ALL SAINTS' COLLEGE

Answers

Science Department

Year 12 Chemistry 2018

Acids & Bases Test

Name: ______________________________

Instructions to Students:

Attempt all questions
Write in the spaces provided
Show all working when required
All answers to be in blue or black pen, diagrams in pencil.

Multiple Choice	Short Answer	TOTAL	Final Percentage
/11	/49	/60	

Section 1: Multiple Choice **10 marks**

Use the multiple Choice grid provided

1. In which of the following reactions is the underlined species acting as an acid?

   (a) $H_3O^+{}_{(aq)}$ + $\underline{HPO_4}^{2-}{}_{(aq)}$ ⇄ $H_2O(l)$ + $H_2PO_4^-{}_{(aq)}$
   (b) $H_2O_{(l)}$ + $\underline{HCO_3}^-{}_{(aq)}$ ⇄ $H_3O^+{}_{(aq)}$ + $CO_3^{2-}{}_{(aq)}$
   (c) $H_2O_{(l)}$ + $\underline{PH_3}_{(g)}$ ⇄ $PH_4^+{}_{(aq)}$ + $OH^-{}_{(aq)}$
   (d) $H_3O^+{}_{(aq)}$ + $\underline{HS}^-{}_{(aq)}$ ⇄ $H_2O_{(l)}$ + $H_2S_{(aq)}$

2. Two solutions of equal concentration, A and B, have a pH of 3 and 6 respectively. Which of the following statements about the solutions is/are true?

   (i) They are both acidic.
   (ii) The concentration of H^+ is higher in B than it is in A.
   (iii) B is a weaker acid than A.

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

3. The conjugate base of the ion HCO_3^- is which of the following?

   (a) CO_3^{2-}
   (b) H_2CO_3
   (c) OH^-
   (d) H_2O

4. Which of the following would NOT change the pH of 10.0 mL of a dilute hydrochloric acid solution when it is added to the acid?

   (a) 10.0 mL of pure water.
   (b) 10.0 mL of sodium hydroxide solution.
   (c) 10.0 mL of concentrated hydrochloric acid solution.
   (d) 10.0 mL of the same hydrochloric acid solution.

5. Consider the following:

I	PO_4^{3-}
II	HPO_4^{2-}
III	$H_2PO_4^-$
IV	H_3PO_4

The term amphiprotic can be used to describe

(a) I only.
(b) II and III only.
(c) I, II and III only.
(d) II, III and IV only.

6. Consider the following equilibrium for the self-ionization of water:

$$H_2O \rightleftarrows H_3O^+ + OH^- \qquad \Delta H = \text{positive}$$

When water has a pH of 7.5, the temperature is

(a) less than 25°C and the solution is basic.
(b) less than 25°C and the solution is neutral.
(c) greater than 25°C and the solution is basic.
(d) greater than 25°C and the solution is neutral.

7. Which one of the following pairs of substances forms a buffer in aqueous solution?

(a) HCl and NaCl
(b) H_2SO_4 and Na_2SO_4
(c) NH_4Cl and $NaNH_2$
(d) HF and NaF

8. Which one of the following describes the acidity/basicity of a solution of the following compounds when dissolved in distilled water?

	Sodium hydrodensulfate	**Potassium carbonate**	**Magnesium chloride**	**Sodium ethanoate**
(a)	acidic	basic	acidic	basic
(b)	acidic	basic	neutral	basic
(c)	basic	acidic	neutral	acidic
(d)	basic	acidic	basic	acidic

9. The concentration of tartaric acid in a sample of diluted wine was determined by titration against a solution of sodium hydroxide. The sodium hydroxide solution was placed in the burette and the diluted wine sample was pipetted into the conical flask.
Which of the following options shows the correct rinsing of glass equipment prior to titration?

	Burette	**Pipette**	**Conical flask**
	Rinsed with		
(a)	Distilled water followed by NaOH solution	Distilled water followed by wine	Distilled water only
(b)	Distilled water followed by NaOH solution	Distilled water only	Distilled water followed by diluted wine
(c)	Distilled water followed by NaOH solution	Distilled water followed by diluted wine	Distilled water only
(d)	Distilled water followed by diluted wine	Distilled water followed by NaOH solution	Distilled water only

10. The properties of a primary standard for use in an acid-base titration include:

(a) reactivity with carbon dioxide in the air and low molar mass
(b) high stability and high purity
(c) low molar mass and low solubility
(d) high purity and ability to absorb water from the air

Section 2: Short Answers **49 Marks**

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

   (a) A solution of sulfuric acid is added to solid copper (II) oxide. (3)

   Equation: **$2\ H^+_{(aq)}\ +\ CuO_{(s)}\ \text{-->}\ Cu^{2+}_{(aq)}\ +\ H_2O_{(l)}$**

   Observation: a clear colourless solution is added to a black solid and a blue solution is produced

   (b) Acetic acid is added to magnesium carbonate solid. (3)

   Equation:

   $2\ CH_3COOH_{(aq)}\ +\ MgCO_{3(s)}\ \text{-->}\ Mg^{2+}_{(aq)}\ +\ 2\ CH_3COO^-_{(aq)}\ +\ CO_{2(g)} + H_2O_{(l)}$

   Observation: a colourless solution is added to a white solid, effervescence produced in a colourless solution

2. Carbonic acid, H_2CO_3, is an example of a polyprotic acid.

   (a) With the aid of equations, describe what it means that carbonic acid is polyprotic. (4)

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

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

   - **Carbonic acid has 2 ionisable hydrogen (1)**
   - **These are removed in 2 separate stages (1)**

   (b) The acid constant, Ka for the first ionisation of carbonic acid is 4.5×10^{-7}, while the Ka constant for the first ionisation of phosphoric acid is 7.5×10^{-3}. If both acids are present at the same concentration, which of the two would have the lower pH? Explain your answer. (3)

   - **Phosphoric acid would have the lower pH (1)**
   - **Phosphoric acid has the larger Ka, therefore products are more favoured, therefore the concentration of [H3O+] will be higher (1)**
   - **Resulting in a lower pH (1)**

3. Consider the following salts: K_3PO_4, NH_4NO_3, Na_2SO_4, KH_2PO_4, $Mg(NO_3)_2$, $CaCl_2$.

a) Explain what is meant with the term 'salt hydrolysis' and how this affects the pH of an aqueous salt solution. (2)

- **Salt hydrolysis is when ions in a salt are interfering with the self-ionisation of water (1)**
- **This can cause an imbalance in the concentrations of [H+] and [OH-], thereby affecting pH (1)**

b) Choose two salts from the list above, one which will produce an acidic solution and one that will produce a basic solution.
Write a hydrolysis equation for each.

i) Salt producing acidic solution: **NH_4NO_3**

Hydrolysis equation:

$NH_4^+ + H_2O \leftrightarrow NH_3 + H_3O^+$ (2)

ii) Salt producing basic solution: **K_3PO_4 or Na_2SO_4**

Hydrolysis equation:

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

$SO_4^{2-} + H_2O \leftrightarrow HSO_4^- + OH^-$ (2)

4. Calculate the pH of the resulting solution when 500.0 mL of 0.250 mol L^{-1} HNO_3 is mixed with 550.0 mL of 0.200 mol L^{-1} $Ba(OH)_2$. (9)

- **$Ba(OH)_2$ + 2 HNO_3 --> $Ba(NO_3)_2$ + 2 H_2O (1)**
- **n($Ba(OH)_2$) = c x V = 0.2 x 0.55 = 0.11 mol (1)**
- **n(HNO_3) = c x V = 0.25 x 0.5 = 0.125 mol (1)**
- **n($Ba(OH)_2$) = ½ x n(HNO_3) = 0.0625 mol required**
- **More is available; therefore HNO_3 is limiting (1)**
- **n($Ba(OH)_2$) Xs = n($Ba(OH)_2$ added) - n($Ba(OH)_2$, used)**

  = 0.11 - 0.0625 = 0.0475 mol (1)
- **n(OH^-) = 2 x n($Ba(OH)_2$) = 2 x 0.0475 = 0.095 mol (1)**
- **c(OH^-) = n/V = 0.095 mol/1.05 L = 0.09048 mol/L (1)**
- **c(H^+) = 10^{-14}/0.09048= 1.1052 x 10^{-13} mol/L (1)**
- **pH = -log[H^+] = 13.0 (1)**

5. Buffer solutions are necessary to keep the correct pH for effective bodily functions to be maintained.

In the body, the most common metabolic process involving the production of substances that change the pH of blood is respiration. One of the products of respiration, carbon dioxide, is acidic and lowers the pH of body fluids.

The buffer system that is most important in keeping the pH of blood constant during respiration is the carbonic acid/hydrogencarbonate ion buffer found in blood plasma, which must maintain a pH of between 7.35 and 7.45.

$$CO_{2\,(g)} + H_2O_{\,(l)} \rightleftarrows H_2CO_{3\,(aq)}$$

$$H_2CO_{3\,(aq)} + H_2O_{\,(l)} \rightleftarrows H_3O^+_{\,(aq)} + HCO_3^-{}_{\,(aq)}$$

(a) What is the buffer capacity of a system? (2)

The ability of a solution to resist a change in pH (1)

When small amounts of acid or base are added to it (1)

(b) During strenuous exercise, more carbon dioxide is produced in respiration, causing an increase in the concentration of H_3O^+.
Use Le Chatelier's Principle to predict how the blood plasma buffer would respond to this change. Use an equation. (3)

- **$H_3O^+_{\,(aq)} + HCO_3^- \rightleftarrows H_2CO_{3\,(aq)} + H_2O_{\,(l)}$ (1)**
- **An increase in the concentration of H3O+ would shift the equilibrium to the right using up the additional H3O+ (1)**
- **and thereby keeping the pH constant (1)**

6. A sample of 1.10 g of impure magnesium oxide was dissolved in 25.0 mL of 3.2 mol L^{-1} hydrochloric acid. The resulting solution was diluted to 250 mL in a volumetric flask. From this diluted solution, 20.0 mL aliquots were taken and titrated with the 0.102 mol L^{-1} sodium hydroxide solution to reach the end-point. The results of this titration are shown in the table below:

Trial	Rough	Two	Three	Four	Five
Volume of NaOH (mls)	25.10	24.85	24.65	24.95	24.80

(a) Calculate the average titre volume for the sodium hydroxide solution: (1)

Titre = (24.85 + 24.95 + 24.80)/3 = 24.87 mL

(b) Write a molecular equation for the reaction between magnesium oxide and the hydrochloric acid. (1)

$MgO + 2\ HCl \rightarrow MgCl_2 + H_2O$

(c) Calculate the mass of magnesium oxide in the original sample. (7)

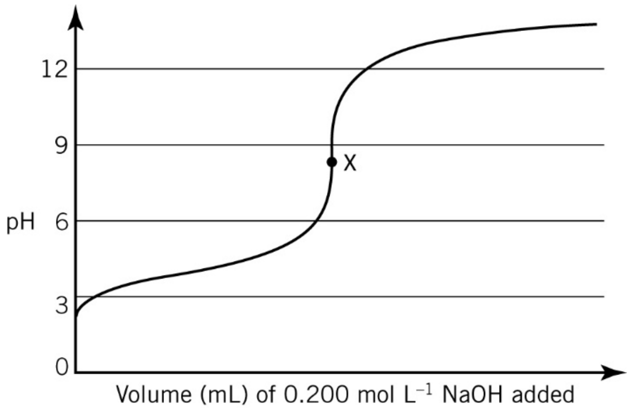
- **n(NaOH) = c x V = 0.102 x 0.02487 = 2.5367 x 10^{-3} mol (1)**
- **n(HCl) = n(NaOH) = 2.5367 x 10^{-3} mol (1)**
- **n(HCl) in volumetric flask = 2.5367 x 10^{-3} mol x 250/20 = 0.03171 mol (1)**
  this is the excess
- **n(HCl, added) = (0.025 x 3.2) = 0.08 mol (1)**
- **n(HCl) used to neutralise MgO = n(HCl, added) – n(HCl, xs)**
  n(HCl, used) = 0.08 - 0.0371 mol = 0.0429 mol (1)
- **n(MgO) = ½ x n(HCl) = ½ x 0.0429 = 0.02145 mol (1)**
- **m(MgO) = n x M = 0.02145 mol x 40.31 = 0.8646 g (1)**

(d) Calculate the percentage purity of magnesium oxide of the original sample. Quote your result to the appropriate number of significant figures (2)

- **% purity = 0.8646/1.10 x 100 = 78.6 (1)**
  = 79% (2 SF) (1)

7. Benzoic acid is a weak acid used as a preservative, for example in soft drinks. In aqueous solution it dissociates according to the equation:

$$C_6H_5COOH(aq) \rightleftharpoons C_6H_5COO^-(aq) + H^+(aq)$$



The graph shows the changes in pH that occur when 20.00 mL of 0.100 mol L^{-1} benzoic acid solution in a conical flask is titrated with 0.200 mol L^{-1} NaOH solution from a burette.

(a) Calculate the volume of the sodium hydroxide that has been added to the conical flask at point X. (3)

n(benzoic acid) = c x V = 0.1 x 0.02 = 0.002 mol (1)
n(NaOH) = n(benzoic acid) (1)
V(NaOH) = n/c = 0.002/0.2 = 0.01 L (1)

(b) For the indicator bromophenol blue, the pH range for the colour change is 3.0 (yellow) to 4.6 (blue).
Would this be a suitable indicator for this titration of benzoic acid with sodium hydroxide? Explain your answer. (3)

- **No (1)**
- **The equivalence point for this titration will be above pH 7 as it is a titration between a weak acid and strong base. (1)**
- **The endpoint of the indicator is below pH 7 (1)**

END OF TEST