Chemistry Department
Christ Church Grammar School

Year 12
2020

Acids & Bases Topic Test

Time allowed: 45 minutes

Instructions
Please ensure you enter your name and circle your teacher's initials below.
Scientific calculators only. Chemistry Data Sheet will be provided

Name

ANSWERS

Teacher: (circle)

CEM NMO KLD MXC

Mark:_____ / 41

CCGS Year 12 Chemistry 2020 Acids and Bases Test

Section 1: Multiple Choice **(Total 10 marks)**

1. Consider the following reaction:

$$HCN_{(aq)} + H_2O_{(\ell)} \rightleftharpoons H_3O^+_{(aq)} + CN^-_{(aq)}$$

Which of the species in the equations shown are acting as bases?

A. $HCN_{(aq)}$ and $H_2O_{(\ell)}$
B. $H_2O_{(\ell)}$ and $CN^-_{(aq)}$
C. $CN^-_{(aq)}$ and $HCN_{(aq)}$
D. $HCN_{(aq)}$ and $H_3O^+_{aq)}$

2. The conjugate base of the species $H_2PO_4^-{}_{(aq)}$ is:

A. $PO_4^{3-}{}_{(aq)}$
B. $H_3PO_{4(aq)}$
C. $H_2PO_4^-{}_{(aq)}$
D. $HPO_4^{2-}{}_{(aq)}$

3. The strength of an acid is determined by:

A. the number of hydrogen atoms in the formula of the acid
B. the concentration of the acid
C. the degree of ionisation in aqueous solution
D. the purity of the acid

4. Which species is likely to be **most** abundant in 1 mol L^{-1} NH_4Cl solution?

a) NH_4^+
b) Cl^-
c) NH_3
d) H_3O^+

5. Which of the following compounds, when dissolved in water, would not form a solution with a pH less than 7?

I NH_4NO_3
II Na_2CO_3
III $Ba(OH)_2$
IV NH_3

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

6. The table below lists the pH of 0.00001 $molL^{-1}$ solutions of four acids:

Acid solution	pH
I	4.0
II	3.5
III	5.0
IV	3.0

The acid that cannot be monoprotic and weak is

A. I
B. II
C. III
D. IV

7. Which of the following solutions will have the lowest pH at 25°C?

A. 0.10 mol L^{-1} H_2SO_4
B. 0.05 mol L^{-1} H_3PO_4
C. 0.20 mol L^{-1} HNO_3
D. 0.20 mol L^{-1} CH_3COOH

8. Propanoic acid and benzoic acid are both monoprotic weak acids whose equilibrium constants are listed below:

* Propanoic acid $C_3H_7COOH + H_2O \rightleftharpoons H_3O^+ + C_3H_7COO^-$; $K = 1.35 \times 10^{-5}$
* Benzoic acid $C_6H_5COOH + H_2O \rightleftharpoons H_3O^+ + C_6H_5COO^-$; $K = 6.31 \times 10^{-5}$

Which of the following statements is true?

A. Benzoic acid is a weaker acid than propanoic acid.
B. The pH of a 0.100 $molL^{-1}$ solution of benzoic acid will be higher than that of a 0.100 $molL^{-1}$ solution of propanoic acid.
C. The benzoate ion is a stronger base than the propanoate ion.
D. A 0.100$molL^{-1}$ solution of benzoic acid will react faster with a piece of magnesium metal than will a 0.100$molL^{-1}$ solution of propanoic acid with an identical piece of magnesium.

9. A substance which can accept and donate a proton is amphiprotic. Which of the following species are amphiprotic?

I H_2O
II The hydrogencarbonate ion
III The hydroxide ion
IV The ethanoate ion

A. I, II and III only
B. I, III and IV only
C. II and III only
D. all of them

10. Which of the options below best describes the solutions of the three salts?

	$KC\ell$	Na_2SO_4	NH_4NO_3
A.	✓ neutral	✓ basic	✓ acidic
B.	acidic	acidic	acidic
C.	✓ neutral	acidic	acidic
D.	✓ neutral	✓ basic	basic

END OF SECTION ONE

Section 2: Short Answer **(Total 32 marks)**

Question 1 **4 marks**

Write a balanced ionic equation and observations for the reaction between ammonium sulfate solution and barium hydroxide. solution.

Equation:

$2NH_4^+ + SO_4^{2-} + Ba^{2+} + 2OH^- \longrightarrow 2NH_3 + 2H_2O + BaSO_4$

Observations:

Two colourless solutions are mixed. A white precipitate and a pungent smelling gas are produced in a colourless solution.

Question 2 **6 marks**

The pH of pure water at 90°C is 6.13.

(a) What is the K_w, the equilibrium constant for water, at 90°C ? Show all working.

$[H^+] = 10^{-6.13} = 7.41 \times 10^{-6}$

$K_w = [H^+][OH^-]$ For pure water $[H^+] = [OH^-]$

$\therefore K_w = (7.41 \times 10^{-6})^2$

$= 5.50 \times 10^{-13}$

(3 marks)

(b) Using this information determine whether the self ionization of water:

$$H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$$

is an exothermic or endothermic reaction. Explain your answer.

As K_w is larger at higher temperature, the equilibrium position has shifted to the right towards products. As the endothermic direction is favoured by an increase in T, the self-ionisation of water is endothermic (or collision theory).

(3 marks)

Question 3 **6 marks**

(a) Chloroethanoic ($CH_2ClCOOH$) is a monoprotic weak acid. A 0.100 $molL^{-1}$ solution of chloroethanoic acid has a pH of 1.93 (at 25°C). Calculate the percentage of chloroethanoic molecules that is ionised.

$[H^+] = 10^{-1.93} = 0.0117\ mnL^{-1}$

% ionisation $= \frac{0.0117}{0.100} \times 100 = 11.75\%$.

(2 marks)

(b) Two experiments were conducted that measured the rate of reaction of acids with magnesium carbonate solid. In this experiment, the acid used was the independent variable. Hydrochloric acid was used in **Experiment 1** whilst chloroethanoic acid was used in **Experiment 2**. All other variables were adequately controlled.

(i) The initial rate of **Experiment 2** was:

higher the same (lower) (circle your answer)

than **Experiment 1.**

(ii) The mass of the hydrogen produced was found to be

higher (the same) lower (circle your answer)

than in **Experiment 2.**

(2 marks)

(iii) Explain your response to (i).

As chloroethanoic, is a weak acid, the $[H^+]$ is lower than hydrochloric acid which is strong. The frequency of collisions for HCl would be much higher than for chloroethanoic acid and so the rate would be higher in Experiment 1, lower in 2 than 2 than 1.

(2 marks)

Question 4 **6 marks**

(a) What is the pH of 100 mL of 0.001 $molL^{-1}$ nitric acid?

$pH = 1 - \log(1 \times 10^{-3}) = 3$

(1 mark)

(b) Calculate the number of moles of H_3O^+ in the nitric acid in (a).

$n(H_3O^+) = 0.1 \times 1 \times 10^{-3} = 1 \times 10^{-4}$ mol.

(1 mark)

(c) Calculate the number of moles of OH^- in 70 mL of 0.001 $molL^{-1}$ potassium hydroxide.

$n(OH^-) = 0.07 \times 0.001 = 7 \times 10^{-5}$ mol.

(1 mark)

(d) Calculate the pH of the solution produced by mixing the potassium hydroxide and nitric acid together.

$H_3O^+ > OH^-$ → unreacted $n(H_3O^+) = 1 \times 10^{-4} - 7 \times 10^{-5}$

$n(H_3O^+) = 3 \times 10^{-5}$ ✓

Total volume = 170 mL ∴ $[H_3O^+] = \frac{3 \times 10^{-5}}{0.170}$

$= 1.765 \times 10^{-4}$

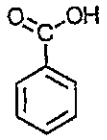
(3 marks)

$pH = -\log(1.765 \times 10^{-4})$

$= 3.75$

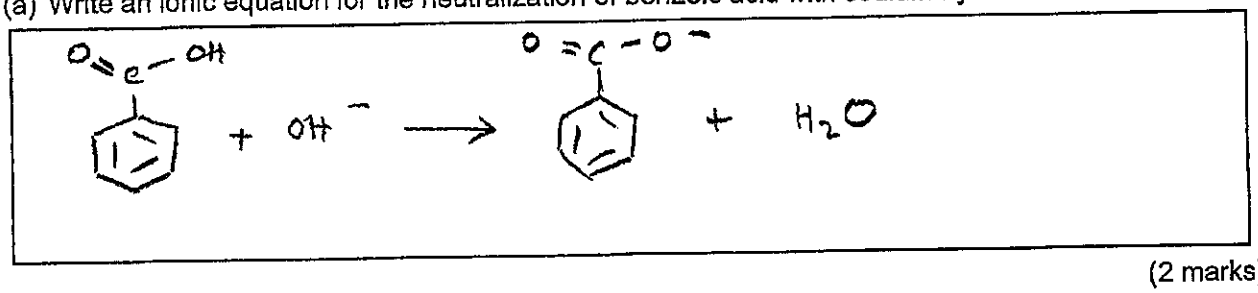
Question 5 **10 marks**

Benzoic acid is a weak acid and its structure is shown below. A buffer can be made by adding sodium hydroxide solution to benzoic acid.



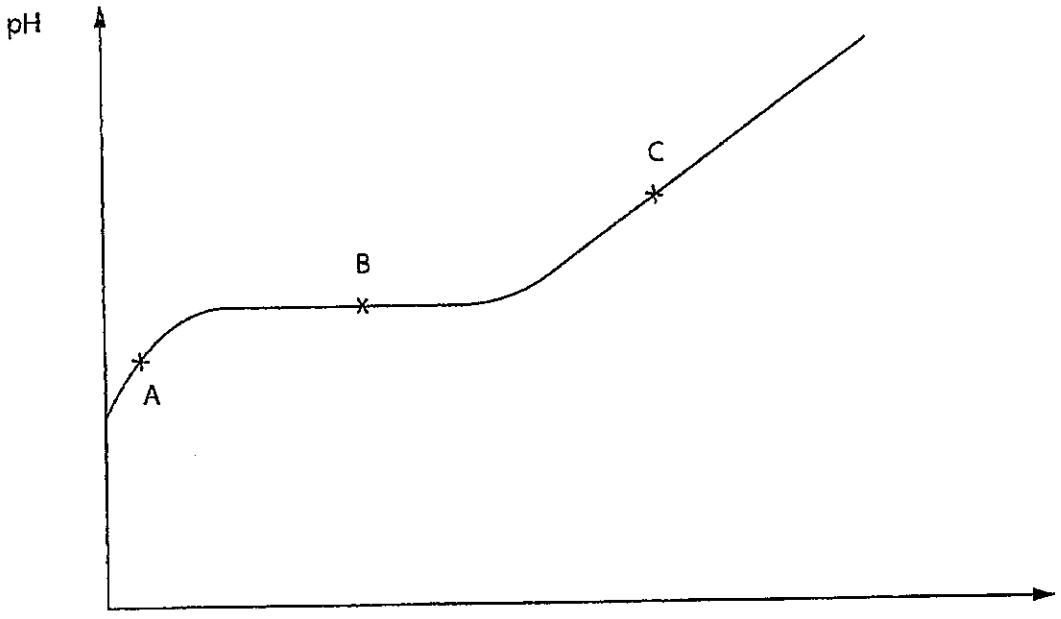
benzoic acid
(C_6H_5COOH)

(a) Write an ionic equation for the neutralization of benzoic acid with sodium hydroxide.



(2 marks)

(b) Adding sodium hydroxide to benzoic acid results in a buffer solution being formed. Using a pH meter, the following graph was produced. Three points A, B and C are marked on the graph.



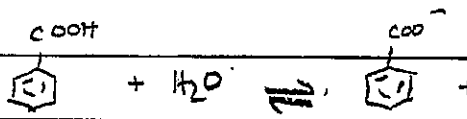
Using your knowledge of buffers, complete the table by writing one of the symbols =, > or < in the boxes below.

Point on graph	Concentration of species		
A	C_6H_5COOH	>	$C_6H_5COO^-$
B	C_6H_5COOH	=	$C_6H_5COO^-$
C	C_6H_5COOH	<	$C_6H_5COO^-$

(3 marks)

(c) Using relevant equations and appropriate theory, explain why the pH of the mixture at point B is resistant to further change to pH by addition hydroxide ions.

WACE accepted (but better answer)



✓ + H_2O ⇌ + H_3O^+ (1)

At point B, the buffer system shown above (1) is produced. When hydroxide ions are added they react with H_3O^+ which decreases the concentration of H_3O^+ in solution (2). This ✓ reduces the rate of the reverse reaction ✓ while the fwd rxn initially remains unaffected so more H_3O^+ is produced than consumed. ✓

$H_3O^+ + OH^- \longrightarrow 2H_2O$. (2)

✓ Once equilibrium is re-established there has been no significant decrease in $[H_3O^+]$ and so pH does not change significantly. (5 marks)

Explanations: using:

+ OH^- accepted. (WACE preferred)

END OF TEST

[Benzoic] ↓ & [Benzoate] ↑ accepted.