Chemistry Assessment

Task 3

Term 2 2013

Theory

General Instructions

For Theory and Research

- **Reading time** – 5 minutes
- **Working time** – 90 minutes

- **Write using black or blue pen**
- **Write your Student Number at the top of pages 5 and 6**
- **Board-approved calculators may be used**

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

Total Marks – 39

Part A – 7 marks

- Attempt Questions (1-7)
- Allow about 10 minutes for this part

Part B – 32 marks

- Attempt Questions (8-15)
- Allow about 35 minutes for this part

Part A: Multiple Choice: 7 marks
Attempt Questions (1-7)
Allow about 10 minutes for this part
Use the answer grid on page 5

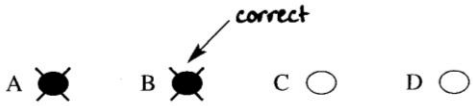
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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.

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.



Multiple Choice
Mark your answer on the answer grid on page 5

1. Identify the catalyst used in the industrial production of sulfuric acid.

(A) magnetite

(B) platinum

(C) enzymes

(D) vanadium (V) oxide

2. An unknown solution gave a white precipitate with sulfuric acid. What result will it give in a flame test?

(A) blue flame

(B) red flame

(C) green flame

(D) yellow-green flame

3. How can the validity and reliability of the tests for ions be improved?

	Reliability	*Validity*
(A)	Repeat the test using proportionally larger quantities of reagents than the previous trial	Use exactly the same quantities of test solutions and reagents
(B)	Get the results from your classmates	Use equal quantities of test solutions and keep the amount of reagents added constant
(C)	Repeat the test using exactly the same amount of test solutions and reagents as the previous trials	Use equal quantities of test solutions and keep the amount of reagents added constant
(D)	Get the results from your classmates	Use equal quantities of test solution and reagents

4. A water sample containing some sediments was found to have a pH of 2. Which of the following substances is *unlikely* to be present in the solid sediment?

(A) calcium carbonate

(B) magnesium sulfate

(C) lead (II) chloride

(D) barium sulfate

5. The atomic absorption spectrophotometer (AAS) is an analytical instrument which has been widely used in industrial, chemical and environmental applications. What is the main disadvantage of this technique?

(A) It is not sensitive enough.

(B) It is a destructive method of analysis.

(C) It can only be used to determine transition metals.

(D) It can only be used to determine semi-metals.

6. Which statement below is the correct description of BOD ?

(A) BOD measures the concentration of dissolved oxygen in water over time.

(B) BOD is the quantity of oxygen produced by microorganisms.

(C) BOD is a measure of the amount of dissolved oxygen consumed in a set time.

(D) BOD is an indication of chemical pollution in a water sample.

7. O_2 and O_3 are allotropes of oxygen. Which property of the two allotropes would be similar?

(A) melting point

(B) density

(C) colour

(D) nature of combustion products

Student Number ……

Part A . Answer grid for multiple choice questions

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

Total: ……../7

Student Number ……

Part B
Attempt Questions 8- 15.
Allow about 35 minutes for this part **Marks**

▸ ***Show all relevant working in questions involving calculations***

Question 8 (5 marks)

The determination of the sulfate content of fertilizer is one of the mandatory practical experiments you did in class. Using the procedure you used in class, a student obtained 1.645 g of $BaSO_4$ from 1.00 g fertilizer.

(a) Calculate the percentage sulfate of the fertilizer? **3**

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(b) State one important assumption for this investigation to be valid?
Describe one important step in the experiment that was designed to ensure that this assumption worked? **2**

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Marks

Question 9 (4 marks)

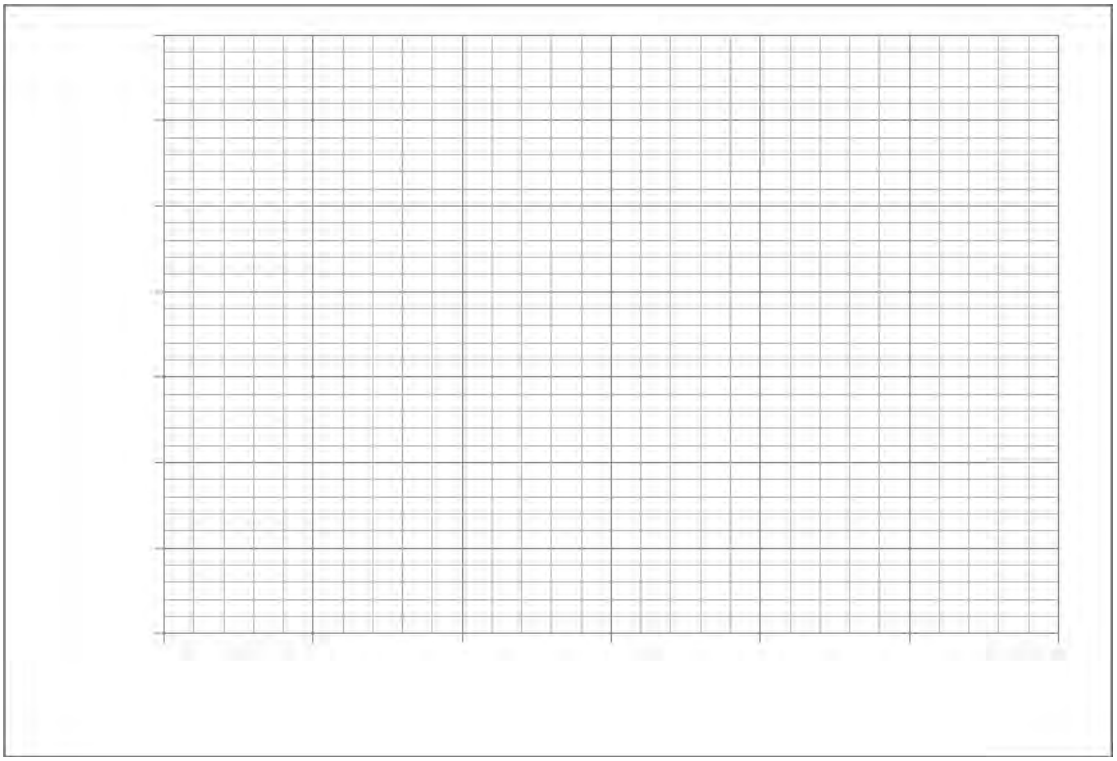
Hip replacement surgery consists of installing metal implants into the hips. Years after surgery, a female patient complained of various symptoms such as severe headaches, anorexia, weight loss and symptoms of depression and dementia. These symptoms have been traced to elevated levels of cobalt in the blood serum. Her serum cobalt level was 4.10×10^{-7} molL^{-1} (*normal range, 0–2.00 x 10^{-8}* molL^{-1}).

The patient underwent another surgery replacing the metal with a polymer implant. After several weeks, the patient's blood serum was analysed for cobalt using atomic absorption spectrometry (AAS). The results are given below:

Conc of standard (mgL^{-1})	*Absorbance*
1.00×10^{-3}	0.130
2.00×10^{-3}	0.258
3.00×10^{-3}	0.370
4.00×10^{-3}	0.520
5.00×10^{-3}	0.650
unknown serum	0.450

(a) Plot the data and draw the line of best fit. From the graph determine the concentration of cobalt in mgL^{-1}

3



Question 9 continues on next page

Marks

Question 9 continues..

(b) Has the level of cobalt in the patient's serum gone back to normal? Show your working. **1**

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Question 10 (7 marks)

Assess the need to monitor the temperature, turbidity and total dissolved solids in recreational waterways in terms of survival of organisms. **7**

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Marks

Question 11 (2 marks)

Describe a test used to identify the chloride ion and give the positive result for this test. **2**

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Question 12 (4 marks)

Explain why ozone is a problem in the troposphere but necessary in the stratosphere. **4**

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Test continues on next page

Question 13 (2 marks)

Use half-equations to identify the products at the anode and the cathode in the electrolysis of concentrated sodium chloride solution. **2**

Anode .....

Cathode.....

Question 14 (5 marks)

Hydrogen gas may be obtained industrially by the following process.

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

A reaction flask initially contained 1.5 mol L^{-1} CO and 2.3 mol L^{-1} of H_2O at 110^0C.

At equilibrium, 0.5 moL^{-1} of CO_2 was present.

(a) Calculate the equilibrium constant for this reaction. **3**

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(b) The equilibrium constant for this reaction at 1500^0C is 5.67.
Is this reaction endothermic or exothermic? Explain your answer. **2**

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Marks

Question 15 (3 marks)

Explain the temperature conditions used in the Contact Process for the manufacture of sulfuric acid. **3**

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End of Theory Test

Chemistry Assessment

Task 3

Term 2 2013

Theory

ANSWERS

General Instructions

for Theory and Research

- **Reading time** – 5 minutes
- **Working time** – 90 minutes

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Total Marks – 39

Part A – 7 marks

- Attempt Questions (1-7)
- Allow about 10 minutes for this part

Part B – 32 marks

- Attempt Questions (8-15)
- Allow about 40 minutes for this part

Part A: Multiple Choice: 7 marks
Attempt Questions (1-7)
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 ○

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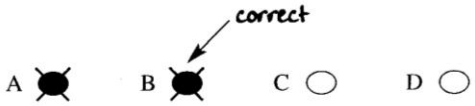

Multiple Choice

1. Identify the catalyst used in the Contact Process.

(A) magnetite

(B) platinum

(C) enzymes

(D) vanadium (V) oxide

Outcomes : H8

2. An unknown solution gave a white precipitate with sulfuric acid. What result will it give in a flame test?

(A) blue flame

(B) red flame

(C) green flame

(D) yellow green flame

3. How can the validity and reliability of the spot test for ions be improved?

	Reliability	*Validity*
(A)	Repeat the test using proportionally larger quantities of reagents than the previous trial	Use exactly the same quantities of test solutions and reagents
(B)	Get the results from your classmates doing exactly the same tests	Use equal quantities of test solutions and keep the amount of reagents added constant
(C)	**Repeat the test using exactly the same amount of test solutions and reagents as the previous trials**	**Use equal quantities of test solutions and keep the amount of reagents added constant**
(D)	Get the results from your classmates doing exactly the same tests	Use equal quantities of test solution and reagents

Outcomes: H12, H13

4. A water sample containing some sediments was found to have a pH of 2. Which of the following substances is unlikely to be present in the solid sediment?

(A) calcium carbonate

(B) magnesium phosphate

(C) lead (II) chloride

(D) barium sulfate

Outcomes: H8, H13

5. The atomic absorption spectrometry, AAS is an analytical instrument which has been widely used in industrial, chemical and environmental applications. What is the main disadvantage of this technioque?

(A) It is not sensitive enough.

(B) It is a destructive method of analysis

(C) It can only be used to determine transition metals.

(D) It can only be used to determine semi-metals.

Outcomes: H13

6. Which statement below is the correct description of BOD ?

(A) BOD measures the concentration of dissolved oxygen in water over time.

(B) BOD is the quantity of oxygen produced by microorganisms.

(C) BOD is a measure of the amount of dissolved oxygen consumed in a set time.

(D) BOD is an indication of chemical pollution in a water sample.

Outcomes : H4

7. O_2 and O_3 are allotropes of oxygen. Which property of the two would be similar ?

(A) melting point

(B) density

(C) colour

(D) combustion products

Outcomes : H6

Student Number ……

Part A . Answer grid for multiple choice questions

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

Total: ……../7

Student Number ……

Part B
Attempt Questions 8 - 15
Allow about 40 minutes for this part

▸ ***Show all relevant working in questions involving calculations***

Question 8 (5 marks)

Determination of the sulfate content of fertilizer is one of the mandatory practical experiments you did in class. Using the same procedure, a student obtained 1.645 g of $BaSO_4$ from 1.00g fertilizer.

(a) What is the percentage sulfate of the fertilizer? (3 marks)

Outcomes: H10, H11, H12, H13
Sample answer:

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

$$\text{moles of } SO_4^{2-} = \text{moles } BaSO_4 = \frac{mass\ BaSO_4}{M_{BaSO4}} = \frac{1.645}{137.3 + 32.07 + 4(16)} = 7.049 \times 10^{-3} \text{ (1 mark)}$$

$$\text{mass } SO_4^{2-} = 7.049 \times 10^{-3} \ (32.07 + 4\ (16.00) = 0.677 \text{ (1 mark)}$$

$$\%\ SO_4^{2-} = \frac{0.677}{1.00} \times 100 = 67.7\% \text{ (1 mark)}$$

(b) What is one important assumption for this experiment to be valid? What one important step in the experiment was designed to ensure that this assumption worked? (2 marks)

Sample answer

The assumption is that all the sulfate ions have been precipitated with the Ba^{2+} as $BaSO_4$ and no other ions in the fertilizer precipitated with the Ba^{2+}
Various ways have been done to do this. Addition of HCl to ensure that only the sulfate precipitates; addition of excess Ba^{2+} in order to complete the precipitation; use of agar to increase the filterability of the $BaSO_4$ ppt.

Criteria	*Mark(s)*
Discussion of one assumption	*1*
Discussion of one method to ensure the assumption works	*1*

Question 9 (4 marks)

Hip replacement surgery consists of installing metal implants into the hips. Years after surgery, a female patient complained of various symptoms such as severe headaches, anorexia, weight loss and had suffered symptoms of depression and dementia. These symptoms have been traced to elevated levels of cobalt in the blood serum. Her serum cobalt level was 4.10×10^{-7} mol/L (normal range, 0–2.00×10^{-8} mol/L).

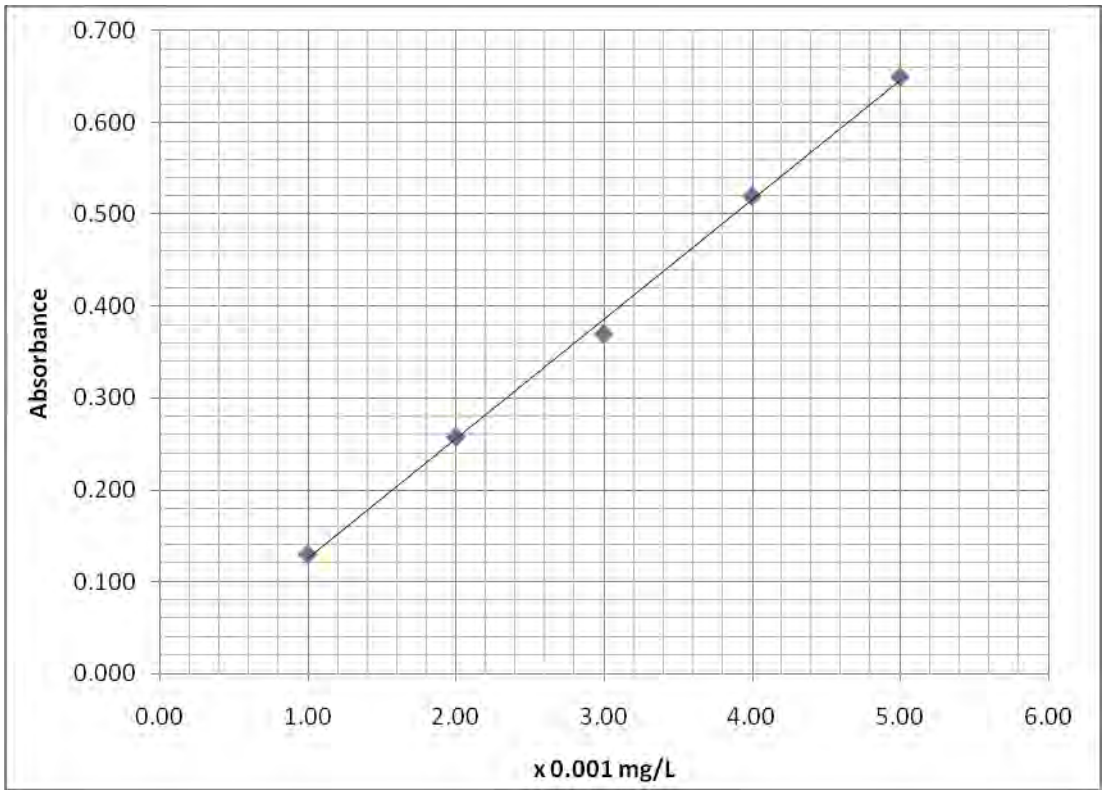
The patient underwent another surgery replacing the metal with a polymer implant. After several weeks, the patient's blood serum was analysed using atomic absorption spectrometry (AAS). The results are given below:

Conc of standard (mgL^{-1})	*Absorbance*
1.00×10^{-3}	0.130
2.00×10^{-3}	0.258
3.00×10^{-3}	0.370
4.00×10^{-3}	0.520
5.00×10^{-3}	0.650

Absorbance of unknown serum: 0.450

(a) Use the grid to graph the data and from the graph determine the concentration of cobalt in mg/L (3 marks)

Sample answer:



Marking Guidelines

Criteria	Mark(s)
Correct orientation of axis	1
Correct plotting of points and line of best fit	1
Correct reading of the graph for the concentration of cobalt	1

(b) Has the level of cobalt in the patient's serum gone back to normal? Show your working. (1 mark)

Sample answer:

The level of cobalt in the patient's serum is 3.50 x 10^{-3} mg/ L.

$$\text{moles of Co/L} = \frac{3.50 \times 10^{-6}\ g/L}{58.93\ g/mole} = 5.94 \times 10^{-8} mol/L$$

The normal level is from 0–2.00 x 10^{-8} mol/L, therefore her Co serum level has not gone back to normal. (1 mark)

Outcomes:H10, H13, H14

Question 10 (7 marks)

Assess the need to monitor the temperature, turbidity and total dissolved solids in recreational waterways used for fishing.
Sample answer:

Temperature:

Temperature affects the ability of organisms to live in the waterway. Some fish as with other organisms cannot tolerate freezing or high temperatures as they both destroy cells and their components. Moreover an elevated temperature lowers the solubility of oxygen (or any other gas) in the water. This limits the diversity of life in the water as only those with reduced requirement for oxygen can survive. (T)

Turbidity:

Turbidity affects the ability of aquatic plants to photosynthesise. Turbid water does not allow much sunlight to penetrate the water. Photosynthesis is important in the sustenance of plants and in turn fish. Fish depend on plants for food and for oxygen. Moreover, suspended materials may enter the gills of fish hampering respiration resulting in death for the fish.(Td)

Total dissolved solids(TDS)

Total dissolved solids directly affect the osmotic pressure of the water. Very high dissolved salts in the water can destroy the cells of both aquatic plants and animals. High salt concentration can cause dehydration of the cell. (DS)

Therefore, because of their importance to aquatic life and to the general health of the waterway, temperature, turbidity and TDS need to be monitored so that remediation can be applied if any deviation from the normal values are observed. (J)

Outcomes: H4, H11,H13,H16

Criteria	*Mark(s)*
Thorough discussion of the role of each of the factors in the maintenance of aquatic life in the waterway	2 each factor
Summarises the role of each factor without much discussion	1 each factor
Judgement should include not only the importance of the factors but also the management of any deviations observed from normal values.	1

Question 11 (2 marks)

Describe a test and the positive result to identify the chloride ion.

Outcomes : H4

Sample Answer : Add silver nitrate solution and a white precipitate form.

Marking Guidelines

Criteria	*Marks*
Correct description and result	2
Correct description or result	1

Question 12 (4 marks)

Explain why ozone is a problem in the troposphere but necessary in the stratosphere. (3 marks)

Sample answer:

In the troposphere O_3 is a powerful oxidant and poisonous in low concentrations. It has a pungent smell and destroys tissue in the lower atmosphere and causing respiratory problems, fatigue and headaches. In the stratosphere it blocks harmful UV from reaching Earth's surface thus protecting living things from cancers and cataracts.

Criteria	*Mark*
Explains of harmful effect of ozone in the troposphere and necessary in the stratosphere for protection from UVwirh specific symptoms for both cases	4
One or the other of the above	3
Two of the above missing	2
Identification of ozone as an irritant	1

Question 13 (2 marks)

Use half-equations to identify the products at the anode and the cathode in the electrolysis of concentrated sodium chloride solution.

Anode .....

Cathode.....

Sample answer:

Anode $2Cl^- \rightarrow Cl_2 + 2e^-$

Cathode $H_2O + 2e^- \rightarrow \frac{1}{2}H_2\,(g) + OH^-$

Outcomes : H3, H8

Question 14 (5 marks)

Hydrogen gas may be obtained industrially by the following process.

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

A reaction flask initially contained 1.5 $molL^{-1}$ CO and 2.3 $molL^{-1}$ of H_2O at 110^0C.

At equilibrium, 0.5 moL^{-1} of CO_2 was present.

(a) Calculate the equilibrium constant for this reaction. (3 marks)

Sample answer:

	CO (g)	+ *H_2O (g)*	⇌	*CO_2 (g)*	+ *H_2 (g)*
start	*1.5*	*2.3*			
eqm	*1.0*	*1.8*		*0.5*	*0.5*

$K = [CO_2][H_2]/[CO][H_2O]$
$K = 0.5 \times 0.5 / 1.0 \times 1.8$
$K = 0.14$

Criteria	*Mark(s)*
• Correctly calculates K using the K expression	3
• Calculates K from incorrect concentrations OR • Correctly calculates K without the K expression given	2
• Gives a K expression	1

(b) The equilibrium constant for this reaction at 1500^0C is 5.67.
Is this reaction endothermic or exothermic? Explain your answer. (2 marks)

Sample answer:

K increases with increasing temperature. More heat favours the endothermic reaction (Le Chatelier). If K has increased then the products have increased therefore the forward reaction is endothermic.

Criteria	*Mark(s)*
• Explains the endothermic nature of the reaction in terms of Le Chatelier's principle and using the K values.	2
• Identifies the reaction as endothermic	1

Outcomes : H7, H10

Question 15 (3 marks)

Explain the temperature conditions used in the Contact Process for the manufacture of sulfuric acid..

Sample Answer

500^0C is a compromise temperature used in the Contact Process.

$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3(g) + heat$

The forward reaction is exothermic so a high temperature will favour the reverse endothermic reaction. However, low temperatures would favour the exothermic forward reaction but the reaction would be too slow. Therefore a comprise temperature is used to increase the reaction rate and provide a moderate yield in a moderate time.

Criteria	*Mark(s)*
• Identifies the equilibrium as exothermic and explains the compromise between rate and equilibrium position	3
• Outlines the reaction condition	2
• Gives the equation OR • Identifies the temperature	1

Outcomes : H8

End of Theory Test