Chemistry

Unit 3

Area of Study 2 Test:

Acids and bases

This sample test paper has been prepared as part of the Pearson suite of resources for the Year 12, Unit 3, ATAR Chemistry Course prescribed by the Western Australian School Curriculum and Standards Authority.

Time allowed

Reading time: 5 minutes Working time: 45 minutes

Materials required

An approved non-programmable calculator.

Chemistry Data Booklet. This may be downloaded from the SCSA website.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of total test
Section 1: Multiple choice	8	8	12	16	25
Section 2: Short answer	4	4	16	23	36
Section 3: Extended answer	2	2	17	25	39
		Total	**45**	**64**	**100**

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Section 1: Multiple choice 25% (16 marks)

This section has **8** questions. Answer **all** questions by circling the correct option. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 12 minutes

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1 Which one of the following species forms when the hydrogen arsenate ion ($HAsO_4^{2-}$) acts as a base in water?

A AO_4^{3-}

B HAO_4^{2-}

C $H_2AO_4^{-}$

D H_3AO_4

2 Which of the following acids can be classified as polyprotic in water?

I CH_3COOH

II H_2SO_3

III NH_4^{+}

A I only

B II only

C I and II only

D I, II and III

3 Consider the following statements, which compare 20.00 mL of 0.10 mol L^{-1} solution of nitric acid with 20.00 mL of 0.10 mol L^{-1} solution of ethanoic acid.

I The two solutions are of the same strength.

II The pH of the nitric acid solution will be higher.

III The electrical conductivity of the nitric acid solution will be higher.

IV Both solutions will require the same volume of 0.10 mol L^{-1} NaOH for neutralisation.

Which two of the above statements are correct?

A I and II

B I and III

C II and IV

D III and IV

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4 A solution of sodium hydroxide has a pH of 11.3. If 10.0 mL of this solution is mixed with 90.0 mL of water, what will be the pH of the diluted solution?

A 10.3

B 11.1

C 11.5

D 12.3

5 Trichloroethanoic acid (Cl_3CCOOH) is a stronger acid than ethanoic acid (CH_3COOH). Which of the following statements about 0.10 mol L^{-1} solutions of these two acids is/are correct?

I The trichloroethanoic acid solution is ionised to a greater extent.

II The trichloroethanoic acid solution will react faster with a solution of potassium carbonate.

A I only

B II only

C both I and II

D neither I nor II

6 A buffer can be formed by mixing which of the following?

I 100 mL of 0.01 mol L^{-1} NH_4Cl with 100 mL of 0.01 mol L^{-1} NH_3

II 100 mL of 0.01 mol L^{-1} HCl with 200 mL of 0.01 mol L^{-1} NH_3

III 100 mL of 0.01 mol L^{-1} HCl with 100 mL of 0.01 mol L^{-1} NaCl

A I only

B I and II only

C I and III only

D All three will be buffer solutions.

7 The self-ionisation of water can be represented by the following equation:

$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

This reaction is endothermic and $K_w = 1.0 \times 10^{-14}$ at 25°C. Therefore, if water is heated to 100°C, which of the following would be correct?

A The pH will be less than 7 and the water will be neutral.

B The pH will be less than 7 and the water will be acidic.

C The pH will be 7 and the water will be neutral.

D The pH will be 7 and the water will be acidic.

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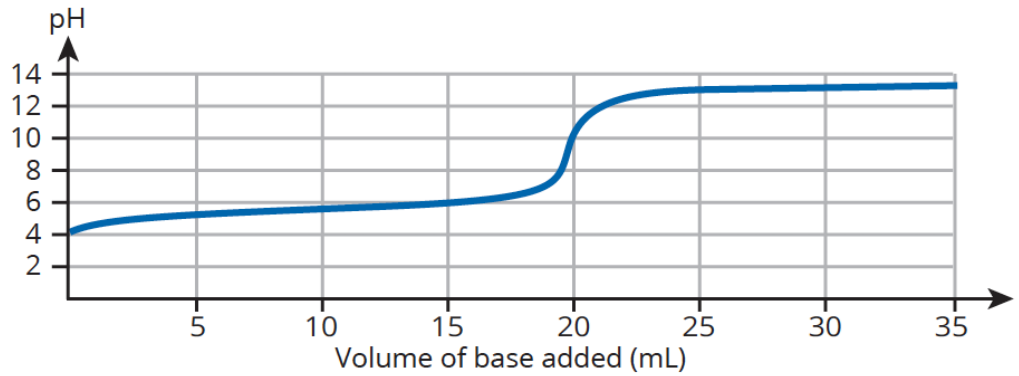
8 The following acid–base titration curve shows the way pH changes when a base is added from a burette to a measured volume of acid. The concentration of both acid and base is approximately 0.1 mol L^{-1}.



From the shape of the curve, it can be deduced that this titration is between which of the following?

A a weak acid and a strong base

B a strong acid and a strong base

C a weak acid and a weak base

D a strong acid and a weak base

End of section 1

Section 2: Short answer 36% (23 marks)

This section has **4** questions. Answer **all** questions. Write your answers in the space provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Do not use abbreviations, such as 'nr' for 'no reaction', without first defining them.

Suggested working time: 16 minutes

Question 9 **(5 marks)**

Over the years, there have been many proposed definitions of acids and bases.

a How did Arrhenius describe an acid? (1 mark)

_____

_____

b How did Brønsted-Lowry define an acid and why is this definition considered to be more general than that of Arrhenius? (2 marks)

_____

_____

c Give an equation for a reaction that would be described as an acid–base reaction by the following.

i both Arrhenius and Brønsted–Lowry

_____

_____

ii Brønsted–Lowry but not Arrhenius (2 marks)

_____

_____

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Question 10 **(8 marks)**

$NaCl$, NH_4Cl and Na_2CO_3 are all ionic compounds, yet when dissolved in water they form solutions with very different pH.

Complete the following table to identify the compound that forms an acidic solution, the one that forms a basic solution and the one that forms a neutral solution. Explain your answer, including any relevant equations.

Compound in solution	Solution acidic, basic or neutral	Equation	Explanation
$NaCl$			
NH_4Cl			
Na_2CO_3			

Question 11 **(4 marks)**

The pH of three different acids is given below.

Acid	Concentration in mol L^{-1}	pH
Nitric acid, HNO_3	0.010	2.0
Propanoic acid, C_2H_5COOH	0.010	3.4
Sulfuric acid, H_2SO4	0.010	1.7

The three acids have the same concentration. Explain why:

a propanoic acid has the highest pH of the three. (2 marks)

_____

_____

_____

b sulfuric acid has the lowest pH of the three. (2 marks)

_____

_____

_____

Question 12 **(6 marks)**

a A solution has a pH of 5.2. What is the concentration, in mol L^{-1}, of hydroxide ions in the solution at 25°C? (2 marks)

_____

_____

b A solution of 75 mL of hydrochloric acid of concentration 0.0150 mol L^{-1} is added to 125 mL of sodium hydroxide of concentration 0.0100 mol L^{-1}. Both solutions are at 25°C.

Calculate the pH of the resultant solution. (4 marks)

_____

_____

_____

_____

End of section 2

Section 3: Extended answer 39% (25 marks)

This section has **2** questions. Answer **both** questions. Write your answers in the space provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Do not use abbreviations, such as 'nr' for 'no reaction', without first defining them.

Suggested working time: 17 minutes

Question 13 **(9 marks)**

Hypochlorous acid, HOCl, is a *weak*, *monoprotic* acid.

a Write an equation for the reaction of hypochlorous acid with water. (1 mark)

_____

b Explain the meaning of the following terms. (2 marks)

i weak acid

_____

_____

ii monoprotic acid

_____

_____

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c By contrast, hydrochloric acid is classified as a strong acid. Given 0.5 mol L^{-1} solutions of each of these two acids, deduce which one will have the:

i higher acidity constant (K_a)

ii higher pH

iii stronger conjugate base.

Justify your deductions. (6 marks)

i Formula of acid with the higher K_a value	Justification
ii Formula of acid that forms a 0.5 mol L^{-1} solution with the higher pH	Justification
iii Formula of acid with the stronger conjugate base	Justification

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Question 14 **(16 marks)**

Many household cleaners contain ammonia (NH_3) as the active ingredient. An acid–base titration is performed in order to determine the concentration of ammonia in a commercially available cleaner.

Water is used to dilute 10.00 mL of the cleaner to 100.0 mL in a volumetric flask. Next, 20.00 mL of this diluted cleaner solution is placed in a dry conical flask and titrated against 0.0950 mol L^{-1} hydrochloric acid using methyl orange as an indicator. The average of three concordant titres is 17.40 mL.

a Write an equation for the reaction between ammonia and hydrochloric acid. (1 mark)

_____

b Calculate the concentration, in moles per litre (mol L^{-1}), of ammonia in the cleaner. (3 marks)

_____

_____

_____

_____

_____

c Calculate the mass, in grams, of ammonia in a 750 mL bottle of cleaner. (2 marks)

_____

_____

_____

d Methyl orange is pink at a pH lower than 3.1 and yellow at a pH greater than 4.4. Explain why methyl orange is a suitable indicator for this titration and state the colour change that would be observed. (4 marks)

_____

_____

_____

Colour change: _____

e State whether each of the following changes to this titration procedure would lead to a result that is higher, lower or the same for the concentration of ammonia in the cleaner. Give an explanation for your answer. (6 marks)

	Result would be higher/lower/the same as the actual concentration of ammonia	**Explanation**
Added 20.00 mL of water to the 20.00 mL of diluted cleaner solution in the conical flask prior to titration.		
Phenolphthalein indicator was used instead of methyl orange. Phenolphthalein is colourless at a pH less than 8.3 and pink at a pH higher than 9.5.		
The conical flask was washed, then rinsed with the diluted cleaner solution before using it.		

End of questions

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