Student Number

# ASCHAM

# 2015

# CHEMISTRY

## TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

**General Instructions**

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- Use the Data Sheet and Periodic Table provided
- Use the Multiple-Choice Answer Sheet provided
- Write your Student Number at the top of this page, page 11, the Multiple-Choice Answer Sheet and on your blank work booklet.

**Total marks – 100**

**Section I** Pages 2-23

**75 marks**

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1-20
- Allow about 35 minutes for this part
- Answer on the Multiple-Choice answer Sheet provided

Part B – 55 marks

- Attempt Questions 21-31
- Allow about 1 hour and 40 minutes for this part
- Answer in the question book in the spaces provided

**Section II** Pages 24-25

**25 marks**

- Allow about 45 minutes for this section
- Answer in the blank work booklet provided

**SECTION II – ELECTIVE TOPIC**

**Attempt ONE question from Questions 32 to 36**

**Allow about 45 minutes for this section.**

Answer in a writing booklet. Extra booklets are available.

Show all relevant working in questions involving calculations.

Note; You will answer question 32 on Industrial Chemistry. The other elective questions are not provided

Question 32 Industrial Chemistry

Question 33 Shipwrecks, Corrosion and Conservation

Question 34 Biochemistry of Movement

Question 35 The Chemistry of Art

Question 36 Forensic Chemistry

# Section I — 75 marks

## Part A – Multiple Choice — 20 marks

## Attempt Questions 1-20

## Allow about 35 minutes for this part

Use the Multiple Choice Answer Sheet provided to answer Questions 1-20

1. A chemist observed a colour change after adding bromine water, $Br_{2(aq)}$, to an unknown hydrocarbon.

   Which one of the following substances could she have produced in this reaction?

   (A) pentane

   (B) 2-pentene

   (C) 2,3-dibromopentane

   (D) 1,3-dibromopentane

2. Which of the following pairs of compounds could be used to produce a condensation polymer?

| | | |
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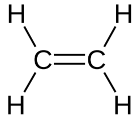
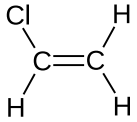
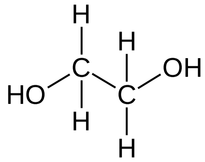
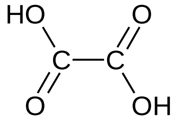
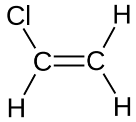
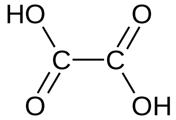
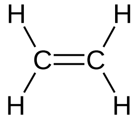
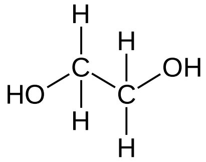
| (A) |  |  |
| (B) |  |  |
| (C) |  |  |
| (D) |  |  |

3. Which of the following pairs of chemicals could spontaneously react to form products?

(A) $I_2$ and $Br^-$

(B) $H^+$ and Cu

(C) $MnO_4^-$ and $F_2$

(D) $Ag^+$ and $Fe^{2+}$

4. Four monoprotic acids, W, X, Y and Z were tested and the following data collected:

| Acid | Concentration (mol/L) | pH |
|---|---|---|
| W | 0.01 | 2.0 |
| X | 0.01 | 3.8 |
| Y | 0.10 | 3.5 |
| Z | 0.05 | 1.35 |

Which one is the weakest acid?

(A) W

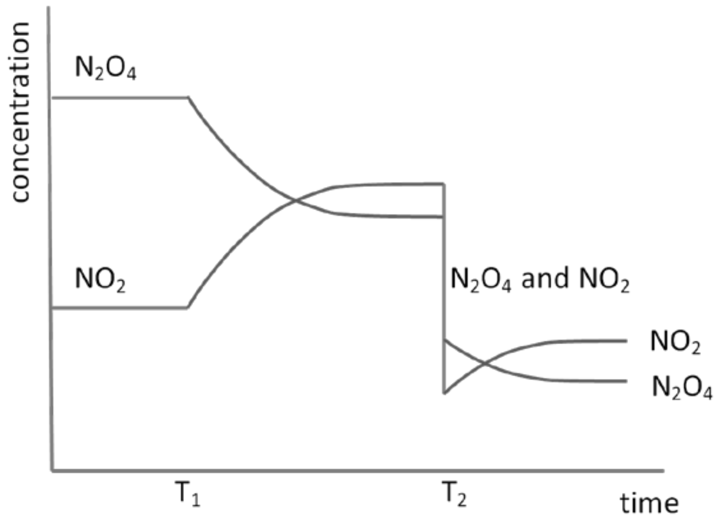
(B) X

(C) Y

(D) Z

5 The graph shows the concentrations over time for the equilibrium system:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \quad \Delta H = -58 \text{ kJ mol}^{-1}$$




What has happened to the temperature at $T_1$ and to the volume at $T_2$?

| | Temperature change at $T_1$ | Volume change at $T_2$ |
|---|---|---|
| (A) | Decrease | Increase |
| (B) | Increase | Increase |
| (C) | Decrease | Decrease |
| (D) | Increase | Decrease |

6. An alkanol with a molar mass of 74g/mol was added to an alkanoic acid with a molar mass of 60g/mol, forming an ester.

Which of the following must be the molar mass of the ester produced?

(A) 116 g/mol

(B) 118 g/mol

(C) 134 g/mol

(D) The molar mass cannot be determined from the data provided.

**7.** Energy content per kg is an important consideration for bushwalkers carrying liquid fuels.

Which one of the following fuels releases the most energy per kg when it undergoes complete combustion?

| Alkanol | Molar mass | Heat of combustion (kJ/mol) |
| --- | --- | --- |
| ethanol | 46.1 | 1364 |
| butane | 58.1 | 2877 |
| 1-propanol | 60.1 | 2021 |
| hexane | 86.2 | 4163 |

(A) ethanol

(B) butane

(C) 1-propanol

(D) hexane

8. The table below shows the results of 3 tests performed on a solution of an unknown compound X.

| | **HCl added** | **$H_2SO_4$ added** | **$AgNO_3$ added** |
|---|---|---|---|
| Result | White precipitate | White precipitate | No precipitate |

Based on the above results, which of the following could identify compound X?

(A) lead(II) chloride

(B) lead(II) nitrate

(C) barium nitrate

(D) barium chloride

9. Which of the following species contains a coordinate covalent bond?

(A) NaCl

(B) $O_2$

(C) $H_2O$

(D) $NH_4^+$

10. Ethanol can be used to produce ethene. This is achieved by:

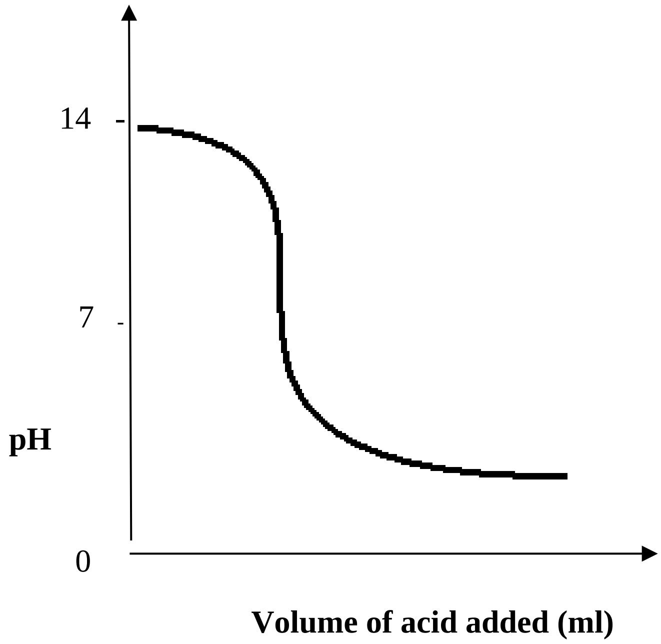
(A) Dehydration of the ethanol using dilute sulfuric acid as a catalyst

(B) Hydration of the ethanol using dilute sulfuric acid as a reactant

(C) Dehydration of the ethanol using concentrated sulfuric acid as a catalyst

(D) Hydration of ethanol using concentrated sulfuric acid as a catalyst

11. A student performed a titration using computer based technology and the following graph was produced.




From the information in the graph it can be deduced that:

(A) the acid was a weak acid and the end point was at pH 8

(B) the acid was a strong acid and the end point was at pH 8

(C) the acid was a weak acid and the end point was at pH 2.5

(D) the acid was a strong acid and the end point was at pH 11

12. The following equation shows the reaction of ammonia with hydrogen sulfate ions.

$$NH_3 + HSO_4^- \rightarrow NH_4^+ + SO_4^{2-}$$

Which statement correctly describes the $SO_4^{2-}$ ions?

(A) It is the conjugate base of $HSO_4^-$

(B) It is the conjugate acid of $HSO_4^-$

(C) It is the conjugate base of $NH_4^+$

(D) It is the conjugate acid of $NH_4^+$

13. Which one of the following identifies a major pollutant found in the lower atmosphere and states its correct source?

(A) Ozone from CFC's interacting with oxygen molecules.

(B) Nitrogen dioxide from thunderstorms

(C) Sulfur dioxide from the reduction of metallic ores

(D) Carbon monoxide from the complete combustion of natural gas.

14 A student performed an investigation to measure the sulfate content of ammonium sulfate lawn fertilizer by precipitating the sulfate as barium sulfate ($BaSO_4$) and weighing the precipitate. His results are tabulated below.

| What was weighed | Mass (g) |
|---|---|
| *Ammonium sulfate fertiliser sample* | 2.00 |
| *Clean filter paper* | 1.05 |
| *Filter paper + dry barium sulfate precipitate* | 1.88 |

What is the percentage of sulfate, by mass, in the measured ammonium sulfate fertilizer?

(A) 17.1 %

(B) 24.4 %

(C) 38.7 %

(D) 72.7 %

15 Which of the following reactions represents combustion in the presence of an inadequate oxygen supply?

(A) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

(B) $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

(C) $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$

(D) $CH_4(g) + O_2(g) \rightarrow C(s) + 2H_2O(l)$

16 The following acid-base indicators change colour depending on pH as shown in the following table.

| pH / Indicator | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
|---|---|---|---|---|---|---|---|
| **Methyl orange** | red | Yellow | | | | | |
| **Bromothymol blue** | Yellow | | | Blue | | | |

What colour will the following indicators be if a few drops are added to 0.1 M hydrochloric acid, and to 0.1 M acetic (ethanoic) acid ($CH_3COOH$)?

| | **Methyl orange** | | **Bromothymol blue** | |
|---|---|---|---|---|
| | **HCl** | **$CH_3COOH$** | **HCl** | **$CH_3COOH$** |
| (A) | Red | Red | Yellow | Yellow |
| (B) | Red | Yellow | Yellow | Yellow |
| (C) | Yellow | Yellow | Blue | Blue |
| (D) | Red | Yellow | Blue | Blue |

17. Which one of the following types of chemist would be most likely to collaborate with a polymer chemist to manufacture a new type of plastic?

(A) an industrial chemist

(B) a biochemist

(C) a forensic chemist

(D) a metallurgical chemist

18. Which one of the following species is the strongest oxidant?

(A) $Na^+$

(B) Na

(C) $F^-$

(D) $F_2$

19. The following are statements made by a student about biopolymers:

I . Condensation polymers are also called biopolymers

II Biopolymers are biodegradable.

III All biopolymers are plastics.

IV Biopolymers can be produced from renewable resources.

How many correct statements did the student make?

(A) 1

(B) 2

(C) 3

(D) 4

**20.** CFC molecules can be identified by a numbered code. To assign the numbered code for each molecule, the following rules are followed:

1. Count the numbers of each C, H and F atom present in the molecule.
2. Write this number as a three digit number. For example, in the molecule $CCl_2F_2$, there is 1 carbon atom, 0 hydrogen atoms and 2 fluorine atoms, so the number becomes 102.
3. Subtract 90 from this number to determine the code for the molecule.
4. Thus dichlorodifluoromethane is CFC 12

Using this rule, which of the following would be the correct code for 2,2-dichloro-1,1,1,2-tetrafluoroethane?

(A) CFC 24

(B) CFC 112

(C) CFC 114

(D) CFC 204

## Section I (continued)

### Part B – 55 marks

**Attempt all questions**

**Allow about 1 hour 55 minutes**

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**Question 21. (5 marks)**

Vinyl chloride and styrene are monomers used to make polymers.

a) Draw the structure of each of these monomers 2

Vinyl chloride styrene

b) Name a polymer made from one of these monomers. Give a use for this polymer and relate its use to one of its properties 3

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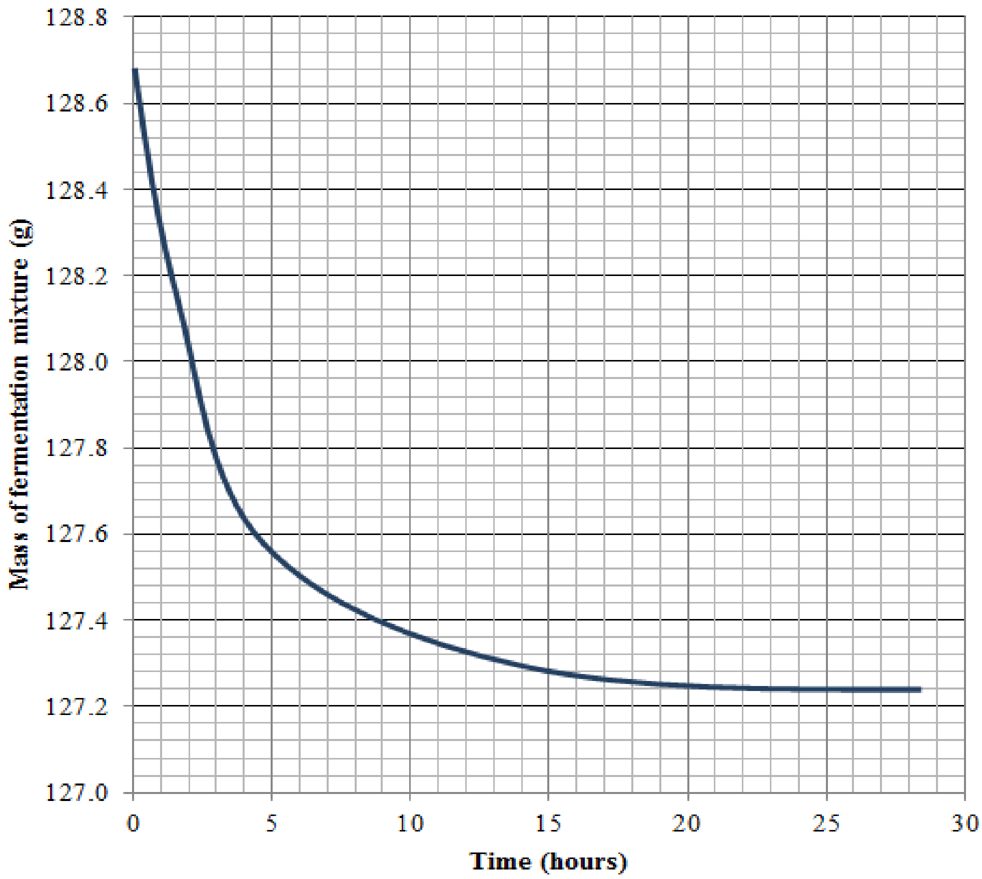
**Question 22** **(5 marks)**

Fermentation converts glucose into ethanol according to the equation:

$$C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$$

A student added 12g of glucose to a conical flask along with 1g of yeast and 50 mL of water at 37 °C.
The conical flask was attached to a computer to monitor mass changes in the reaction vessel.

The graph below shows how the mass of the reaction mixture changes over a 24 hour period.




(a) Use the graph to calculate the mass change in the conical flask. **1**

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**Question 22 continues over the page**

(b) Use the mass change to calculate the mass of ethanol produced by the reaction, and compare this to the theoretical mass of ethanol that you would expect to be produced.

Show all working. 4

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**Question 23** **(3 marks)**

Describe what you would observe (if anything) when an iron nail is placed in a solution of copper sulfate. Include equations to support your description

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**Question 24.** **(4 marks)**

In your course you were required to gather and present information on either a lead acid cell, a dry cell and one other cell that you researched.
Identify the cell you researched and describe its chemistry, including the identification of the anode and cathode, the electrolyte, the overall cell reaction and the voltage produced.

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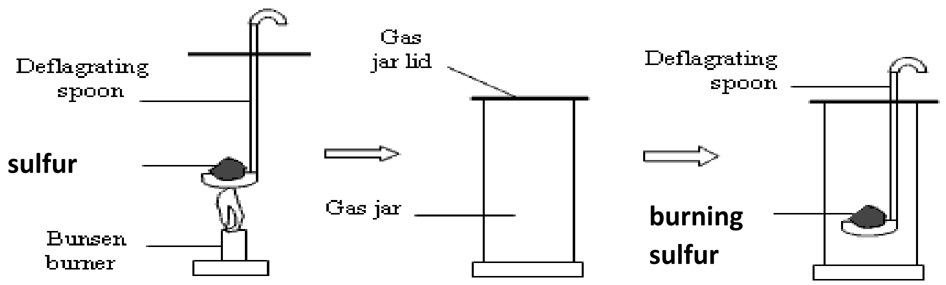
**Question 25** **(5 marks)**

A chemistry teacher carried out the following demonstration.

A small mass of sulfur was combusted a in a spoon, burning with a blue flame.
Whilst alight, it was placed into a gas jar to collect the gas produced.




A mist of water was sprayed into the gas jar. Some of the water which fell to the bottom of the jar was collected and tested with universal indicator. The indicator turned red.

Evaluate the above demonstration as a model for the formation of environmental acid rain. Include relevant balanced equations in your answer.

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**Question 26 (4 marks)**

The list below contains acids, bases and salts.

| | |
|---|---|
| $H_2SO_4$ | $CH_3COOH$ |
| $Na_2CO_3$ | $NaOH$ |
| $NH_4Cl$ | $NH_3$ |
| $HCl$ | |

(a) Identify the species which would react together to form a basic salt and write an equation for this reaction. 2

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(b) Outline how a buffer solution could be prepared from two of the above compounds. 2

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**Question 27 (4 marks)**

I order to measure the concentration of mercury in seawater near an industrial plant a team of chemists used Atomic Absorption Spectroscopy. They first made of standard solution by dissolving 0.106g of mercury II nitrate in water and making up to a volume of 250mL

a) Calculate the concentration of Mercury ions in this solution in ppm 1

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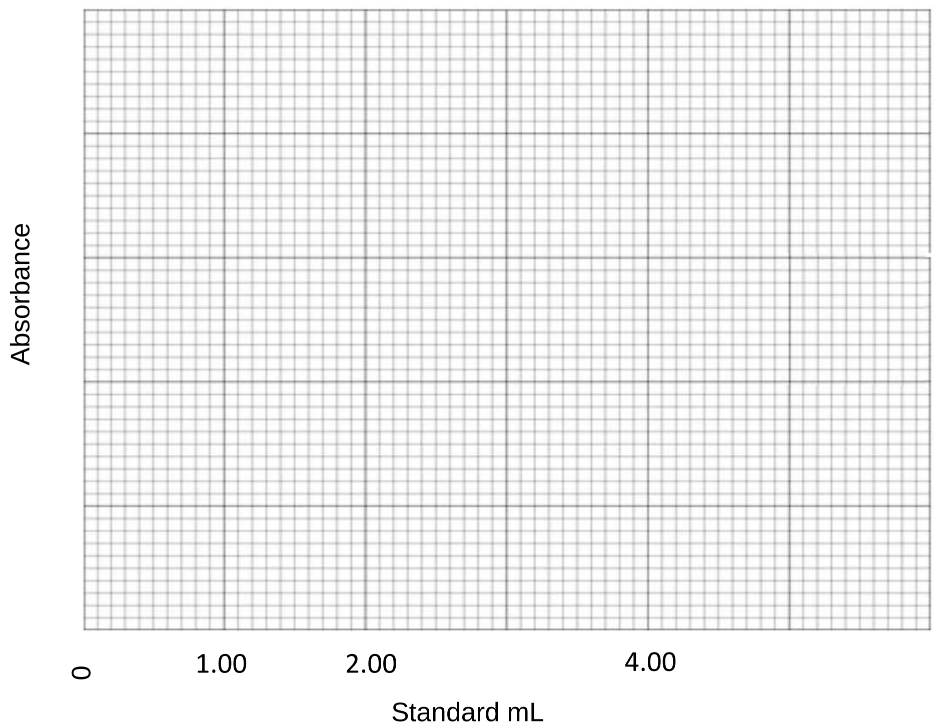
This solution was then diluted 1.00 ml in 100 mL, 2.00 mL in 100 mL and 4.00 mL in 100 mL

Absorbances for the each dilution were then determined

| Standards mL | 1.00 | 2.00 | 4.00 | Sample | A |
|---|---|---|---|---|---|
| Absorbance | 0.083 | 0.164 | 0.331 | | 0.21 |

b) Graph the standard (mL) vs Absorbance 1




**Question 27 continues over the page.**

c) Use the calibration curve you have constructed to find the concentration of mercury ions (in ppm) in sample A. 2

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**Question 28 (5 marks)**

During the course you produced esters in the laboratory

a) Draw a labelled diagram of the equipment you used (set up) 3

b) If ethanol and butanoic acid were used in your reaction write a balanced equation with structural formula. Include any necessary conditions. 2

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## Question 29 (7 marks)

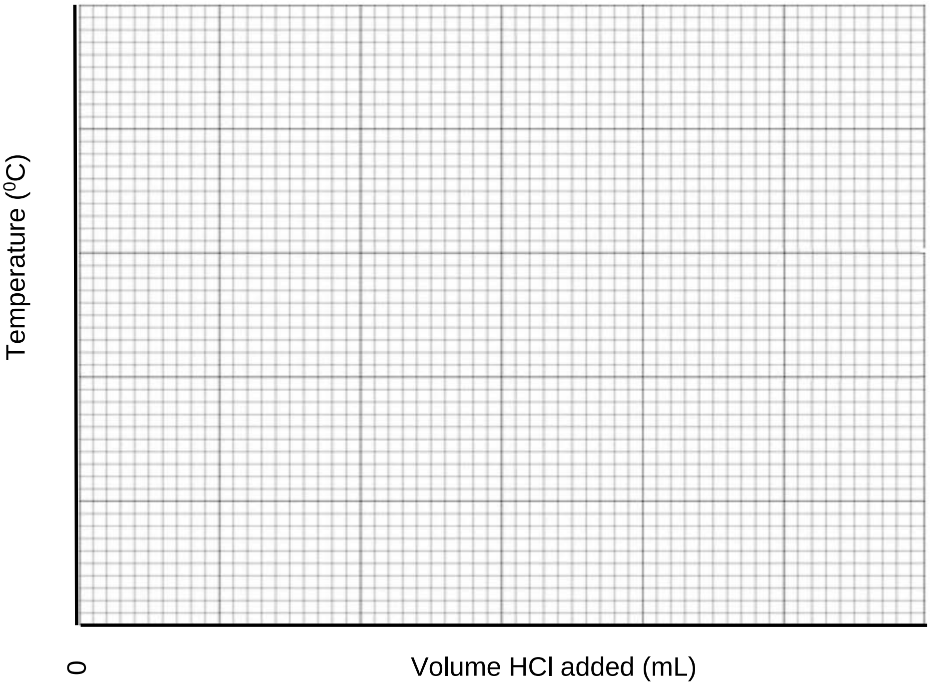
A student used temperature change during neutralization to calculate the concentration of hydrochloric acid. The method they used was:

1. 1L of 0.145 M NaOH and 1L of HCl were allowed to sit at room temperature for 60 minutes.
2. 25.0 mL of 0.145 M NaOH was added to a polystyrene cup using a volumetric pipette.
3. The temperature of the NaOH(aq) was measured using a thermometer.
4. 10.0 mL of HCl was added to the cup using a volumetric pipette.
5. The highest temperature reached was measured.
6. Steps 1 – 4 were repeated with 20, 30, 40, 50 and 60 mL of HCl.

The results they obtained are shown in the table below.

**V (HCl) added vs temp. when neutralizing 0.145 M NaOH.**

| Volume of HCl added (mL) | Max. temperature reached ($^{o}$C) |
|---|---|
| 0 | 21.0 |
| 10 | 28.0 |
| 20 | 35.0 |
| 30 | 35.0 |
| 40 | 32.5 |
| 50 | 30.0 |
| 60 | 27.5 |




(a) Use the grid below to graph the data above. 1

(b) Draw two straight lines through the points and extend them until they cross. 1

(c) What volume of HCl was required to completely neutralize the NaOH?
On your graph, show how you obtained this value. 2

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**Question 29 continues over the page**

(d) Calculate the concentration of the HCl. 3

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**Question 30 (6 marks)**

(a) Outline Le Chatelier's Principle. 1

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(b) Assess the significance of this principle to the work carried out by Haber in his efforts to produce ammonia on an industrial scale. 5

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**Question 31.** **(7 marks)**

Explain the chemistry of ozone destruction in the upper atmosphere using equations to support your answer. Discuss the measures taken to reduce the depletion and evaluate their success.

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# Section II

**25 marks**

**Attempt ONE question from Questions 32-36**

**Allow about 45 minutes for this section**

Answer in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

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Pages

**Question 32 Industrial Chemistry (25 marks)**

a) Chemists have sought to make replacements for natural products for many reasons, including to replace diminishing natural resources and to satisfy a higher demand

Describe measures being take to increase the supply of rubber in order to satisfy increasing demand. 3

b) Many industrial processes involve equilibrium reactions, and manipulating equilibrium conditions is an important part of industrial chemistry.

(i) Identify the experimental variable that changes the value of the equilibrium constant. 1

(ii) The water-gas shift reaction is a useful industrial method for the production of hydrogen gas, some of which is used to provide hydrogen for the Haber process. The equation for the process is:

$$CO(g) + H_2O(g) \leftarrow\rightarrow CO_2(g) + H_2(g)$$

A Two (2) litre flask initially contained 3.0 mol of CO and 5.0 mol $H_2O$. After a period of time it reached equilibrium and was found to contain 1.0 mol $CO_2$.
Calculate the equilibrium constant K for the reaction. 2

c) A series of reactions are involved in the production of sulfuric acid from elemental sulfur using the Contact process. Describe the reactions and justify the conditions and chemistry involved in the process. 6

d) Aqueous sodium chloride is used as a starting material for the production of sodium hydroxide, which occurs by electrolysis.

(i) In your practical work you have carried out electrolysis of sodium chloride. Outline the method you used to do this. 2

(ii) Explain, using equations to support your answer, why different products are observed when dilute aqueous, concentrated aqueous, and molten NaCl are electrolysed. 4

e) (i) Outline the cleaning action of soap. Include a labelled diagram of a micelle in your answer. 3

(ii) Describe the structure and properties of two types of synthetic detergent that have been developed to meet the increasing demand for surfactants. 4

**STUDENT NUMBER** | | | | | | | | | |

# ASCHAM TRIAL HSC EXAM 2015

## Multiple Choice Answer Sheet

**(Circle the correct answer)**

| Question | | | | |
|---|---|---|---|---|
| 1 | A | B | C | D |
| 2 | A | B | C | D |
| 3 | A | B | C | D |
| 4 | A | B | C | D |
| 5 | A | B | C | D |
| 6 | A | B | C | D |
| 7 | A | B | C | D |
| 8 | A | B | C | D |
| 9 | A | B | C | D |
| 10 | A | B | C | D |
| 11 | A | B | C | D |
| 12 | A | B | C | D |
| 13 | A | B | C | D |
| 14 | A | B | C | D |
| 15 | A | B | C | D |
| 16 | A | B | C | D |
| 17 | A | B | C | D |
| 18 | A | B | C | D |
| 19 | A | B | C | D |
| 20 | A | B | C | D |

STUDENT NUMBER | | | | | | | | |

# ASCHAM TRIAL HSC EXAM 2015

## Multiple Choice Answer Sheet

## (Circle the correct answer)

| Question | | | | |
|---|---|---|---|---|
| 1 | A | B | **C** | D |
| 2 | A | **B** | C | D |
| 3 | A | B | C | **D** |
| 4 | A | B | **C** | D |
| 5 | A | **B** | C | D |
| 6 | **A** | B | C | D |
| 7 | A | **B** | C | D |
| 8 | A | **B** | C | D |
| 9 | A | B | C | **D** |
| 10 | A | B | **C** | D |
| 11 | **A** | B | C | D |
| 12 | **A** | B | C | D |
| 13 | A | B | **C** | D |
| 14 | **A** | B | C | D |
| 15 | A | B | C | **D** |
| 16 | A | **B** | C | D |
| 17 | **A** | B | C | D |
| 18 | A | B | C | **D** |
| 19 | A | **B** | C | D |
| 20 | A | B | **C** | D |

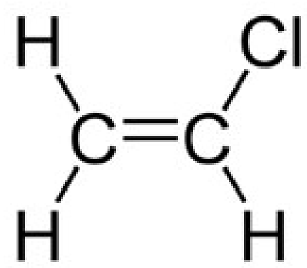
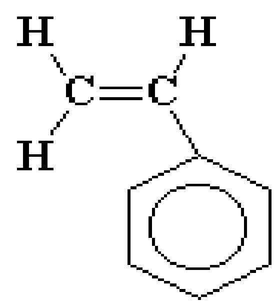
## Section I B

**Question 21**

**a**

| Marking guidelines | Marks |
|---|---|
| Draws correct diagram of both monomers | 2 |
| Draws correct diagram of one monomer | 1 |

Sample answer

| | |
|---|---|
|  |  |
| **Vinyl chloride** | **Styrene monomer** |

**b.**

| Marking guidelines | Marks |
|---|---|
| Names polymer and gives a correct use and relates use to a relevant property of the polymer | 3 |
| Names polymer and gives a correct use | 2 |
| Names polymer | 1 |

Sample answer

**Question 22**

**a.**

| Marking guidelines | Marks |
|---|---|
| Correctly calculates mass and shows working | 1 |

**Sample answer**

**Initial mass = 128.68g**

**Final mass = 127.24g**

**Change in mass = 128.68 – 127.24 = 1.44g**

**b.**

| Marking guidelines | Marks |
|---|---|
| Correctly calculates mass of ethanol produced AND<br>Correctly calculates theoretical mass produced AND shows all working<br>Uses 4 significant figures in formula mass calculations and three or two **significant figures** in answer AND<br>Makes a comparison | 4 |
| One of above missing or incorrect | 3 |
| Two of above missing or incorrect | 2 |
| Three of above missing or incorrect | 1 |

**Sample answer.**

**Actual yield of ethanol**

$$C_6H_{12}O_{6(aq)} \longrightarrow 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$$

n ($CO_2$) = 1.44/44.01

n (ethanol) = 1.44/44.01 formula mass of ethanol = 24.02 + 6.048 + 16.00 = 46.068

m (ethanol) = 1.44/44.01 x 46.068 = 1.51g to three sig fig

**Theoretical yield of ethanol**

n (glucose) = 12/180.152

n (ethanol) = 2 x 12/180.152

m (ethanol) = 2 x 12/180.152 x 46.068 = 6.1g to 2 sig fig

The actual yield of ethanol was much less than the amount that theoretically should have been produced

**Question 23**

| Marking guidelines | Marks |
|---|---|
| Describes displacement reaction AND<br>Writes correct equation AND<br>**Includes states in equation** | 3 |
| One of above missing or incorrect | 2 |
| Two of above missing or incorrect | 1 |

**Sample answer**

The iron nail will, after a short period of time, be covered with a copper coloured material (and the blue colour of the solution will fade) *second observation not necessary for mark*

$Fe (s) + Cu^{2+} (aq) \rightarrow Cu (s) + Fe^{2+} (aq)$

**Question 24**

| Marking guidelines | Marks |
|---|---|
| Identifies the cell researched( no mark value)<br>Identifies anode and cathode AND<br>Identifies electrolyte AND<br>Writes overall cell equation ( or two half equations)AND<br>Gives voltage produced by the cell | 4 |
| One of above missing or incorrect | 3 |
| Two of above missing or incorrect | 2 |
| Three of above missing or incorrect | 1 |

**Sample answer**

Various answers depending on cell chosen

**Question 25**

| Marking guidelines | Marks |
|---|---|
| Describes how the demonstration is related to acid rain formation<br>AND<br>Identifies the natural sources of Sulfur dioxide<br>AND<br>Describes a limitations of the model<br>AND<br>Includes two appropriate and correct chemical equations<br>AND<br>Makes an overall judgment on the demonstration as a model for acid rain | 5 |
| One requirement above missing<br>OR<br>Descriptions lack detail | 4 |
| 2 requirements above are missing | 3 |
| Includes 2 of the requirements only ( with adequate detail in descriptions) | 2 |
| One requirement only | 1 |

Sample answer.

The model is a very good representation of the formation of acid rain because an oxide of S is formed which is then dissolved in water to form an acidic solution:

$S(s) + O_2(g) \rightarrow SO_2(g)$ and then $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$

The merits of the model include:

- it shows the burning of S and as such represents what can occur when coal with S impurities is burnt
- it shows the gas formed, $SO_2$, dissolving in water, which represents $SO_2$ (g) dissolving in rain water in the atmosphere
- as such it allows us to visualize a process that we would be unable to observe

The limitations of the model include:

- it does not attempt to illustrate the formation of acid rain due to oxides of nitrogen, nor due to the formation of $SO_2$ from the smelting of sulfide ores
- the amount of S burnt is relatively large relative to the small space of the gas jar. As a result the pH of the "acid rain" formed is likely to be much lower than would "usually" occur

Overall though it works as a model in the classroom because it shows the oxidation of S to $SO_2$, and then $SO_2$ dissolving in water to form an acidic solution. Thus it is a very effective model.

**Question 26.**

**a.**

| **Marking guidelines** | **Marks** |
|---|---|
| Identifies the two species AND<br>Writes a correct equation (If only equation is written the identity of the two species can be implied) | 2 |
| Identifies the two species | 1 |

**Sample answer**

Strong base (NaOH) with weak acid ( $CH_3COOH$)

$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$

**b.**

| **Marking guidelines** | **Marks** |
|---|---|
| Selects correct solutions for making a buffer ( weak base and its conjugate) AND<br>Specifies that solutions should be equimolar | 2 |
| Selects solutions OR specifies that solutions should be equimolar | 1 |

Sample answer

Select a weak acid/base and its conjugate – $NH_3$ and $NH_4^+$ from the salt $NH_4$ Cl

And combine in roughly equimolar amounts

**Question 27**

**a.**

| Marking guidelines | Marks |
|---|---|
| Correctly calculates the concentration in ppm | 1 |

Sample answer

424 ppm

**b.**

| Marking guidelines | Marks |
|---|---|
| All points plotted correctly and line of best fit drawn | 1 |

**c.**

| Marking guidelines | Marks |
|---|---|
| Correctly calculates concentration from graph in ppm | 2 |
| Correctly converts absorbance reading to standard concentration | 1 |

**Sample answers**

From the graph the absorbance value corresponds to a concentration of 2.6 ml of diluted standard per 100 mL of solution

Concentration of standard is 424ppm

Dliuted standard is 4.24 ppm

Therefore concentration of unknown is 2.6 x 4.24 = 11 ppm

**Question 29**

**a.**

| Marking guidelines | Marks |
|---|---|
| Draws accurate labelled diagram including a condenser (reflux tube) AND suitable heat source and flask AND with reactants labelled | 3 |
| Diagram lacking one of the above | 2 |
| Diagram lacking two of the above | 1 |

b.

| Marking guidelines | Marks |
|---|---|
| Writes correct balanced equation with structural formula and includes catalyst (concentrated sulfuric acid ) as a necessary condition | 2 |
| One error or omission or error or structural formula not used | 1 |

**Sample answer**

Scan this answer

**Question 28**

**a.**

| Marking Guidelines | Marks |
| --- | --- |
| Constructs even and appropriately sized scales on axes, and correctly plots all points. | **1** |

**b.**

| Marking Guidelines | Marks |
| --- | --- |
| Draws lines correctly on graph to show the endpoint neutralise the NaOH, showing working on the graph. | **1** |

**c.**

| Marking Guidelines | Marks |
| --- | --- |
| Identifies the correct volume of HCl required to completely neutralise the NaOH, using working on graph. | **2** |
| Identifies volume without showing any working on the graph | **1** |

Sample answer: In the range 22 – 23 mL.

**d.**

| Marking Guidelines | Marks |
| --- | --- |
| Correctly calculates the concentration of the HCl, based on the answer to 25(c). | **3** |
| Calculation contains one error. | **2** |
| Calculates moles of base used or two errors in calculation | **1** |

Volume of HCl is 22.5 mL( consistent with answer in c.)
Moles of NaOH used = C x V = 0.145 x 0.025 = $3.625 \times 10^{-3}$
Moles of HCl used therefore = $3.625 \times 10^{-3}$ (because $HCl + NaOH \rightarrow NaCl + H_2O$)
Concentration of HCl = n/V = $3.625 \times 10^{-3}$ / 0.0225 = 0.161M.

**Question 30**

**a.**

| **Marking guidelines** | **Marks** |
|---|---|
| States Le Chatelier's Principle clearly. | 1 |

Le Chatelier's Principle states that if a system at equilibrium is disturbed by altering conditions, the system will re-adjust to minimise the effect of the disturbance.

**b.**

| **Marking guidelines** | **Marks** |
|---|---|
| Describes and explains the conditions Haber developed to produce ammonia, relating this to a knowledge of Le Chatelier's Principle<br><br>AND<br><br>Includes a balanced equation for the reaction<br><br>AND<br><br>Makes a judgment on the significance of the Principle to the Haber process | 5 |
| As above with one error or omission | 4 |
| Outlines conditions that Haber employed using Le Chatelier's Principle<br><br>AND<br><br>Provided a balanced equation for the reaction<br><br>OR<br><br>Outlines conditions that Haber employed using Le Chatelier's Principle and provides an explanation of at least ONE of the conditions | 3 |
| Outlines TWO conditions that Haber employed using Le Chatelier's Principle<br><br>OR<br><br>Identifies one reaction condition that Haber employed using Le Chatelier's with a balanced equation | 2 |
| Identifies one reaction condition that Haber employed using Le Chatelier's Principle<br><br>OR<br><br>Provides an equation for the Haber process. | 1 |

**Sample answer**

Haber was a chemist trying to produce ammonia from its constituent elements via the reaction:

$N_2$ (g) + $3H_2$ (g) $\rightarrow$ $2NH_3$ (g)

His aim was to determine the conditions which would give a high enough yield of ammonia at a satisfactory rate which would make the synthesis economically viable.

In a closed system, this process, being reversible, will come to a natural state of equilibrium if conditions are constant. The problem for Haber was that the natural position of the equilibrium favoured the reactants.

Le Chatelier's Principle was very significant in helping Haber determine the optimal conditions for ammonia production. From the Principle we can predict that high pressures will favour the reaction which produces less moles of gas (thus minimizing the disturbance). Since the forward reaction produces less moles of gas, Haber decided that high pressure conditions would both produce a higher yield at a faster rate.

The Principle also predicts that low temperatures favour the exothermic reaction, which releases heat and thus minimizes the disturbance. Since the forward reaction is exothermic, Haber may have predicted that low temperatures should be utilized. However, at low temperatures Haber found the rate of ammonia production too low. He thus decided upon a compromise temperature which gave a satisfactory yield at a high enough rate, also experimenting with hundreds of catalysts to determine one which increased the rate most effectively. Le Chatelier's Principle would predict that the catalyst would not alter the yield, but increase the rate of reaction.

Thus this example illustrates the importance in selecting the right reaction conditions (via using Le Chatelier's Principle) to produce optimum yields in industrial production.

**Question 31**

| Marking guidelines | Marks |
|---|---|
| Answer displaying extensive knowledge and including<br>identifies CFC as responsible for Ozone depletion and the source of CFCs<br>AND<br>Writes at least 2 equations to show how CFCs are involved in ozone destruction<br>AND<br>Discusses measures to reduce CFCs including Montreal protocol and alternatives HCFC, HFC and reasons they are effective.<br>AND<br>Evaluates the success of these measures | **6-7** |
| An answer with less extensive knowledge which may omit or partly omit one of the requirements above | **4-5** |
| An answer that omits or partly omits or gives wrong information about two of the above | **3-4** |
| Lacks three of the above | **1-2** |

**Sample answer**

**Section II**

**Total marks: 25**

**Question 32**

| Marking Guidelines | Marks |
|---|---|
| Gives good description of 1. genetic engineering to increase supply 2. production of synthetic repalcements and 3. recycling of rubber | 3 |
| Gives description of only 2 of above or lists all three rather than describes | 2 |
| Gives description of only 1 of above | 1 |

Sample answer

One approach is to increase the production of natural rubber by selective breeding of rubber plants (heavea) to increase yield and genetic engineering of other latex producing plants such as sunflowers as an alternative source

Another approach is to produce synthetic rubbers such as styrene-butadiene from petrochemicals to replace natural rubbers

A third strategy is to improve the properties of recycled rubber

**b.i.**

| Marking Guidelines | Marks |
|---|---|
| Identifies temperature. | **1** |

**b.ii.**

| Marking Guidelines | Marks |
|---|---|
| Correctly calculates K. | **2** |
| Uses the correct equilibrium constant expression. | **1** |

Sample answer

$CO(g) + H_2O(g) \leftarrow \rightarrow CO_2(g) + H_2(g)$

| | | | | |
|---|---|---|---|---|
| Initially | 1.5M | 2.5M | | |
| At equilibrium | 1.0M | 2.0M | 0.5M | 0.5M |

$K = [H_2][CO_2]/[CO][H_2O]$

$K = (0.5x0.5)/(1.0x2.0)$

$K = 0.125$

**c.**

| | |
|---|---|
| Provides a full description of all the reactions and reaction conditions used in the Contact process and includes justifications for the conditions in the equilibrium step, AND justifies the need tor for the intermediate production of oleum. | 5-6 |

| | |
|---|---|
| Provides a description of the reactions and reaction conditions used, and justifies the conditions used in the equilibrium step OR the production of oleum. | 4-5 |
| Describes the chemistry and steps involved in the Contact process. | 3 |
| Outlines one step in the process and provides one correct chemical equation. | 2 |
| Provides one correct chemical equation from the Contact process, or outlines one step. | 1 |

Sample answer

Sulfuric acid is made in a multi-step process called the Contact Process. In the first step, elemental sulfur is converted to sulfur dioxide by burning molten sulfur in air, in an exothermic reaction which goes to completion: $S(l) + O_2(g) \rightarrow SO_2(g)$.

The second step, the oxidation of $SO_2(g)$ to $SO_3(g)$ is an equilibrium reaction: $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$. The forward reaction is exothermic. To maximise both rate and yield in this equilibrium reaction, reaction conditions are carefully controlled, and a catalyst, $V_2O_5(s)$ is used. The catalyst is in pellet form to increase its surface area and make it more effective at increasing the rate. A temperature of about 600 $^0$C is used which provides for a rapid rate, but not 100% conversion of sulfur dioxide to sulfur trioxide. To further increase the yield an excess of oxygen gas is used, which shifts the equilibrium position to the right (consistent with Le Chatelier's principle). The reaction mixture is also passed over three separate beds of catalyst, each at a slightly lower temperature, at atmospheric pressure. This results in essentially complete conversion of the $SO_2$ to $SO_3$, and therefore expensive high pressure equipment is not needed.

The $SO_3$ is then dissolved in concentrated sulfuric acid to produce oleum: $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$. Water is added to the oleum to produce 98% sulfuric acid: $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$. The final product is produced in this way because addition of $SO_3$ directly to $H_2O$ to produce $H_2SO_4$ is highly exothermic and can produce a dangerous mist of $H_2SO_4$. The heat produced by the process (in the oxidation of S and $SO_2$) is used to generate steam and electricity to reduce the operating costs of production.

**d.i.**

| **Marking guidelines** | **Marks** |
|---|---|
| Response outlines the method used to electrolyse NaCl in one state. | 2 |
| Response identifies one aspect of a procedure used to electrolyse NaCl in one state. | 1 |

Sample answer

To carry out the electrolysis of NaCl(aq) we filled a Hoffmann's voltammeter with 0.01 M NaCl. We connected one electrode to the positive DC terminal of a power pack set to 6V, and the other electrode to the negative terminal. After gas had been collected in both sides of the voltammeter we turned off the power pack.

**d.ii.**

| Marking guidelines | Marks |
|---|---|
| - Response **explains** the different products observed in the electrolysis of NaCl(l), dilute NaCl(aq) and concentrated NaCl(aq) in terms of species available for reaction and E° values AND<br>- Includes supporting equations in each of these three cases | 4/3 |
| Outlines the difference between the products formed for NaCl in 2 states, and includes correct supporting equation(s) | 2 |
| Identifies one correct aspect of the electrolysis of NaCl in any state, or includes one correct equation. | 1 |

Sample answer

The electrolysis products of NaCl depend on the state in which it is electrolysed. For example, when NaCl(l) is electrolysed, the only species present are $Na^+$ and $Cl^-$ ions, thus the only products that can form are Na(s) and $Cl_2$(g): 2NaCl(l) → 2Na(s) + $Cl_2$(g).

When NaCl(aq) is electrolysed, the products depend on the concentration of NaCl. In NaCl(aq) there are $Na^+$, $Cl^-$, $H^+$, and $OH^-$ ions present. That means that the following reductions (with their associated $E^0$ values) are possible at the cathode:

a) $Na^+$(aq) + $e^-$ → Na(s) $E^0$ = -2.71 V
b) $2H_2O$ + $2e^-$ → $H_2$(g) + $2OH^-$ $E^0$ = -0.83 V

and at the anode, the following oxidations are possible:

c) $2Cl^-$ → $Cl_2$(g) + $2e^-$ $E^0$ = -1.36 V
d) $2H_2O$ → $O_2$ (g) + $4H^+$ + $4e^-$ $E^0$ = -1.23 V

It is obvious that water is much more easily reduced than $Na^+$ ions, and so at the cathode, regardless of concentration, water is reduced in preference to sodium ions. However, the oxidations of water and chloride ions are similar in energy requirements, and thus concentration also plays a part. In dilute solutions water is oxidized, whereas in more concentrated solutions, chloride ions are oxidized in preference to water.

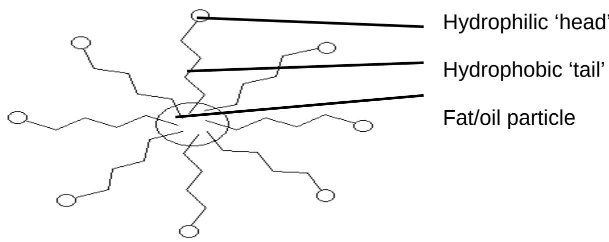
In the first case the overall reaction is $2H_2O$(l) → $2H_2$(g) + $O_2$(g) and in the latter, $2H_2O$(l) + 2NaCl(aq) → 2NaOH(aq) + $Cl_2$(g) + $H_2$(g)

**e. i**

| Marking Guidelines | Marks |
|---|---|
| • Outlines the cleaning action of soap and draws a correct diagram of a micelle. | **3** |
| • Outlines the cleaning action of soap and draws a partially correct diagram of a micelle.OR<br>• Draws a correct labelled diagram of a micelle and identifies a correct aspect of the cleaning action of soap. | **2** |
| • Identifies one aspect of the cleaning action of soap, or draws a partially correct diagram of a micelle. | **1** |

Sample answer

Soaps clean by forming an emulsion between water and fats/oils. In doing so, they act as a surfactant in the following way. The hydrophobic ‘tail’ of the soap particle dissolves in the fat/oil droplet. The hydrophilic ‘head’ dissolves in water. Agitation of the mixture results in soap particles surrounding the fat/oil droplet, forming a 3D structure called a micelle. The structure of a micelle is shown below.  The formation of an emulsion between the water and oil allows the oil to be washed away.

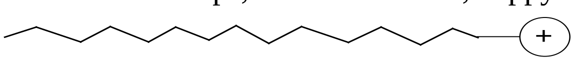



**e .ii.**

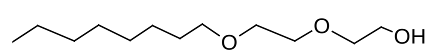
| Marking Guidelines | Marks |
|---|---|
| • Describes the structure and properties of two types of synthetic detergent (ie anionic, cationic and non-ionic detergents). | **4** |
| • Outlines the structure and properties of two types of synthetic detergent | **3** |
| • Describes the structure and properties of one of the above types of detergent. | **2** |
| • Outlines the structure or one property of one of the three types of detergent. | **1** |

Sample answer

To meet the increasing demand for soaps, and to provide for a more diverse range of needs, synthetic detergents have been developed. They fall into three categories – anionic, cationic and non-ionic. All three types consist of a non-polar, hydrocarbon ‘tail’, and either an ionic or polar ‘head’. The structures of two types are illustrated below. For non-ionic detergents the polar head consists of a polyether group. For cationic detergents the polar ‘head’ is derived from ammonia. Neither cationic nor non-ionic detergents interact with $Mg^{2+}$ or $Ca^{2+}$ ions, thus these detergents are more effective in hard water than anionic detergents, which can precipitate with these cations, reducing their effectiveness. Cationic detergents have antiseptic properties, which makes them useful as anti bacterial soaps, surface cleaners, nappy wash etc.




cationic detergent




Non-ionic detergent