Chemistry Assessment

Task 2 Term 1 2014

Theory

Acidic Environment
& Chemical Monitoring

General Instructions

- **Reading time – 5 minutes**

- **Working time – 55 minutes**

- **Write using black or blue pen**

- **Write your Student Number on top of pages 6 and 7.**

- **Board-approved calculators may be used**

  A data sheet and a periodic table are provided

Total Marks – 41

Part A – 9 marks

- Attempt Questions 1 – 9
- Allow about 10 minutes for this part

Part B – 32 marks

- Attempt Questions 10 – 16
- Allow about 45 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.

correct

A ✖   B ✖   C ◯   D ◯

▸ **Mark your answers for the multiple choice questions in the multiple choice grid on page 6**

Multiple Choice (*Mark your answers on the multiple choice grid on page 6*)

1.   Who was the first scientist to attribute acidity of a substance to the presence of a particular element in the substance?
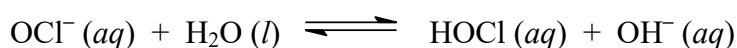
(A)   Lavoisier

(B)   Davy

(C)   Arrhenius

(D)   Bronsted

2.   Which of the pairs of species listed below are conjugate acid-base pairs?

(i) $H_2 - H^+$

(ii) $NH_3 - NH_2^-$

(iii) $H_2O - OH^-$

(iv) $H_2O - O^{2-}$

(A)   (i) – (iv)

(B)   (ii), (iii), (iv) only

(C)   (ii) and (iii) only

(D)   (i) and (iv) only

3.   The forward reaction in the equilibrium shown below is endothermic.

$$OCl^- \ (aq) \ + \ H_2O \ (l) \ \rightleftharpoons \ HOCl \ (aq) \ + \ OH^- \ (aq)$$

Which change increases the concentration of hypochlorous acid (HOCl)?

(A)   increasing the pressure

(B)   increasing the pH

(C)   lowering the temperature

(D)   adding sodium hypochlorite (NaOCl)

4. The air quality in large cities is often adversely affected by emissions from car exhausts. Which lower atmosphere pollutant is found in the highest concentration in emissions from car exhausts?

    (A)   Ozone

    (B)   CFCs

    (C)   Halons

    (D)   Oxides of nitrogen

5. Ammonia is produced during an industrial process that involves the use of a catalyst. What catalyst is used?

    (A)   Concentrated sulfuric acid

    (B)   Finely ground iron particles

    (C)   Hot metal coils

    (D)   Aluminium silicate

6. Which class of compounds is commonly used to flavour foods?

    (A)   Esters

    (B)   Haloalkanes

    (C)   Bases

    (D)   Alkanes

7. A 0.10 mol L^{-1} solution of a certain acid HA has a pH of 1.00.

What will be the hydronium ion concentration in mol L^{-1} if 810 mL of the solution is diluted to 1.00 L?

    (A)   0.081

    (B)   0.0081

    (C)   0.019

    (D)   0.0019

8   Which of the following alternatives show the three compounds listed in order of decreasing boiling point?

(A)   Pentane, butanol, propanoic acid

(B)   Propanoic acid, butanol, pentane

(C)   Propanoic acid, pentane, butanol

(D)   Butanol, propanoic acid, pentane

9.   The figure shows the pH values of some substances.

Stomach Acid	Lemon juice	Wine	Rain	Milk	Distilled water	Seawater	Baking soda	Soap solution	Laundry detergent	Bleach	Oven cleaner
2	3	4	5	6	7	8	9	10	11	12	13

Based on the pH values shown in the figure, which of the following statements about the concentration of hydrogen ions is correct?

(A)   It is 1000 times lower in distilled water than in soap.

(B)   It is 3 times lower in wine than in bleach.

(C)   It is 1000 000 times lower in soap than in wine.

(D)   It is 2 times lower in milk than in lemon juice

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

1. A O   B O   C O   D O

2. A O   B O   C O   D O

3. A O   B O   C O   D O

4. A O   B O   C O   D O

5. A O   B O   C O   D O

6. A O   B O   C O   D O

7. A O   B O   C O   D O

8. A O   B O   C O   D O

9. A O   B O   C O   D O

Total ....

Part B: Free Response Questions: (32 marks)

Attempt Questions 10 - 16   Allow about 45 minutes for this part.
‣ *Show all relevant working in questions involving calculations.*

Marks

Question 10 (2 marks)

Describe how indicators are used in soil testing.   **2**

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Question 11 (4 marks)

Sodium hydrogen carbonate is a chemical substance with many uses due to its amphiprotic
properties.

(a)   Use ionic equations to illustrate the amphiprotic nature of sodium hydrogen carbonate.   **2**

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(b)   Describe a practical use of sodium hydrogen carbonate which is due to its amphiprotic
         property.   **2**

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Question 12 (6 marks)

The burning of coal to create steam is the major method used to produce electricity in NSW.
An analysis of a coal sample was completed and the results are shown below.

Percentage composition of coal sample	
Ash	13.20
Water	8.30
Nitrogen	0.50
Sulfur	0.40
Total carbon	77.60

(a) Explain, using Le Chatelier's Principle and relevant chemical equations, how an
increase in the burning of coal can change the pH of the oceans. **4**

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(b) Calculate the maximum volume of sulfur dioxide that could be produced at 298 K and
100 kPa from the burning of 100.0 g of this coal sample. **2**

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Question 13 (6 marks)

Ammonia is manufactured in a process between two naturally occurring diatomic gases, in the presence of a catalyst.

(a)   Write a balanced chemical equation to represent this reaction.   **1**

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(b)   The reaction mixture is passed into a chamber at a pressure of 200 Atm at 450°C in contact with a catalyst. These conditions are relatively unique for an industrial process. In particular, the temperature is unusually low.

 Explain why the conditions are used in the production of ammonia.   **5**

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Question 14 (3 marks)

A solution of hydrochloric acid has a pH of 1.50.

(a)   Calculate the $[H^+]$ of this solution.   **1**

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(b)   10.0 mL of this solution is made up to 1.00 L with distilled water.
        Calculate the pH of the new solution.   **2**

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Question 15 (7 marks)

Methanol and butanoic acid are reacted using appropriate apparatus and specific conditions.

(a)   Identify a catalyst used in this reaction.   **1**

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(b)   Draw a balanced chemical equation using structural formulae to show the reaction between
         methanol and butanoic acid. Name the products.   **3**

Marks

(c)   Identify the specialised glassware used to prepare the major product and give
        TWO reasons for its use.   **3**

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Question 16 (4 marks)

Solutions of 0.01 mol L^{-1} acetic acid, citric acid and hydrochloric acid were prepared.
The pH of each solution were measured and found to be 3.41, 2.65 and 2.00 respectively.

(a)   Describe how the pH of the solutions were measured.   **1**

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(b)   Explain the difference in pH between the 0.01 mol L^{-1} solution of the three acids.   **3**

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⌂ END of Theory Test

Chemistry Assessment

Task 2 Term 1 2014

Theory

Acidic Environment

& Chemical Monitoring

ANSWERS

General Instructions

- **Reading time – 5 minutes**

- **Working time – 55 minutes**

- **Write using black or blue pen**

- **Write your Student Number on top of pages 6 and 7**

- **Board-approved calculators may be used**

   A data sheet and a periodic table are provided

Total Marks 41

Part A – 9 marks

- Attempt Questions
- Allow about 10 minutes for this part

Part B – 32 marks

- Attempt Questions
- Allow about 45 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.

correct

A ✖   B ✖   C ◯   D ◯

▶ **Mark your answers for the multiple choice questions in the multiple choice grid on page 6**

Multiple Choice (*Mark your answers on the multiple choice grid on page 6*)

1.   Who is the first scientist to attribute acidity of a substance to the presence of a particular element in the substance?

     (A)   Lavoisier

     (B)   Davy

     (C)   Arrhenius

     (D)   Bronsted

Outcome(s): H1

2.   Which of the pairs of species listed below are conjugate acid-base pairs?

          (i) $H_2 - H^+$

          (ii) $NH_3 - NH_2^-$

          (iii) $H_2O - OH^-$

          (iv) $H_2O - O^{2-}$

     (A)   (i) – (iv)

     (B)   (ii), (iii), (iv) only

     (C)   (ii) and (iii) only

     (D)   (i) and (iv) only

3.   The forward reaction in the equilibrium shown below is endothermic.

          OCl^- (*aq*) + H_2O (*l*) ⇌ $HOCl$ (*aq*) + OH^- (*aq*)
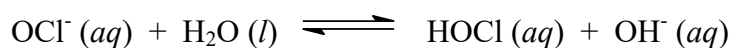
     Which change increases the concentration of hypochlorous acid?

     (A)   adding water

     (B)   increasing the pH

     (C)   lowering the temperature

     (D)   adding sodium hypochlorite

Outcomes : H4, H8

4. The air quality in large cities is often adversely affected by emissions from car exhausts. Which lower atmosphere pollutant is found in the highest concentration in emissions from car exhausts?

(A) Ozone

(B) CFCs

(C) Halons

(D) Oxides of nitrogen

Outcomes :H1, H4, H9

5. Ammonia is produced during an industrial process that involves the use of a catalyst. What catalyst is used?

(A) Concentrated sulfuric acid.

(B) Finely ground iron particles.

(C) Hot metal coils

(D) Aluminium silicate

Outcome(s): H3

6. Which class of compounds is commonly used to flavour foods ?

(A) Esters
(B) Haloalkanes
(C) Bases
(D) Alkanes

Outcomes :H6

7. A 0.10 molL^{-1} solution of a certain acid HA has a pH of 1.00.

What will be the hydronium ion concentration in mol L^{-1} if 810 mL of the solution is diluted to to 1.00 L?

(A) 0.081

(B) 0.0081

(C) 0.019

(D) 0.0019

Outcomes : H10

8. Which of the following alternatives show the three compounds listed in order of decreasing boiling point?

(A)   Pentane, butanol, propanoic acid

(B)   Propanoic acid, butanol, pentane

(C)   Propanoic acid, pentane, butanol

(D)   Butanol, propanoic acid, pentane

Outcomes :H9

9. The figure shows the pH values of some substances.

Stomach Acid	Lemon juice	Wine	Rain	Milk	Distilled water	Seawater	Baking soda	Soap solution	Laundry detergent	Bleach	Oven cleaner
2	3	4	5	6	7	8	9	10	11	12	13

Based on the pH values shown in the figure, which of the following statements about the concentration of hydrogen ions is correct ?

(A)   It is 1000 times lower in distilled water than in soap.

(B)   It is 3 times lower in wine than in bleach.

(C)   It is 1000000 times lower in soap than in wine.

(D)   It is 2 times lower in milk than in lemon juice.

Outcomes :H4

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

1.   A ●   B O   C O   D O

2.   A O   B O   C ●   D O

3.   A O   B O   C O   D ●

4.   A O   B O   C O   D ●

5.   A O   B ●   C O   D O

6.   A ●   B O   C O   D O

7.   A ●   B O   C O   D O

8.   A O   B ●   C O   D O

9.   A O   B O   C ●   D O

Total ....

Part B: Free Response Questions: (32 marks)

Attempt Questions 10-16   Allow about 45 minutes for this part.
▸Show all relevant working in questions involving calculations.

	Marks

Question 10 (2 marks)

Describe how indicators are used in soil testing.   **2**

Outcome(s):H13

Sample answer:
Indicators are used to ascertain the pH of soil in order to decide the suitability of the soil to the cultivation
of particular crops. Testing consists of sprinkling barium sulfate, as white background, on the soil and
then adding a drop of universal indicator. The colour developed indicates the pH of the soil.

Marking Guidelines

Criteria	Marks
A detailed description of how indicators are used in agriculture which may include soil testing OR a detailed description of how the test is conducted	*2*
A description of how indicators are used in agriculture with no actual details on the technique involved.	*1*

Question 11 (4 marks)

Sodium hydrogen carbonate is a chemical substance with many uses due to its amphiprotic
properties.

(a)   Use ionic equations to illustrate the amphiprotic nature of sodium hydrogen carbonate (3 marks)

Outcome(s):H4, H9, H13

Sample answer:

An amphiprotic substance is a substance able to donate a proton to a base or to a weaker acid or accept a
proton from a stronger acid and thus act as a base.

Sodium hydrogen carbonate is an amphiprotic substance which exhibits the following behaviour in acid
and basic media:

as a base in acid medium: HCO_3^- (aq) + H_3O^+ (aq) $\rightleftharpoons$ H_2CO_3 (aq) $\rightleftharpoons$ H_2O(l) + CO_2 (g)

as an acid in basic medium: HCO_3^- (aq) + OH^- (aq) $\rightleftharpoons$ H_2O(l) + CO_3^{2-}(aq)
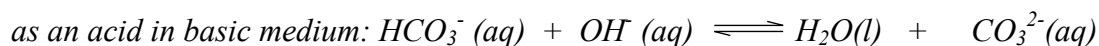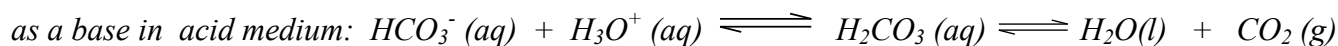
Marking Guidelines

Criteria	Marks
two equations to show amphiprotic nature of the hydrogen carbonate ion equation which should involve an acid and a base as reactants	*2*

| two equations to show amphiprotic nature of the hydrogen carbonate ion involving water as reactant in the two roles | 1 |

(b)   Describe a practical use of sodium hydrogen carbonate which is due to its amphiprotic property.
(2 marks)

Sample answer:

As an amphiprotic substance, sodium hydrogen carbonate is useful as a neutralizer in both acidic and basic chemical spill. It is a weak acid and a weak base and hence an excess of the substance will harm neither the experimenter nor the environment.

Marking guidelines

Criteria	Marks
correct use of sodium hydrogen carbonate with a detailed explanation of how it works	*2*
correct use of sodium hydrogen carbonate with no detailed explanation on how it works	*1*

Question 12 (6 marks)

The burning of coal to create steam is the major method used to produce electricity in NSW.
An analysis of a coal sample was completed and the results are shown below.

Percentage composition of coal sample	
Ash	13.20
Water	8.30
Nitrogen	0.50
Sulfur	0.40
Total carbon	77.60

(a)   Explain, using Le Chatelier's Principle and relevant chemical equations, how an increase in the burning of coal can change the pH of the oceans. (4 marks)

Sample answer

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

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

$H_2CO_3(aq)\ +\ H_2O(l)\ \rightleftharpoons\ H_3O^+(aq)\ +\ HCO_3^-(aq)$
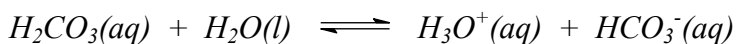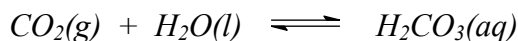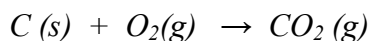
Carbon in the coal burns in oxygen to produce carbon dioxide.
Carbon dioxide forms an equilibrium in water with carbonic acid.
By Le Chatelier's Principle, an increase in carbon dioxide will cause the equilibrium to shift to the right increasing the concentration of acid in the ocean and therefore causing a decrease in the pH.

Marking Guidelines

Criteria	Marks
• Demonstrates an understanding of Le Chatelier's Principle • Explains that an increase in carbon dioxide leads to a decrease in pH • Gives two relevant equations including the equilibrium that involves carbon dioxide as an acid	4
• Demonstrates an understanding of Le Chatelier's Principle • Explains that an increase in carbon dioxide leads to a decrease in pH • Gives one relevant equations including the equilibrium that involves carbon dioxide as an acid	3
• Gives one relevant equation AND • Identifies that the ocean will become more acidic	2
• Gives one relevant equation OR • Identifies that the ocean will become more acidic	1

Outcome(s):H4, H8, H9

(b)   Calculate the maximum volume of sulfur dioxide that could be produced from the burning of 100.0 g of this coal sample at 298 K and 100 kPa.

Sample answer

Mass of sulfur in 100.0 g is 0.40% x 100.0 = 0.40g
Mol S = mass/molar mass = 0.40/32.06 = 0.0125 mol
S + O_2 → SO_2
Mol S =mol SO_2
V SO_2 at 298 K =mol x 24.79 L
*   = 0.125 x 24.79 L*
*   = 0.31L*


Marking Guidelines

Criteria	Marks
Complete calculation with relevant working	2
Some correct working	1

Outcome(s):H10

Question 13 (1 mark)

Ammonia is manufactured in a process between two naturally occurring diatomic gases, in the presence of a catalyst.

(a)   Write an appropriate balanced chemical equation to represent this reaction. (1 mark)

$N_2(g)$ + $3H_2(g)$ $\underset{\xleftarrow{\hspace{1cm}}}{\overset{Fe}{\xrightarrow{\hspace{1cm}}}}$ $2 NH_3(g)$ *(1 mark)*
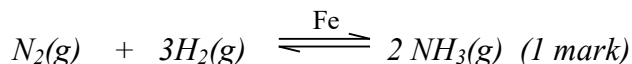
Outcome(s): H6, H7

(b)   The reaction mixture is passed into a chamber at a pressure of 200 Atm at 450°C in contact with a catalyst. These conditions are relatively unique for an industrial process. In particular, the temperature is unusually low.

Explain why the conditions are used during the production of ammonia.

Outcome(s):H3, H7, H8, H10

ANSWERS	MARKS
The production of ammonia is an equilibrium reaction and requires a compromise. *OR* *Mentions Le Chatelier and relates to reaction* *AND* *Exothermic Reaction so heat is released in forward reaction. Higher temperatures would push the reaction to the left to use up heat and reduce ammonia production.* *AND* *Moderately high temperatures are required to produce a reasonable yield.* *AND* *The catalyst increases the rate of both the forward and reverse reaction.* *AND* *A relatively high pressure of 200 Atm is required to push equilibrium to the right. More moles of gas on LHS than on RHS.*	5 marks
The production of ammonia is an equilibrium reaction and requires a compromise. *OR* *Mentions Le Chatelier and relates to reaction.* *AND* *Exothermic Reaction so heat is released in forward reaction. Higher temperatures would push the reaction to the left to use up heat and reduce ammonia production.* *AND* *Moderately high temperatures are required to produce a reasonable yield.* *AND* *A relatively high pressure of 200 Atm is required to push equilibrium to the right. More moles of gas on LHS than on RHS.*	4 marks
Implies that the production of ammonia requires a compromise. *OR* *Recognises that it is an equilibrium process.* *OR* *Mentions Le Chatelier and relates to reaction* *AND* *Exothermic Reaction so heat is released in forward reaction. Higher temperatures would push the reaction to the left to use up heat and reduce ammonia production.* *AND* *A relatively high pressure of 200 Atm is required to push equilibrium to the right. More moles of gas on LHS than on RHS.*	3 marks
Mentions Le Chatelier and relates to reaction *AND* *Exothermic Reaction so heat is released in forward reaction. Higher temperatures would push the reaction to the left to use up heat and reduce ammonia production.*	2 marks

OR *Mentions Le Chatelier and relates to reaction* *AND* *A relatively high pressure of 200 Atm is required to push equilibrium to the right. More moles of gas on LHS than on RHS.*	
Exothermic Reaction so heat is released in forward reaction. Higher temperatures would push the reaction to the left to use up heat and reduce ammonia production. *OR* *A relatively high pressure of 200 Atm is require to push equilibrium to the right. More moles of gas on LHS than on RHS.* *OR* *The production of ammonia is an equilibrium reaction and requires a compromise.* *OR* *Mentions Le Chatelier and relates to reaction*	1 mark
Demonstrates no understanding of the equilibrium or the Haber Process.	0 marks

Sample Answer

Le Chatelier states that by disturbing a system that is at equilibrium, the system will shift to reduce the effects of the disturbance. The production of ammonia is an equilibrium process that is exothermic in the forward reaction. Higher temperatures would push the reaction to the left to use up heat but this will reduce ammonia yield. Moderately high temperatures (450°C) are required to produce a reasonable yield. A catalyst is used to increases the rate of both the forward and reverse reaction. A relatively high pressure of 200 Atm is required to push equilibrium to the right. More moles of gas on LHS than on RHS. The production of ammonia requires a compromise. This is achieved by using moderately high temperatures and high pressure in the presence of a catalyst.

Question 14 (3 marks)

A solution of hydrochloric acid has a pH of 1.50.

(a)   Calculate the $[H^+]$ of this solution.   (1 mark)

(b)   10.0 mL of this solution is made up to 1.00 L with distilled water.
          Calculate the pH of the new solution. (2 marks)

Sample Answer :

pH = 1.5 thus $[H^+] = 10^{-1.5} = 3.16 \times 10^{-2}$ molL-1
new [H+] = $3.16 \times 10^{-2} \times 10 / 1000 = 3.16 \times 10^{-4}$ molL^{-1}
thus pH = $-log10 [3.16 \times 10^{-4}] = 3.5$

14 a) Marking Guidelines

Criteria	Marks
Correct calculation of $[H^+]$ and use of pH = $-log10[H^+]$	
Correct use of pH = $-log10[H^+]$	1

14 b) Marking Guidelines

| Criteria	Marks
Correct calculation of new $[H^+]$ and follow through correct calculation of pH	3
Correct calculation of pH with a follow through error from incorrect $[H^+]$ calculation	2
	1

Outcome: H8, H9

Question 15 (7 marks)

Methanol and butanoic acid are reacted using appropriate apparatus and specific conditions.

(a)   Identify the catalyst used in this process. (1 mark)

conc sulfuric acid or H_2SO_4

(b)   Write a chemical equation using structural formula to show the reaction between methanol and butanoic acid.   Name the products.   (3 marks)
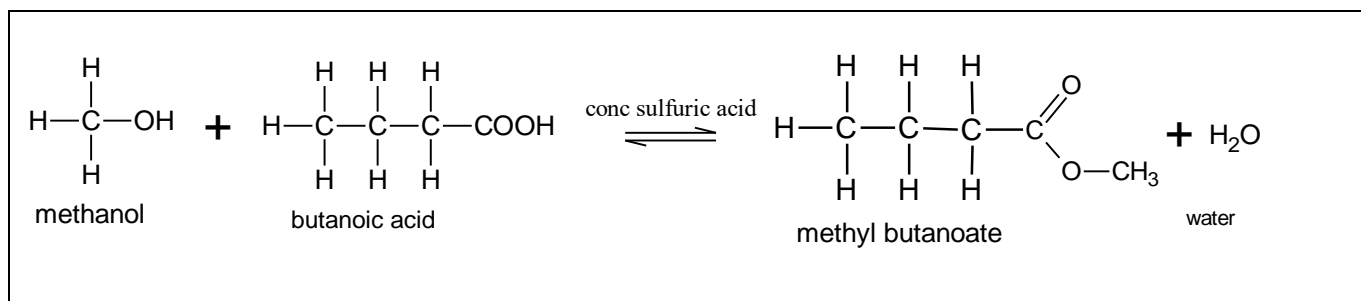
(c)   Identify the specialised glassware used to prepare the major product and give TWO reasons for its use. (3 marks)

Sample Answer :

Concentrated sulphuric acid or H_2SO_4

Reflux condenser and refluxing ; so that volatile reactants and products are condensed back to liquid state to allow them to react further.

15a) Marking Guidelines

Criteria	Marks
Correct identification of the catalyst used in the process.	1

15 b

Criteria	Marks
Correct structural formula and names for reactants and products	4
One incorrect formula or name	3

Two incorrect formula or name	2
Three incorrect formula or name	1

15 c

Criteria	Marks
Correct identification of glassware/apparatus, process and explanation for use of this process	3
One of the above incorrect or incomplete explanation	2
Two of the above incorrect or incomplete explanation	1

Outcomes: H6, H8

Question 16 (4 marks)

A 0.01 mol L^{-1} solutions of acetic acid, citric acid and hydrochloric acid were prepared
 The pH of each solution were measured and found to be 3.41, 2.65 and 2.00 respectively.

(a)   Describe how the pH of the solutions were measured (1 mark)

(b)   Explain the difference in pH between the 0.01 mol L^{-1} solution of the three acids. (3 marks)

Sample Answers :

Place a pH probe connected to a calibrated pH meter in each solution with rinsing in distilled water between solutions OR appropriate use of a range of indicators with varying pH ranges.

*All 3 acids have the same concentration but different pHs due to different degrees of
ionisation of each acid. HCl is the strongest acid thus ionises to the greatest extent(complete ionization) thus has the highest [H$^+$] and lowest pH.*
Acetic acid is the weakest acid thus ionises least(incomplete ionization) and has the lowest [H$^+$] and highest pH.
Citric acid is also a weak acid but ionizes to a greater extent than acetic acid thus has a higher [H$^+$] than acetic acid thus has a higher pH than HCl but lower than acetic acid.

16a) Marking Guidelines

Criteria	*Mark*
One correct outline of measuring pH	*1*

16b

Criteria	*Marks*
Correct and complete explanation of the differences in pH for the same concentration of each of the 3 acids	*3*
Correct and complete explanation of the differences for 2 of the acids or outline of differences for the 3 acids	*2*
Correct explanation for one of the acids or outline of the differences for 2 acids	*1*

⌂ *END of Theory Test*