REVISED!

Chemistry Department
Christ Church Grammar School

Year 12
2022

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 (MARKING KEY)

8/4/2022

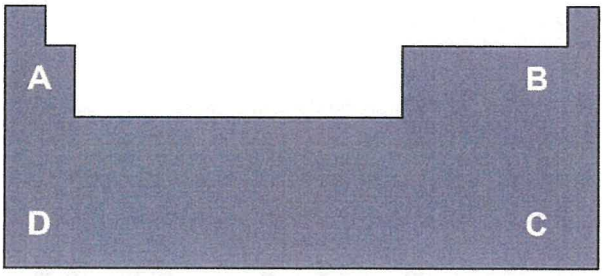
Teacher: (circle)

MXC NMO BLR

Mark:_____ / 42

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

1. The diagram below shows four regions on the Periodic Table. Which of these regions would produce the most acidic oxides?



(a) Region A
(b) Region B
(c) Region C
(d) Region D

2. If Solution **X** has a pH of 3 and Solution **Y** has a pH of 6, we can conclude that

(a) $[H^+]$ in Solution **X** is 1000 times that of $[H^+]$ in Solution **Y**.
(b) $[H^+]$ in Solution **X** is half that of $[H^+]$ in Solution **Y**.
(c) $[OH^-]$ in Solution **Y** is twice that of $[OH^-]$ in Solution **X**.
(d) Solution **Y** must contain a stronger acid than Solution **X**.

3. What is the pH of a solution of barium hydroxide with a concentration of 0.1 mol L^{-1}?

(a) 13.3
(b) 9.0
(c) 12.7
(d) 13.0

4. Which of the following statements about aqueous solution of weak acids is true?

(a) A weak acid is a concentrated acid that has been diluted.
(b) A 1.00 mol L^{-1} solution of a weak acid contains more molecules of acid than ions.
(c) Less than 1.0 mol of sodium hydroxide is required to react completely with 1.0 mol of a monoprotic weak acid.
(d) The salt produced through the neutralisation of a weak acid by a strong base is slightly acidic.

5. Which of the substances in bold is acting as a Bronsted-Lowry acid?

(a) $\mathbf{CH_3CH_2NH_2}(aq) + H_2O(l) \rightleftharpoons CH_3CH_2NH_3^+(aq) + OH^-(aq)$

(b) $2\mathbf{H_2O}(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

(c) $H_2S(aq) + NH_3(aq) \rightleftharpoons \mathbf{HS^-}(aq) + NH_4^+(aq)$

(d) $H_2CO_3(l) + H_2O(l) \rightleftharpoons H_3O^+(l) + \mathbf{HCO_3^-}(aq)$

6. Which of the following solutions contains hydroxide ions?

(i) 2 mol L^{-1} HNO_3

(ii) pure water at 50°C

(iii) 0.1 mol L^{-1} NaCl

(iv) 3.0 mol L^{-1} NH_4NO_3

(a) (iv) only

(b) (ii) and (iv)

(c) (ii) and (iii)

(d) all of them

7. Which of the following correctly lists the expected pH of solutions of a series of salts at 25°C?

	Potassium carbonate	Lithium chloride	Ammonium nitrate	Sodium phosphate
(a)	Less than 7	neutral	less than 7	greater than 7
(b)	greater than 7	neutral	less than 7	greater than 7
(c)	greater than 7	greater than 7	more than 7	less than 7
(d)	less than 7	less than 7	less than 7	less than 7

8. Which of the following can be used to prepare a buffer solution with the highest buffer capacity?

(a) 100mL of 0.1 mol L^{-1} NH_3 and 50mL of 0.1 mol L^{-1} HCl

(b) 50mL of 0.1 mol L^{-1} NH_3 and 100mL of 0.1 mol L^{-1} HCl

(c) 100mL of 0.1 mol L^{-1} NH_3 and 100mL of 0.1 mol L^{-1} CH_3COOH

(d) 50mL of 0.1 mol L^{-1} NH_3 and 50mL of 0.1 mol L^{-1} HCl

9. Which one of the following statements about 1.00×10^{-8} mol L^{-1} HCl is correct?

(a) The pH is 6

(b) The pH is a little less than 7

(c) The pH is 8

(d) Such a solution cannot exist

10. The pH of pure water, measured at 50°C, is about 6.6. Which of the following is true?

(a) The concentration of hydroxide ions is lower at 50°C than at 25°C.

(b) This proves that the self-ionisation of water is an exothermic reaction.

(c) The water is acidic.

(d) Kw at 50°C is higher than it is at 25°C.

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

Question 1 **4 marks**

Hydroiodic acid, HI, has a K_a of 3.2×10^9 at 25°C and is highly soluble in water.

(a) Write an equation showing hydroiodic acid behaving as a Bronsted-Lowry acid. (1 mark)

$HI + H_2O \longrightarrow H_3O^+ + I^-$

(b) Write the expression for K_a. (1 mark)

$$K_a = \frac{[H_3O^+][I^-]}{[HI]}$$

(c) State if hydroiodic acid is a strong or weak acid and briefly explain how you know this. (2 marks)

HI is strong ✓

Ka is large meaning there is a significant amount of ionisation / large [ ] of products vs. reactants ✓

(or words to that effect).

Question 2 **7 marks**

(a) Consider the following acids and their K_a values.

Iodic acid, HIO_3 $K_a = 1.6 \times 10^{-1}$ – LARGER
Nitrous acid, HNO_2 $K_a = 7.2 \times 10^{-4}$ – SMALLER,

(i) Rank the salt solutions of equal concentration given below from highest to lowest pH. (3 marks)

KNO_2 KIO_3 NH_4NO_2 $Ca(NO_2)_2$

Highest $Ca(NO_2)_2$ KNO_2 KIO_3 NH_4NO_2 Lowest

(ii) Explain the placement of the solution with the highest pH. Use suitable chemical equations to support your answer. (4 marks)

Highest:

From Ka values HIO_3 is the stronger acid and HNO_2 the weaker ✓ The conjugate base of HNO_2 is therefore stronger than that of HIO_3 ✓ and would produce more OH^- ions as shown below:

$NO_2^- + H_2O \longrightarrow HNO_2 + OH^-$ ✓

As $Ca(NO_2)_2$ produces 2 NO_2^- ions for every $Ca(NO_2)_2$, the concentration of NO_2^- will be highest and consequently the $[OH^-]$ ✓ will also be highest. This means the $[H_3O^+]$ will be lower and as $pH = -\log [H_3O^+]$ the pH will be highest.

Question 3 **8 marks**

Naturally occurring calcite is crystalline calcium carbonate. 25.00 mL of dilute hydrochloric acid was added to 0.6342 g of calcite which was in excess. The reaction, shown below, ceased after 2 minutes. The unreacted solid was filtered and washed. It was then dried at 120°C to a constant mass of 0.392 g.

$$CaCO_3\,(s) + 2H^+(aq) \longrightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$$

(a) Using this information determine the pH of the dilute hydrochloric acid solution that was used. (5 marks)

$m(CaCO_3)_{reacted} = 0.6342 - 0.392 = 0.2422$ g (1)

$n(CaCO_3)_{reacted} = 0.2422 / 100.09 = 2.4198 \times 10^{-3}$ mol (1)

$n(HCl) = 2 \times n(CaCO_3) = 2 \times 2.4198 \times 10^{-3} = 4.8396 \times 10^{-3}$ mol

$n(HCl) = n(H^+) \rightarrow [H^+] = \dfrac{4.8396 \times 10^{-3}}{25 \times 10^{-3}}$ (1)

$[H^+] = 0.19536$ mol L^{-1} (1)

$pH = -\log[0.19536] = 0.71$ (1)

(b) If the hydrochloric acid was replaced by ethanoic acid of the same concentration, would you expect the reaction to be complete in 2 minutes as described above? Explain your answer. (3 marks)

No. ✓

Ethanoic acid is a weak acid and only partially ionises. As a result the $[H_3O^+]$ is less than for HCl ✓ and so less frequent collisions occur ✓ meaning a lower rate of rxn.

Question 4 **6 marks**

A student investigating buffers prepared a buffer by dissolving ammonium chloride in ammonia solution, establishing the following equilibrium:

$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

She tested her buffer by adding KOH solution, 5 drops at a time, and measured the pH of the mixture with a pH meter. After the addition of 25 drops of KOH the pH of the buffer solution had only increased by 0.1.

(a) Describe how this buffer is able to withstand a significant change in pH when the potassium hydroxide solution is added.

As OH^- is added, the frequency of collisions for the reverse rxn and consequently the rate increases. while the forward rxn initially is unaffected. This means OH^- ions are consumed more rapidly than they are produced reducing their concentration until equilibm is re-established. This results in a small change in OH^- concentration and pH does not change significantly as a result.

(4 marks)

(b) State the two factors to give a buffer the highest possible buffer capacity.

(1) highest concentration

(2) equimolar amounts of acid & conjugate base

(2 marks)

*The wording of this question is interpretable in two ways. 2:1 base : acid was the intended meaning but 1:2 base : acid will also be accepted.

Question 5 **7 marks**

A strong acid with a pH of 6 has double the volume of a strong base with a pH of 8 added to it. Determine the pH of the resultant solution. *

Let volumes be 1L & 2L

$[H^+]_{acid} = 1 \times 10^{-6}$ mol L^{-1} ✓

$[H^+]_{base} = 1 \times 10^{-8}$ mol L^{-1} so...

$[OH^-]_{base} = 1 \times 10^{-6}$ mol L^{-1} ✓

$n(H^+)_{acid} = 1 \times 10^{-6} \times 1 = 1 \times 10^{-6}$ mol ✓

$n(OH^-)_{base} = 1 \times 10^{-6} \times 2 = 2 \times 10^{-6}$ mol

∴ OH^- is in XS.

$n(OH^-)_{left} = 2 \times 10^{-6} - 1 \times 10^{-6}$

$= 1 \times 10^{-6}$ mol L^{-1} ✓

$[OH^-] = \frac{1 \times 10^{-6}}{3} = 3.33 \times 10^{-7}$ ✓

∴ $[H^+] = \frac{1 \times 10^{-14}}{3.33 \times 10^{-7}} = 3 \times 10^{-9}$ ✓

$pH = -\log [3 \times 10^{-9}]$

$= \boxed{8.52}$

Let volumes be 1L & 2L

$[H^+]_{acid} = 1 \times 10^{-6}$ ✓

$n(H^+)_{acid} = 2 \times 10^{-6}$ ✓

$[H^+]_{base} = 1 \times 10^{-8}$ ✓ ∴ $[OH^-] = 1 \times 10^{-6}$ ✓

$n(OH^-)_{base} = 1 \times 10^{-6}$

∴ H^+ is in XS.

$n(H^+)_{left} = 2 \times 10^{-6} - 1 \times 10^{-6}$ ✓

$= 1 \times 10^{-6}$

$[H^+] = \frac{1 \times 10^{-6}}{3} = 3.33 \times 10^{-7}$ ✓

$pH = -\log [3.33 \times 10^{-7}]$

$= \boxed{6.47}$

END OF TEST