Student Number	
Mark /	

Chemistry Assessment

Task 2 Term 1 2008

Acidic Environment & Chemical Monitoring

Theory

ANSWERS
Marking Guidelines

General Instructions

- **Reading time** – 5 minutes
- **Working time** – 50 minutes
- **Write using black or blue pen**
- **Write your Student Number at the top of this page and on the response sheet on page 5**
- **Board-approved calculators may be used**

A data sheet and a periodic table are provided at the back of the paper.

Total Marks – 41

Part A – 7 marks – pages 3 -4

- Attempt Questions **1-7**
- Allow about **5** minutes for this part

Part B – 34 marks – pages .6 – 12

- Attempt Questions **8- 15**
- Allow about **45** minutes for this part

Part A: Multiple Choice: 7 marks
Attempt Questions 1-7
Allow about 5 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

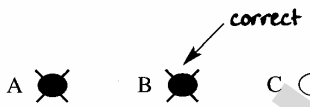
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



▸ **Mark your answers for Questions 1-7 in the multiple choice grid on page 5**

1. Which of the following 0.1 mol L^{-1} solutions has a pH greater than 7 at 25 ^oC?

(A) Ammonium chloride
(B) Ammonium nitrate
(C) Sodium fluoride
(D) **Sodium acetate**

Outcome: H8

2. Which of the following is a conjugate acid/base pair?

(A) PO_4^{3-} / $H_2PO_4^-$

(B) H_3O^+ / OH^-

(C) **H_2O / OH^-**

(D) HPO_4^{2-} / H_3PO_4

Outcome: H8

3. What is produced when an acidic oxide and a base react?

(A) carbon dioxide and water
(B) hydrogen and a salt
(C) water and a basic oxide
(D) **water and a salt**

Outcome: H8

4. Which equation best shows the formation of acid rain?

(A.) $S(s) + O_2(g) \rightarrow SO_2(g)$

(B) $C(s) + O_2(g) \rightarrow CO_2(g)$

(C) **$2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + HNO_2(aq)$**

(D) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

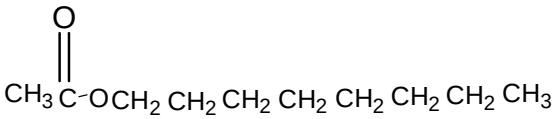
Outcome: H4

5. What is the maximum volume of nitrogen (IV) oxide that could be produced when one litre of nitrogen (II) oxide and 1 litre of oxygen are reacted?

(A) 0.5 L
(B) 1.0 L
(C) 1.5 L
(D) 24.79 L

Outcome: H10

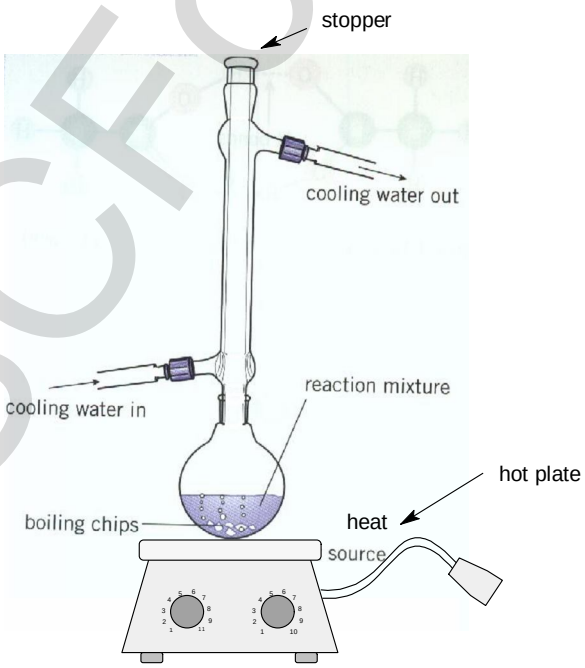
6. The chemical formula of a flavouring agent compound used to give an orange odour is shown.



What is the IUPAC name of this compound?

(A) ethyl octanoate
(B) octyl ethanoate
(C) 2-ethyl octanoate
(D) propyl hexanoate

7. A student's refluxing apparatus used in esterification is shown.



What is *incorrect* about the student's refluxing apparatus?

(A) Water enters the condenser at the base.
(B) Using a round – bottomed flask as the reaction vessel.
(C) The use of a hot plate
(D) **Inserting a stopper at the top of the condenser**.

Outcome: H12

Part A . Answer grid for multiple choice questions **Total .....**

1.	A O	B O	C O	D ●
2.	A O	B O	C ●	D O
3.	A O	B O	C O	D ●
4.	A O	B O	C ●	D O
5.	A O	B ●	C O	D O
6.	A O	B ●	C O	D O
7.	A O	B O	C O	D ●

Part B. 34 marks
Attempt Questions 8-15
Allow about 45 minutes for this part
▸ ***Show all relevant working in questions involving calculations.***

Question 8 (4 marks) **MARKS**

Antacids are used to combat indigestion by neutralizing excess acid in the stomach.

(a) Write a chemical equation for the reaction between the antacid, magnesium hydroxide and stomach acid, hydrochloric acid. **1**

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Sample Answer:

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$ *(1 mark no subscripts req'd)*

Outcome: H10

(b) Stomach acid has a pH of 2.

Calculate the mass of antacid, magnesium hydroxide, required to neutralize 20 mL of stomach acid. **3**

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Sample Answer:

$[H^+] = 10^{-2}$

$\text{mol HCl} = 10^{-2} \times V$
$= 10^{-2} \times 0.02L$
$= 2 \times 10^{-4}\ mol$

$\text{mol } Mg(OH)_2 = ½ \text{ mol HCl}$
$= 1 \times 10^{-4}\ mol$

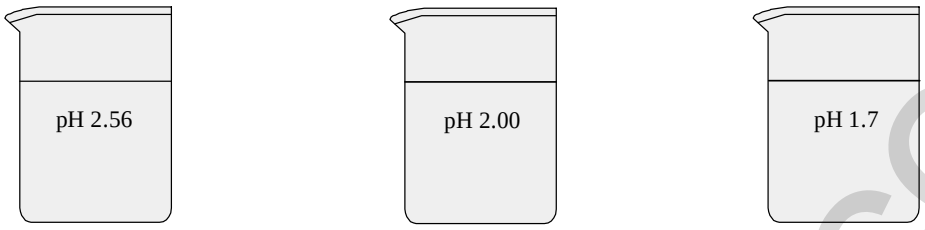
$\text{mass } Mg(OH)_2 = \text{mol} \times fw$
$= 1 \times 10^{-4} \times (24.3 + 2(1 + 16))$
$= 5.83 \times 10^{-3}\ g$

Marking criteria	***Marks***
• *Correct answer with relevant working*	*3*
• *2 of the responses below (excluding the first)*	*2*
• *correct answer with no working shown or* • *mass calculated from incorrect moles or* • *recognizes stoichiometric relationship 1:2* • *calculates mol HCl or* • *calculates $[H^+]$*	*1*

Outcomes H10

Question 9 (5 marks) **MARKS**

The diagram shows 3 beakers containing acids.



0.01 M citric acid | 0.01 M hydrochloric acid | 0.01 M sulfuric acid

(a) Explain the difference in pH between the three acids in the diagram. **3**

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Sample Answer

The pH of an acid solution is determined by the degree of ionization of the acid and also by the number of protons in the acid.

Citric acid is a weak acid which only partially ionizes in water. The fewer H^+ produce a higher pH.

HCl is a strong acid which completely ionizes in water. All the molecules ionize to produce H^+ and therefore the pH is lower than the same concentration of citric acid.

H_2SO_4 is a diprotic strong acid. Its ionization can produce two H^+ and therefore it has a lower pH than the same concentration of HCl which is monoprotic.

Marking criteria	*Marks*
• Explains the difference in pH between the three acids	*3*
• Explains the difference in pH between two of the acids • Identifies citric acid as a weak acid and HCl and H_2SO_4 as strong acids AND links ionization to pH for any of the three acids.	*2*
• Identifies citric acid as a weak acid and HCl and H_2SO_4 as strong acids or • Links ionization to pH for any of the three acids	*1*

Outcomes H6, H8

(b) Calculate the pH after 20 mL of 0.01 mol L^{-1} hydrochloric acid is diluted with 180 mL of water. (2 marks)

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Sample Answer:

$c1v1 = c2v2$
$0.01 \times 0.02 = c2 \times 0.2$
$c2 = 1 \times 10^{-3}$ *(1 mark)*

$pH = -\log[H^+]$
$= -\log 1 \times 10^{-3}$
$= 3.0$ *(1 mark)*

Question 10 (6 marks)

Different theories of acid and bases were developed by Lavoisier, Davy, Arrhenius and Bronsted-Lowry. Sulfuric acid was classified as an acid by all of these scientists.

Explain how each of their theories predict that sulfuric acid is an acid. Support your answer by using equations where appropriate.

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Sample answer

Lavoisier proposed that acids contained oxygen, and H_2SO_4 contains oxygen.

Davy suggested that acids were substances that contained replaceable hydrogen. When acid reacted with metals they replaced hydrogen with the metal to form a metal salt. H_2SO_4 contains hydrogen.

$H_2SO_4 + Mg \rightarrow H_2 + Mg\,SO_4$

Arrhenius proposed that an acid was a substance that ionized in water to produce hydrogen ions.

$H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$

The chemists Bronsted and Lowry proposed that acids were proton donors and bases were proton acceptors. H_2SO_4 donates a proton. (see equation)

Marking criteria	Marks
• Links each proposed theory to H_2SO_4 and uses at least two relevant equations.	6
• Links each proposed theory to H_2SO_4 and uses only one relevant equation.	5
• Links each proposed theory to H_2SO_4 or • Links three theories and one equation	4
• Links two theories to H_2SO_4 with one equation • Links three theories to H_2SO_4	3
• Explains one theory with an equation • Identifies two theories	2
• Identifies any of the four theories of acids • Gives one relevant equation • Identifies H_2SO_4 as a proton donor	1

Outcomes : H1,H2

Question 11 (3 marks)

The hydrogen carbonate ion can act as both an acid and a base, and, with carbonic acid, forms a buffer pair.

(a) What name is given to a substance that can donate a proton or accept a proton? (1 mark)

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ANS *Amphiprotic* *(1 mark)*

(b) Describe the effect of a specific buffer in a natural system. (2 marks)

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Outcomes : H6

Conjugate pairs like $H_2PO_4^-$ and HPO_4^{2-} act as buffers in the blood. Buffers maintain a constant pH when small amounts of acids or bases are added. The acid part of the pair reacts with any base to remove it and the conjugate base reacts with any acid that is added.

Marking criteria	Marks
• Links the effects of a buffer with an example in a natural system.	2
• Identifies a buffer pair in a natural system or • Describes the effect of a buffer	1

Outcomes H4

Question 12 (3 marks)

Write balanced chemical equations to show the difference in products when heptane gas is combusted in:

(a) (i) excess oxygen and (1 mark)

(ii) limited oxygen. (1 mark)

(b) Which reaction would require the more careful monitoring? Give a reason for your answer (1 mark)

(a) (i)…….....

(ii)…….....

(b)…….....

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Sample Answer:

(a)(i) $C_7H_{16}\,(g) + 11O_2\,(g) \rightarrow 7CO_2\,(g) + 8H_2O\,(g)$

(ii) $C_7H_{16}\,(g) + 15/2\,O_2(g) \rightarrow 7CO\,(g) + 8H_2O\,(g)$

(b) In (ii) the production of CO is very poisonous to human health as it reduces the oxygen carrying capacity of the blood.

Marking Guidelines:

Criteria	***Marks***
• Writes correct equation for complete combustion • Writes any correct equation for incomplete combustion • Provides a reason for CO or C requiring careful monitoring	3
Any two of above	2
Any one of above	1

Outcome: H9

Question 13 (5 marks)

A student carried out an experiment to decarbonate a 300 mL bottle of soft drink. He opened the bottle and noticed the bubbles of carbon dioxide escaping from the soft drink.

(a) Explain these observations using an equation in your answer. (3 marks)

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Sample answer:

$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

When the lid is removed the volume increases and pressure of carbon dioxide decreases. The equilibrium of the reaction above will be shifted to the left to counteract this change, and carbon dioxide will pass from the solution to the gas phase (and bubbles seen to rise to the surface)

Marking Guidelines

Criteria	***Marks***
• Writes a relevant equation • Explains the significance of opening the bottle in terms of disturbing the equilibrium • Uses the equation to explains the shift in equilibrium	3
Any two of the above	2
Any one of the above.	1

Outcome H13

(b) The student measured the mass of the bottle of soft drink before and after decarbonation and found the mass to have decreased by 1.25g.. Assume that all carbon dioxide has been removed from the bottle.

What volume of carbon dioxide (at 25º C and 100 kPa) would be required to carbonate 1 L bottle of soft drink? Show all working. (2 marks)

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Sample answer:

Number of moles of CO_2 = 1.25/44.01

Volume in 300ml bottle = 1.25/44.01 X 24.79L
= 0.704L
Volume for one litre =1.25/44.01 X24.79 X 1000/300
=2.35L

Marking Guidelines

Criteria	***Marks***
• Correct calculation of the number of litres for the 300ml bottle to be carbonated. • Correct calculation for a 1 litre bottle.	2
One of the above.	1

Question 14 (5 marks)

(a) Using IUPAC nomenclature, give the name of the ester formed from the reaction between 1-propanol and ethanoic acid. (1 mark)

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ANS: *propyl ethanoate* (1)

(b) Using structural formulae write a balanced equation to describe the reaction between 1-propanol and ethanoic acid. (1 mark)

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ANS: $CH_3CH_2CH_2OH + CH_3COOH \rightleftharpoons CH_3COOCH_2CH_2CH_3 + H_2O$ (1)

(c) State the purpose of including a small quantity of acid in the reaction vessel in order to prepare the ester. (1 mark)

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ANS: *Acid acts as a catalyst – increasing the rate of the esterification reaction.* (1)

(d) Describe the purpose of refluxing in esterification. (2 marks)

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ANS: *Using heat increases the rate of the esterification reaction. (1) Refluxing prevents the escape of the volatile reactants and products. (1)*

Outcome: H13

Question 15 (3marks)

The boiling points of some alkanoic acids and their equivalent alkanols are presented in the table.

Compound	***Boiling point (^oC)***
Butanoic acid	163
Pentanoic acid	186
Hexanoic acid	206
1-butanol	118
1-pentanol	138
1-hexanol	157

Explain the differences between the boiling points of alkanoic acids and their equivalent alkanols.
(3 marks)

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Outcomes: H12, H14

Sample Answer:

Alkanoic acids have greater boiling points than their equivalent alkanols for two reasons. Firstly, alkanoic acids are slightly bigger than their equivalent alkanols and thus contain more dispersion forces acting between adjacent alkanoic acid molecules. (1) Second, there are greater amounts of hydrogen bonding between alkanoic acid molecules compared with the hydrogen bonding between alkanol molecules. This is due to the alkanoic acid molecule having an extra oxygen atom in its functional group. (1)

Outcome criteria	***Marks***
Recognising that alkanoic acids have higher boiling points than the equivalent alkanols + alkanoic acids and alkanols have hydrogen bonding + alkanoic acids have more hydrogen bonding	3
Recognising that alkanoic acids have higher boiling points than the equivalent alkanols + alkanoic acids and alkanols have hydrogen bonding	2
Recognising that alkanoic acids have higher boiling points than the equivalent alkanols.	1

End of Test