Australian Islamic College 2019

ATAR Chemistry Units 3 and 4

Task 4 (Weighting: 3%)

Acids and Bases Test

Test Time: 40 minutes

Please do not turn this page until instructed to do so.

First Name	Surname
ANSWERS	

Student Number

Mark / 46	Percentage

Equipment allowed: Pens, pencils, erasers, whiteout, rulers and non-programmable calculators permitted by the Schools Curriculum and Standards Authority.

Special conditions:

2 marks will be deducted for failing to write your full name on this test paper.

Teacher help: Your teacher can only help you during your test in one situation.

> If you believe there is a mistake in a question show your teacher and your teacher will tell you whether or not there is a mistake in the question and if appropriate, how to fix that mistake.

Spelling of Science words should be correct. Science words with more than one letter wrong (wrong letter and/or wrong place) will be marked wrong.

Equations must be written balanced and with correct state symbols or they will be marked wrong.

Questions must be answered in this booklet.

Total marks: 46

PART ONE: MULTIPLE CHOICE **(13 marks)**

Answer the questions by marking the corresponding letter of your selected answer on the answer sheet provided.

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1. A student measured the pH of two solutions. One solution was 1.00 x 10^{-4} mol L^{-1} nitric acid and the other was 1.00 mol L^{-1} oxalic acid. She found that both had similar pH values. Which of the following is the best explanation for this result?

    a. They are both strong acids so they will give similar pH readings.
    b. The oxalic acid is a monoprotic acid, resulting in a low pH.
    c. There must have been an error in her recording.
    d. The nitric acid solution has a low concentration of a strong acid and the oxalic acid solution has a high concentration of a weak acid.

2. Which of the following is likely to have the most acidic oxide?

    a. Ca
    b. Cr
    c. Cu
    d. Cl

3. Which of the following mixtures is likely to be the most effective buffer?

    a. 1 mol L^{-1} HCl and 1 mol L^{-1} NaCl
    b. 0.01 mol L^{-1} of CH_3COOH and 0.01 mol L^{-1} of $NaCH_3COO$
    c. 1 mol L^{-1} of CH_3COOH and 1 mol L^{-1} of $NaCH_3COO$
    d. 1 mol L^{-1} HCl and 1 mol L^{-1} NaOH

4. A buffer solution is prepared by mixing equal moles of sodium ethanoate and ethanoic acid in water. Which one of the following statements applies to the buffer?

    a. Increasing the concentration of sodium ethanoate and ethanoic acid will reduce its buffering capacity.
    b. The sodium ions play a significant role in the buffering action.
    c. Addition of a few drops of concentrated nitric acid will produce more acetic acid molecules.
    d. Most of the hydronium ions will be supplied by water.

5. Water will ionise according to the following reaction, which is endothermic in the forward direction.

    $$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

    Which of the following statements concerning this process is true?

    a. Adding a soluble base to water will cause the forward reaction to be favoured.
    b. Addition of a few drops of a strong acid will increase the value of K.
    c. At 25 ^oC the value of $[H_3O^+]$ is 1.00 x 10^{-14} mol L^{-1}.

d. An increase in temperature causes an increase in $[H_3O^+]$.

6. Assuming equal concentrations, which of the following salt solutions would have the lowest pH?

   a. $NaCH_3COO$
   b. NH_4Cl
   c. NH_4CH_3COO
   d. Na_3PO_4

7. Which of the following is the strongest acid?

	Acid	**K_a**
(a)	CH_3COOH	1.8×10^{-5}
(b)	HCO_3^-	5.6×10^{-11}
(c)	HF	6.8×10^{-4}
(d)	**$H_2C_2O_4$**	**5.4×10^{-2}**

8. Consider the following reaction.

   $$OBr^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HOBr_{(aq)} + OH^-_{(aq)}$$

   Which one of the following represents an acid-base conjugate pair for this reaction?

   a) OBr^-/H_2O
   b) $HOBr/OH^-$
   c) H_2O/OH^-
   d) OBr^-/OH^-

9. Which one of the following equations is the correct representation for the ionisation of a weak acid?

   a. $HCl_{(aq)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$
   b. $H_2C_2O_{4(aq)} + H_2O_{(l)} \rightleftharpoons HC_2O_4^-{}_{(aq)} + H_3O^+_{(aq)}$
   c. $HCl_{(aq)} + H_2O_{(l)} \rightleftharpoons Cl^-_{(aq)} + H_3O^+_{(aq)}$
   d. $H_2C_2O_{4(aq)} + H_2O_{(l)} \rightarrow HC_2O_4^-{}_{(aq)} + H_3O^+_{(aq)}$

10. Which one of the following substances can behave as both a Brønsted-Lowry acid and a Brønsted-Lowry base?

    a. H_2O_2
    b. NH_4^+
    c. H_3PO_4
    d. $H_2PO_4^-$

11. In which of the following is water behaving as a Bronsted-Lowry acid?

    a. $H_2O_{(g)} + C_{(s)} \rightarrow H_{2(g)} + CO_{(g)}$
    b. $H_2O_{(l)} + NH_{3(g)} \rightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$
    c. $H_2O_{(l)} + NH_4^+{}_{(aq)} \rightarrow H_3O^+{}_{(aq)} + NH_{3(g)}$
    d. $H_2O_{(l)} + HCl_{(aq)} \rightarrow H_3O^+{}_{(aq)} + Cl^-{}_{(aq)}$

12. The pH of a 0.01 M solution of sodium hydroxide at 25 ^oC is:

    a. 3
    b. 11
    c. 12
    d. 14

13. According to the Arrhenius definition, a base is a substance with OH in its formula which releases hydroxide ions when dissolved in water. Which of the following substances contradicts this definition?

    a. Ammonia
    b. Barium hydroxide
    c. Citric acid
    d. Calcium hydroxide

END OF PART ONE

PART TWO: SHORT RESPONSE **(33 marks)**

Answer all questions in the spaces provided.

1. Complete the table by writing the formula for the conjugate base, species X or conjugate acid in each blank space as appropriate. Species X is the species that is able to form both a conjugate base and a conjugate acid. (6 marks)

Conjugate Acid	Species X	Conjugate Base
$H_2BO_3^-$	**HBO_3^{2-}**	**BO_3^{3-}**
H_2SO_3	HSO_3^-	**SO_3^{2-}**
$H_2C_4H_4O_5$ or $C_4H_6O_5$	**$HC_4H_4O_5^-$ or $C_4H_5O_5^-$**	$C_4H_4O_5^{2-}$

2. A 0.1 mol L^{-1} water-solution of Na_2HPO_4 has a pH of about 10. Write all the hydrolysis reactions that occur when Na_2HPO_4 is dissolved in water and then explain why the 0.1 mol^{-1} solution of Na_2PO_4 has a pH of 10 (3 marks).

$HPO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + OH^-{}_{(aq)}$ **(1)**

$HPO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons PO_4^{3-}{}_{(aq)} + H_3O^+{}_{(l)}$ **(1)**

$K_b > K_a$ or similar answer **(1)**

3. What mass of barium hydroxide is needed to make a 250 mL solution with a pH of 13.25 at 25 ^oC? (4 marks).

At 25 ^oC if pH = 13.25 then pOH = 14 – 13.25 = 0.75 (or equivalent calculations)
If pOH = 13.25 then $[OH^-] = 10^{-0.75} = 0.17782$ mol L^{-1} **(1)**
n(OH^- in 250 mL) = cV = 0.17782 x 0.250 = 4.4455 x 10^{-2} mol **(1)**
$Ba(OH)_{2(s)} \rightarrow Ba^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$
SR $(Ba(OH)_2/OH^-) = ½$
n($Ba(OH)_2$) = ½ x 4.4455 x 10^{-2} mol = 2.22275 x 10^{-2} mol **(1)**
m($Ba(OH)_2$) = nM = 2.22275 x 10^{-2} x (137.3 + (2 x 16.00) + (2 x 1.008))
= 3.8 g **(1)**

4. a) A buffer of carbonic acid and hydrogen carbonate is present in blood plasma to maintain a pH between 7.35 and 7.45. Write an equation to show the relevant species present in a carbonic acid/hydrogen carbonate buffer solution. (2 marks)

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

1 mark off per mistake.

b) Explain why 200 mL of 1 M carbonic acid/hydrogen carbonate buffer does not change pH significantly when 3 drops of 1 M HCl are added to it, yet when 3 drops of 1 M HCl are added to 200 mL of distilled water there is a significant change in pH. (4 marks)

When HCl is added to the buffer solution the resulting excess of hydronium ions (1) pushes the equilibrium to the left (1) using up most of the excess hydronium ions (1) whereas when it is added to distilled water the added hydronium ions are not used up / result in a great excess of hydronium ions (1)

5. All parts of this question refer to the following reaction:
105 mL of 0.95 mol L^{-1} ethanoic acid reacts with 1.13 g of solid chromium(III) carbonate.

a. Explain why ethanoic acid is a monoprotic acid despite having 4 hydrogen atoms in its formula (1).

Ethanoic acid has only one hydrogen atom that can ionise.

b. Write an ionic equation for this reaction (1 mark for equation with no mistakes).

$6CH_3COOH_{(aq)} + Cr_2(CO_3)_{3(s)} \rightarrow 3CO_{2(g)} + 3H_2O_{(l)} + 2Cr^{3+}_{(aq)} + 6CH_3COO^-_{(aq)}$

c. Describe the change in odour that would occur during this reaction if the reactants were present in their stoichiometric ratio (1 mark).

The vinegar-like odour will disappear.

d. Without repeating any part of your answer to part (c) above, state observations for the above reaction (2 marks, ½ per observation).

A <u>colourless liquid</u> (accept solution) (1/2) is added to a <u>deep green (not just 'green') solid</u> (1/2). The (deep green) <u>solid disappears</u> (1/2), <u>bubbles of a colourless odourless gas</u> appear (1/2) and the <u>liquid (accept solution) becomes deep green</u> (not just green) (1/2).
Any 4, ½ each, 2 marks total.

e. Determine the limiting reagent for this reaction (3 marks).

$n(CH_3COOH) = cV = 0.105 \times 0.95 = 0.09975$ mol **(1)**
$n(Cr_2(CO_3)_3) = m/M = 1.13 / ((2 \times 52.00) + (3 \times 12.01) + (9 \times 16.00))$
$= 0.0039784$ mol **(1)**
SR = $CH_3COOH / Cr_2(CO_3)_3 = 6/1 = 6$
AMR = $CH_3COOH / Cr_2(CO_3)_3 = 0.09975 / 0.0039784 = 25.07$
AMR > SR therefore limiting reagent is $Cr_2(CO_3)_3$. **(1)**
No marks for stating LR without adequate reasoning.

f. Determine the concentration of excess reagent in the final solution, assuming no volume change to the liquid when the solid was added to it (2 marks).

$n(CH_3COOH\ used) = 6 \times n(Cr_2(CO_3)_3) = 6 \times 0.0039784$
$= 0.0238704$ mol
$n(CH_3COOH\ remaining) = 0.09975 - 0.0238704 = 0.0758796$ mol (1)
$c(CH_3COOH\ after\ reaction) = n/V = 0.0758796/0.105 =$
0.72 mol L^{-1} (1)

g. Write the Brønsted-Lowry reaction for the ionisation of ethanoic acid (1 mark for equation with no mistakes, no half marks).

$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$

h. Write the equilibrium expression for the ionisation of ethanoic acid (1, no half marks).

$K_a = [H_3O^+]\,[CH_3COO^-] / [CH_3COOH]$

i. Given that K_a of ethanoic acid is 1.7×10^{-5}, determine the pH of the final solution (2 marks).

$[H_3O^+]^2 = K_a \times [CH_3COOH] = 1.7 \times 10^{-5} \times 0.722663 = 0.000012285$
$[H_3O^+] = 0.003505$ mol L^{-1} (1)
$pH = -\log(0.003505) = 2.5$ (1)

END OF TEST

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CHEMISTRY

Multiple Choice Answer Sheet

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D
11	A	B	C	D
12	A	B	C	D
13	A	B	C	D

END OF TEST