^{2-}**

Base & Conjugate Acid pair 2: **OH^-/H_2O**

b) $PH_3{}_{(g)} + HI_{(g)} \leftrightarrow PH_4^+{}_{(s)} + I^-{}_{(s)}$

B A CA CB

Acid & Conjugate Base pair 1: **PH_3/PH_4^+**

Base & Conjugate Acid pair 2: **HI/I^-**

c) $NH_3{}_{(aq)} + H_2O_{(l)} \leftrightarrow OH^-{}_{(aq)} + NH_4^+{}_{(aq)}$

B A CB CA

Acid & Conjugate Base pair 1: **NH_3/NH_4^+**

Base & Conjugate Acid pair 2: **H_2O/OH^-**

4. Formic acid (HCOOH) and ethanoic acid (CH_3COOH) are both monoprotic acids.

The acid dissociation constants Ka and pH of 0.1 M solutions of these two acids are given below:

Acid	pH of 0.1 mol L^{-1} solution	Ka (at 25 °C)
Formic acid (HCOOH)	2.38	1.8×10^{-4}
Ethanoic acid (CH_3COOH)	2.88	1.8×10^{-5}

a) Using the information provided, explain why these two acids are considered to be weak acids. (2)

Both acids have a small equilibrium constant (1)

This means that they only ionise to a small extent (1)

b) Comparing the information given, explain the observed difference in pH values. (3)

- **Formic acid has a slightly larger Ka constant than ethanoic acid, which means that solution of formic acid will ionise to a larger extent and will have a higher concentration of protons (1)**
- **Therefore the pH will be lower (1)**
- **As both acids have the same concentration, this will not affect pH (1)**

5. Consider the following salts: KCl, NH_4NO_3, $LiCH_3COO$, Na_3PO_4,$NaHSO_4$, $Mg(NO_3)_2$

a) Predict whether aqueous solutions of these salts would be acidic, alkaline or neutral (6)

Acidic salt	Neutral salt	Basic salt
NH_4NO_3	KCl	$LiCH_3COO$
$NaHSO_4$	$Mg(NO_3)_2$	Na_3PO_4

b) Choose two salts, one which will produce an acidic solution and one that will produce a basic solution. Write a hydrolysis equation for each. (2)

Salt producing acidic solution:

$NH_4^+ + H_2O \leftrightarrow NH_3 + H_3O^+$

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

Salt producing basic solution:

$CH_3COO^- + H_2O \leftrightarrow CH_3COOH + OH^-$

$PO_4^{3-} + H_2O \leftrightarrow HPO_4^{2-} + OH^-$

6. Calculate the $[H^+]$ and $[OH^-]$ and pH of the following solutions at 25°C: (6)

a) 0.01 mol L^{-1} HCl

$c(H^+) = c(HCl) = 0.01$ mol/L

$c(OH^-) = 10^{-14}/[H^+] = 10^{-14}/0.01 = 10^{-12}$ mol/L

$pH = -\log[H^+] = -\log[0.01] =$ pH 2

b) 4 mol L^{-1} H_2SO_4

$c(H^+) = 2 \times c(H_2SO_4) = 4$ mol/L

$c(OH^-) = 10^{-14}/[H^+] = 10^{-14}/4 = 2.5 \times 10^{-15}$ mol/L

$pH = -\log[H^+] = -\log[4] =$ pH = -0.6

c) 0.5 mol L^{-1} KOH

$c(H^+) = 2 \times c(H_2SO_4) = 4$ mol/L

$c(OH^-) = c(KOH) = 0.5$ mol/L

$[H^+] = 10^{-14}/[OH^-] = 10^{-14}/0.5 = 2 \times 10^{-14}$ mol/L

$pH = -\log[H^+] = -\log[4] =$ pH = 13.7

mark each for correct concentration of H+ and pH
mark for correct concentration of OH- ions

7. Heartburn, which is a symptom of indigestion, can be caused by elevated levels of acid in the stomach. One particular "antacid" from the pharmacy has the following information on its label:

> ***Each 10.0 mL dose contains 350.0 mg of solid magnesium hydroxide and 300.0 mg of solid aluminium hydroxide, suspended in water.***
>
> **The equations for these neutralisation reactions are given below:**

This "antacid" mixture neutralises hydrochloric acid in the stomach. A patient suffering from 'heartburn', a condition that can be related to diet, was found to have a stomach pH of 1.7.

a) What is the hydrogen ion concentration, in mol L^{-1}, of the acid in the stomach? (1)

$pH = -\log [H^+]$

$[H^+] = 0.01995$ mol/L

b) Write two balanced ionic equations to show the reactions between the acid and each of the magnesium hydroxide and aluminium hydroxide compounds. (2)

$Al(OH)_{3\,(s)} + 3\,H^+_{(aq)} \rightarrow Al^{3+}_{(aq)} + 3\,H_2O_{(l)}$ **(1)**

$Mg(OH)_{2\,(s)} + 2\,H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2\,H_2O_{(l)}$ **(1)**

Do not penalise state symbols

c) Assuming that the stomach volume of this person is 1.4 litres, calculate the pH of the stomach after the patient had taken 10.0 mL of the above medication. (For the purposes of this calculation, you may assume that there is no buffer system in the stomach). (9)

$n(Mg(OH)_2)$ = m/M = 0.35/58.326 = 6.001 x 10-3 mol (1)

$n(Al(OH)_3)$ = m/M = 0.3/78.004 = 3.846 x 10-3 mol (1)

$n(OH^-)$total = 2 x $n(Mg(OH)_2$ + 3 x $n(Al(OH)_3)$ = 0.02354 mol (1)

$n(H^+)$ = c x V = 0.01995 mol/l x 1.4 L = 0.02793 mol (1)

$n(H^+) = n(OH^-)$therefore: 0.02793 mol OH^- needed
not sufficient, therefore OH^- limiting (1)

$n(H^+)$ left = $n(H^+)$ added – $n(H^+)$ used

$n(H^+)$ used = $n(OH^-)$ = 0.02354 mol

$n(H^+)$ left = 0.02793 – 0.02354 = 0.00439 mol (1)

$c(H^+)$ = 0.00439 mol/1.4 L = 0.0031357 (1)

pH = 2.5 (1)

two significant figures 2 (1)

d) Stomach acid also be neutralised by taking a “home remedy” of bicarbonate of soda ($NaHCO_3$), in water. Using your knowledge of acid-base reactions, state what the potential “problem” with this ‘home remedy” could be. (1)

Carbon dioxide is produced, may lead to flatulence

8. Some compounds can behave as buffers, that is, they have a buffering capacity.

a) Using only ammonium chloride (NH_4Cl) and ammonia solution (NH_3), state what you would have to consider to make a buffer solution. (2)

equimolar concentrations of both (1)

sufficiently high concentration (1)

b) Would you be able to produce a buffer using hydrochloric acid and sodium chloride? Explain your answer. (2)

No. Buffers are conjugate in nature, i.e. the reaction has to be reversible (1)
HCl is a strong acid and its ionisation is almost complete, therefore not reversible (1)

c) Explain what is meant with the term ‘buffering capacity’. (1)

The ability to keep pH within a small range/withstand changes in pH when small amounts of acid or base are added to a buffer.

END OF TEST