Student Number	
Mark /	

Chemistry Assessment

Task 2 Term 1 2011

Theory

General Instructions

- **Reading time – 5 minutes**
- **Working time – 65 minutes**
- **Write using black or blue pen**
- **Write your Student Number at the top of this page and on pages 7 and 8**
- **Board-approved calculators may be used**

A data sheet and a periodic table are provided

Total Marks – 43

Part A – 10 marks

- Attempt Questions 1 – 10
- Allow about 15 minutes for this part

Part B – 33 marks

- Attempt Questions 11 - 18
- Allow about 45 minutes for this part

Part A: Multiple Choice: 10 marks
Attempt Questions 1 – 10
Allow about 15 minutes for this part

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

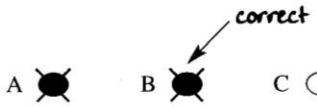
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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 the multiple choice questions in the multiple choice grid on page 7

Multiple Choice (*Mark your answers on the multiple choice grid on page 7*)

1. The following reaction is at equilibrium in a closed vessel at a constant temperature.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2\,(g) + H_2\,(g)$$

What would be the effect of adding more H_2 to the reaction vessel and permitting the reaction to approach equilibrium again?

(A) The concentrations of CO, H_2O, and CO_2 would all increase.

(B) The concentrations of CO, H_2O, and H_2 would all decrease.

(C) The concentrations of CO and H_2O would increase and the concentration of CO_2 would decrease.

(D) The concentrations of CO and H_2O would decrease and the concentration of CO_2 would increase.

2. The formation of hydrogen sulfide (rotten egg gas) in a closed vessel at a constant temperature is an equilibrium reaction.

$$2H_2(g) + S_2(g) \rightleftharpoons 2H_2S(g)$$

What would be expected if the volume of the vessel was reduced from 12.0 L to 6.0 L?

(A) The amount of H_2S would increase and the amounts of H_2 and S_2 would decrease.

(B) The amounts of H_2 and S_2 would increase and the amount of H_2S would decrease.

(C) The concentrations of all species would increase.

(D) The concentrations of H_2 and S_2 would decrease, but the concentration of H_2S would remain unchanged.

3. What is the concentration of a hydrochloric acid solution with a pH of 3.6?

(A) 3.981×10^{-11} mol L^{-1}

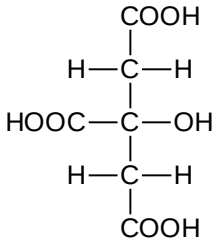
(B) 2.512×10^{-4} mol L^{-1}

(C) 0.2778 mol L^{-1}

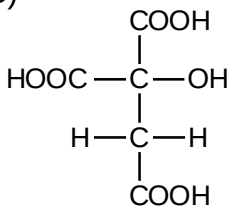
(D) 0.5563 mol L^{-1}

4. Citric acid is a bitter tasting chemical found in many fruits and is a natural preservative. What is the correct structural formula for citric acid?

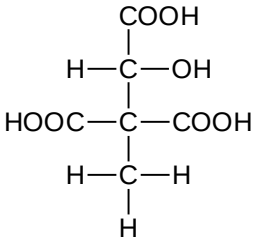
(A)



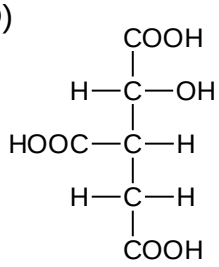
(B)



(C)



(D)



5. Which substance shows the correct indicator colour?

	Substance	*pH*	*Indicator*	*Colour*
(A)	Sodium hydrogen carbonate	8	Bromothymol blue	Blue
(B)	Soda water	4	Phenolphthalein	Pink
(C)	Lemon juice	3	Phenolphthalein	Pink
(D)	Battery acid	2	Bromothymol blue	Blue

6. In which of the following alternatives are the three compounds listed in order of increasing boiling points?

(A) 1-butanol, propanoic acid, pentane

(B) Pentane, 1-butanol, propanoic acid

(C) Propanoic acid, pentane, 1-butanol

(D) Propanoic acid, 1-butanol, pentane

7. What is the conjugate base of HCO_3^-?

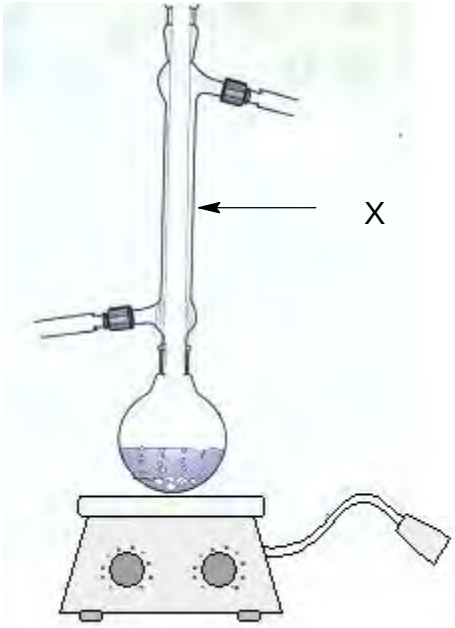
(A) HCO_2^-

(B) CO_3^{2-}

(C) CO_2^{2-}

(D) H_2CO_3

8. Identify the piece of glassware labeled X



(A) distillation tube

(B) reflux condenser

(C) distillation condenser

(D) reflux tube

Test continues next page…

9. Which statement below best describes the need to monitor the reaction vessel in the Haber process?

(A) Oxygen gas makes the reaction go too fast.

(B) Excess nitrogen and hydrogen make the reaction go too slow.

(C) The presence of CO and sulfur compounds can poison the catalyst.

(D) The presence of excess nitrogen and hydrogen can poison the catalyst.

10. What are some of the main products made from ammonia?

(A) fertilizers and detergents

(B) detergents and ethanol

(C) plastics and batteries

(D) nitric acid and cellulose

Student Number .....

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
10	A O	B O	C O	D O

Total .....

Student Number …….....

Part B: Free Response Questions: 33 marks

Attempt Questions 11 – 18. Allow about 45 minutes for this part.
Show all relevant working in questions involving calculations.

Marks

Question 11 (3 marks)

Chlorine can be prepared by reacting hydrogen chloride with oxygen.

$$4\ HCl(g) + O_2(g) \rightleftharpoons 2\ Cl_2(g) + 2\ H_2O(g)$$

Calculate the volume of chlorine formed from reacting 100.0 g of hydrogen chloride with excess oxygen at 25 ^{o}C and 100 kPa. **3**

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Question 12 (2 marks)

Hydroiodic acid is a strong acid often used in the salt industry.

A solution of hydroiodic acid is prepared by adding 2.65 g of hydrogen iodide to enough pure water to make 250.0 mL of solution. Calculate the pH of the solution formed. **2**

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Marks

Question 13 (5 marks)

The electrical conductivity of a solution is a direct measure of the degree of ionisation within the solution. The following conductivity data was obtained for a strong acid and a weak acid.

Solution	*Concentration (mol L^{-1})*	*Electrical conductance (μS)*
W	0.005	1930
X	0.005	134
W	0.01	3730
X	0.01	280

(a) Identify each of these acids as either a strong or weak acid. **1**

Acid *W*..... Acid *X* .....

(b) Justify your answer to (a). **2**

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(c) Explain the effect of changing the concentration of each acid from 0.005 mol L^{-1} to 0.01 mol L^{-1} on the pH of the solutions. Assume the same temperature for both concentrations. **2**

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Marks

Question 14 (5 marks)

A variety of measures have been taken by governments over the past decade to reduce the amount of nitrogen oxides (NO_x) and sulfur dioxide released into the air. In Europe, NO_x emissions have been reduced by the introduction of three-way catalytic converters in motor vehicle exhaust systems. Reduction in SO_2 emissions have been obtained by reducing the sulfur content of fuels.

(a) Write a chemical equation to show the formation of a nitrogen oxide. **1**

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(b) Justify the measures taken by governments to reduce the amount of NO_x and SO_2 in the environment. **4**

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Test continues next page…

Marks

Question 15 (4 marks)

(a) Write a balanced equation using structural formula for the reaction between 1-butanol and acetic acid. **2**

(b) Give the systematic name for the organic product formed. **1**

.....

(c) Identify the class of compounds to which the organic product belongs. **1**

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Question 16 (4 marks)

Describe an experiment you performed in the laboratory to prepare and test a natural indicator. **4**

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Test continues next page.....

Marks

Question 17 (3 marks)

When sodium hydrogen phosphate, Na_2HPO_4, is dissolved in water, the resulting solution contains an amphiprotic ion that is involved in the buffering of living cells and the blood.

(a) Identify the amphiprotic ion produced. **1**

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(b) Write an equation to show how this ion can deal with a sudden decrease in pH. **2**

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Test continues next page.....

Marks

Question 18 (7 marks)

Fritz Haber developed a method for preparing ammonia.

(a) Write a balanced chemical equation for the preparation of ammonia using the Haber process. **2**

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(b) The Haber process is based on a balancing act involving reaction energy, reaction rate and equilibrium conditions.
Discuss the conditions required to maintain optimum yield in the Haber Process in industry with relevance to *Le Chatelier's Principle*. **5**

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END of Theory Test

Student Number	
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Chemistry Assessment

Task 2 Term 1 2011

Theory

Acidic Environment
& Chemical Monitoring

ANSWER

General Instructions

- **Reading time – 5 minutes**
- **Working time – 60 minutes**
- **Write using black or blue pen**
- **Write your Student Number at the top of this page**
- **Board-approved calculators may be used**

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

Total Marks – 43

Part A – 10 marks

- Attempt Questions 1 – 10
- Allow about 15 minutes for this part

Part B – 33 marks

- Attempt Questions 11 - 20
- Allow about 45 minutes for this part

Part A: Multiple Choice:
Attempt Questions 1 – 10
Allow about 10 minutes for this part

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

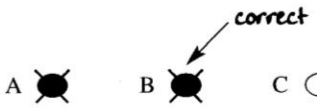
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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 the multiple choice questions in the multiple choice grid on page 6

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

1. The following reaction was at equilibrium in a closed vessel at a constant temperature.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

What would be the effect of adding more H_2 to the reaction vessel and permitting the reaction to approach equilibrium again?

(A) The concentrations of CO, H_2O, and CO_2 would all increase.

(B) The concentrations of CO, H_2O, and H_2 would all decrease.

(C) The concentrations of CO and H_2O would increase and the concentration of CO_2 would decrease.

(D) The concentrations of CO and H_2O would decrease and the concentration of CO_2 would increase.

2. The formation of hydrogen sulfide (rotten egg gas) in a closed vessel at a constant temperature is an equilibrium reaction.

$$2H_2(g) + S_2(g) \rightleftharpoons 2H_2S(g)$$

What would be expected if the volume of the vessel was reduced from 12.0 L to 6.0 L?

(A) The amount of $H_2S(g)$ would increase and the amounts of $H_2(g)$ and $S_2(g)$ would decrease.

(B) The amounts of $H_2(g)$ and $S_2(g)$ would increase and the amount of $H_2S(g)$ would decrease.

(C) The concentrations of all species would increase.

(D) The concentrations of $H_2(g)$ and $S_2(g)$ would decrease, but the concentration of $H_2S(g)$ would remain unchanged.

3. What is the concentration of a hydrochloric acid solution with a pH of 3.6?

(A) 3.981 x 10-11 mol L^{-1}

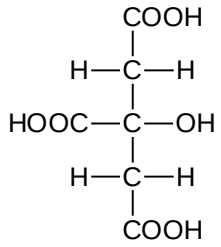
(B) 2.512×10^{-4} mol L^{-1}

(C) 0.2778 mol L^{-1}

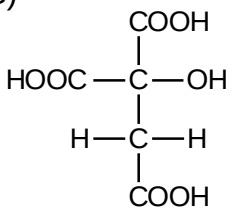
(D) 0.5563 mol L^{-1}

4. Citric acid is a bitter tasting chemical found in many fruits and is a natural preservative. What is the correct structural formula for citric acid?

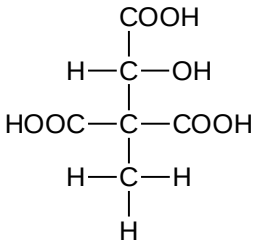
(A)



(B)



(C)



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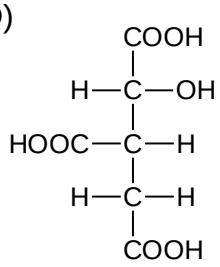


5. Which substance shows the correct indicator colour?

	Substance	*pH*	*Indicator*	*Colour*
(A)	**Sodium hydrogen carbonate**	**8**	**Bromothymol blue**	**Blue**
(B)	Soda water	4	Phenolphthalein	Pink
(C)	Lemon juice	3	Phenolphthalein	Pink
(D)	Battery acid	2	Bromothymol blue	Blue

Outcome(s): H8

6. In which of the following alternatives are the three compounds listed in order of increasing boiling point?

(A) 1-butanol, propanoic acid, pentane

(B) Pentane, 1-butanol, propanoic acid

(C) Propanoic acid, pentane, 1-butanol

(D) Propanoic acid, 1-butanol, pentane

Outcome(s): H9

7. What is the conjugate base of HCO_3^-?

(A) HCO_2^-

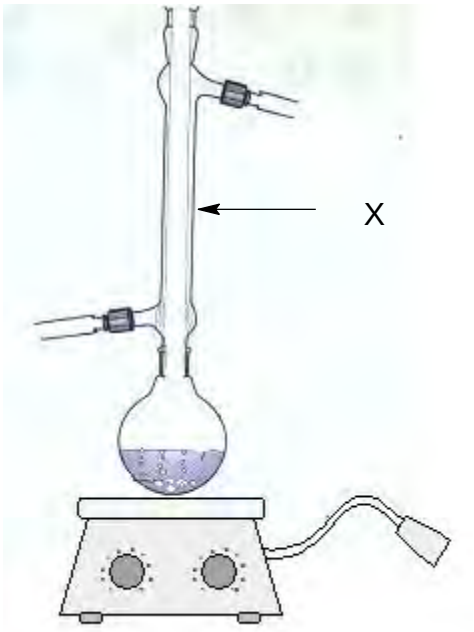
(B) **CO_3^{2-}**

(C) CO_3^-

(D) H_2CO_3

Outcome(s): H8

8. Identify the glassware labeled X



(A) distillation tube

(B) **reflux condenser**

(C) distillation condenser

(D) reflux tube

Outcomes : H9

9. Which statement below best describes the need to monitor the reaction vessel in the Haber process ?

(A) Oxygen gas makes the reaction go too fast

(B) Excess nitrogen and hydrogen make the reaction go too slow

(**C**) **The presence of CO and sulfur compounds can poison the catalyst.**

(D) The presence of excess nitrogen and hydrogen can poison the catalyst

Outcomes: H3

10. Ammonia is ranked second to sulfuric acid in terms of quantity produced. Some of the main products made from ammonia include :

(A) fertilizers and detergents

(B) detergents and ethanol

(C) plastics and batteries

(D) nitric acid and cellulose

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

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

test continues next page…

Student Number ……

Part B Free Response Questions - pages (marks)
Attempt Questions 11 – 20. Allow about 40 minutes for this part.
Show all relevant working in questions involving calculations.

Question 11 (3 marks)

Chlorine can be prepared by reacting hydrogen chloride with oxygen.

$$4\ HCl(g) + O_2(g) \rightleftharpoons 2\ Cl_2(g) + 2\ H_2O(g)$$

Calculate the volume of chlorine formed from reacting 100.0 grams of hydrogen chloride with excess oxygen at 25 ^oC and 100 kPa.

2.74288 moles HCl; 1.37144 moles $Cl_2(g)$ therefore 1.37144 x 24.79 = 33.998 L $Cl_2(g)$

Sample answer:

100g HCl x 1 mole HCl/36.458g HCl x 2 mole Cl_2/4 mole HCl x 24.79 L/1 mole Cl_2 = 34.00 L Cl_2

Outcome criteria	**Marks**
conversion of moles to volume	1 V
applying correct stoichiometric ratio (4 HCl :2 Cl_2)	1 S
Calculation of the number of moles of HCl	1 C

Question 12 (2 marks)

Hydroiodic acid is a strong acid often used in the salt industry.

A solution of hydroiodic acid is prepared by adding 2.65 g of hydrogen iodide to enough pure water to make 250.0 mL of solution. Calculate the pH of the solution formed.

Sample answer

2.65g HI x 1 mole HI/127.908g HI = 0.0207 mole HI

0.0207 mole HI/250 x 10-3 L = 0.0829 M HI

pH = 1.08

Outcome criteria	**Marks**
Calculation of pH of HI(*aq*) using pH = - $\log_{10}[H^+]$	1 P
Calculation of $[H^+]$ (No. moles/250.0 x 10^{-3}L)	1 C

Question 13 (5 marks)

The electrical conductivity of a solution is a direct measure of the degree of ionisation within the solution. The following conductivity data was obtained for a strong acid and a weak acid.

Solution	*Concentration (mol L^{-1})*	*Electrical Conductance (μS)*
W	0.005	1930
X	0.005	134
W	0.01	3730
X	0.01	280

(a) Identify each of these acids as either a strong or weak acid. (1 mark)

Sample answer:

Acid W: strong *Acid X: weak*

(b) Explain your answer to (a). (2 marks)

Sample answer:

W (1930, 3730) ionises more than X (134, 280) at two concentrations. The extent of ionisation is far greater than X even when the concentrations of both acids are the same. W is a strong acid since strong acids completely ionise in aqueous solution. Weak acids only partly ionise in aqueous solutions.

Outcome criteria	**Marks**
Explanation for the differences in ionisation (strong completely ionize, etc)	1 I
Correct interpretation of the data in terms of ionization (link to electrical conductance data)	1 E

(c) Explain the effect of changing the concentration of each acid from 0.005 mol L^{-1} to 0.01 mol L^{-1} on the pH of the solutions. Assume the same temperature for both concentrations. (2 marks)

Increasing the concentration would decrease the pH for both solutions. In both cases the $[H^+]$ is increased.

Outcome criteria	**Marks**
Explanation given for the decrease in pH (must state increase in $[H^+]$	1 E
Identifying a decrease in pH for both solutions	1 P

Question 14 (5 marks)

A variety of measures have been taken by governments over the past decade to reduce the amount of nitrogen oxides and sulfur dioxide released into the air. In Europe, NO_x emissions have been reduced by the introduction of three-way catalytic converters in motor vehicle exhaust systems. Reduction in SO_2 emissions have been obtained by reducing the sulfur content of fuels.

(a) Write a chemical equation to show the formation of a nitrogen oxide. (1 mark)

$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$ $\qquad$ $2\ NO(g) + O_2(g) \rightarrow 2NO_2(g)$

(b) Justify the measures taken by governments to reduce the amount of NOx and SO_2 in the environment. (4 marks)

It is important to reduce the levels of NO_x and SO_2 in the air for several reasons. Oxides of both chemicals may react with H_2O in the air to form acid rain.

E.g., $3\ NO_2(g) + H_2O(l) \rightleftharpoons 2\ HNO_3(aq) + NO(g)$

Acid rain such as nitric acid may have several effects. It reduces the availability of soil nutrients for plants and decomposers. It affects the reproductive cycles of small aquatic organisms and larger ones such as fish by destroying eggs. It may cause corrosion of building materials such as metals and marble.

As an air pollutant, SO_2 is a respiratory hazard. It irritates the nose, throat, and airways to cause coughing, wheezing, and shortness of breath. Those most at risk of developing problems if they are exposed to sulfur dioxide are people with asthma or similar conditions.

Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis.

Outcome criteria (b)	**Marks**
Two environmental effects of NOx and SO_2 described with at least one explanation provided regarding the effect of NO_x and SO_2 on the environment. Must have 2 different effects stated.	4
Two environmental effects of NOx and SO_2 described	2 E, E
One environmental effect of NOx or SO_2 provided (e.g. formation of acid rain)	1 E

E = one environmental effect stated e.g., acid rain formed.
D = description of the environmental effect e.g., health is affected; acid rain affects buildings.
J = justification regarding concerns about the environmental effect e.g., health is affected since SO_2 and NO_x can cause respiratory problems/irritants.

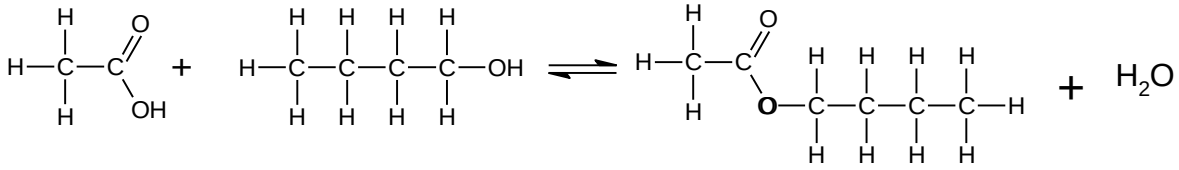
Catalytic converters are efficient at reducing amount of NO_x (1); wide scale implementation of these measures causes further reduction in emissions (1); focuses on reducing fuel content of sulfur since these are generated during the combustion of fuels (1). Max (2) for alternative answers.

Question 15 (4 marks)

(a) Draw a balanced structural equation for the reaction between 1-butanol and acetic acid.

1-butanol + ethanoic acid →butyl ethanoate + water

Complete structures required



Marking criteria	***Marks***
• *Correct equation*	*2*
• *Correct reactants OR* • *Correct products OR* • *Correct products for incorrect reactants*	*1*

(b) Give the systematic name for the organic product formed.

.....

Sample answer:
Butyl ethanoate or butyl acetate (1 mark)

(c) Identify the class of compounds to which the organic product belongs.

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Sample answer:
Esters (1 mark)

Outcomes : H9

Question 16 (4 marks)

Describe an experiment you performed in the laboratory to prepare and test a natural indicator.

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Sample answer:

A red cabbage was chopped up and placed in boiling water. A purple solution was formed and then tested.
The indicator solution was tested with known acids and bases (NaOH and HCl) to determine the colours in these solutions and then the indicator could be used to identify the nature of unknown solutions.

Marking criteria	***Marks***
• *Describes a valid experiment and the tests carried out*	*4*
• *Describes a valid experiment and outlines the tests carried out OR* • *Outlines a valid experiment and describes the tests carried out*	*3*
• *Describes a valid experiment OR the tests carried out OR* • *Outlines a valid experiment and the tests carried out.*	*2*
• *Outlines a valid experiment OR* • *Outlines the tests carried out.*	*1*

Outcomes : H11, H14

Question 17 (3 marks)

When sodium hydrogen phosphate, Na_2HPO_4, is dissolved in water, the resulting solution contains an amphiprotic ion that is involved in the buffering of living cells and the blood.

(a) Identify the amphiprotic ion produced.

.....

(b) Write an equation to show how this ion can deal with a sudden decrease in pH.

.....

Sample answer:

(a) Identify the amphiprotic ion produced.
HPO_4^{2-}

(b) Write an equation to show how this ion can deal with a sudden decrease in pH.
$HPO_4^{2-} + H_3O^+ \rightleftharpoons H_2PO_4^- + H_2O$

Marking criteria	***Marks***
• *Correct equation*	*2*
• *Recognizes increase in H+ OR* • *Correct equation for an incorrect H+ concentration*	*1*

Outcomes : H8

Question 18 (7 marks)

Fritz Haber developed a method for preparing ammonia.

(a) Write a balanced chemical equation for the preparation of ammonia using the Haber process (2 mark)

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Outcomes: H8, H10, H13

(b) The Haber process is based on a balancing act involving reaction energy, reaction rate and equilibrium conditions.

Discuss the conditions required to maintain optimum yield in the Haber Process in industry with relevance to *Le Chatelier's Principle*. (5 marks)

.....

Sample Answers :

(a) $3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g) + heat$

Marking Criteria	*Marks*
Correct balanced equations including states and heat energy	*2*
Correct balanced equation without states or heat energy	*1*

Ammonia NH_3, is produced by reacting H_2 with N_2 at 400^0C and a pressure of 2.5×10^4 kPa in an industrial process called the Haber Process. This equilibrium reaction is dependent on optimal temperatures and pressures to achieve the optimum yield of ammonia at the least cost.

According to Le Chetalier's Principle when a system is in equilibrium and a change is made to the system, the system will shift to counter the change until a new equilibrium is reached.

At temperatures lower than 400^0C the reaction is too slow because the molecules have low kinetic energy, while above 400^0C the reverse reaction is favoured according to Le Chetalier's Principle as it absorbs heat, but this reduces the yield of ammonia.

A relatively low temperature of 400^0C can be used because an iron catalyst is used to reduce the activation energy.

A high pressure maximizes yield by shifting the equilibrium forward, as 4 moles of gas on the reactant side is reduced to 2 moles on the product side thus reducing the pressure. A low pressure will favour the reverse reaction, reducing the yield of ammonia. Use of a higher pressure is too dangerous and expensive.

Marking Criteria	**Marks**
Thorough discussion of the conditions required to maximize yield, including the compromise temperature, high pressure and use of a catalyst to lower activation energy and relating these requirements to *Le Chatelier's Principle*	5
Description with one of the above missing and not clearly related to *Le Chatelier's Principle*	4
Description with two of the above missing and poor relation to *Le Chatelier's Principle*	3
Outline of required conditions with poor relation to *Le Chatelier's Principle*.	2
Identifies two of the conditions to optimize yield in the Haber Process	1

🔔 *END of Theory Test*