



VCE CHEMISTRY 2008

YEAR 12 UNIT 3

Chemical Analysis

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Time allowed: 50 minutes

Total marks: 42

SECTION A

Contains 12 Multiple Choice Questions
14 minutes, 12 marks

SECTION B

Contains 4 Extended Response Questions
36 minutes, 30 marks

To download the Chemistry Data Book please visit the VCAA website:

http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf Page 20

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Student Name.....

VCE Chemistry 2008 Year 12 Unit 3 – Chemical Analysis

Student Answer Sheet

Instructions for completing test. Use only an HB pencil. If you make a mistake erase and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the Question. There are 12 Multiple Choice Questions to be answered by circling the correct letter in the table below.

| | | | |
|--------------------|---------|--------------------|---------|
| <i>Question 1</i> | A B C D | <i>Question 2</i> | A B C D |
| <i>Question 3</i> | A B C D | <i>Question 4</i> | A B C D |
| <i>Question 5</i> | A B C D | <i>Question 6</i> | A B C D |
| <i>Question 7</i> | A B C D | <i>Question 8</i> | A B C D |
| <i>Question 9</i> | A B C D | <i>Question 10</i> | A B C D |
| <i>Question 11</i> | A B C D | <i>Question 12</i> | A B C D |

VCE Chemistry 2008 Year 12 Unit 3 – Chemical Analysis

Multiple Choice Section

Section A – (12 marks, 14 minutes)

*This section contains 12 multiple choice Questions.
For each Question choose the response that is correct or best answers the Question.
Indicate your answer on the answer sheet provided.
(Choose only **one** answer for each Question.)*

Question 1

The nutrient information panel on a packet of salt and vinegar potato chips stated that the product contained 1145 mg of sodium per 100 g of chips. Assuming that the sodium is present as sodium chloride and there are no other species present that will precipitate as silver chloride, what mass of silver chloride would a chemist expect to collect when they analysed 20.00 g of potato chips?

- A. 0.561 g.
- B. 0.143 g
- C. 1.43 g
- D. 1.07 g

Question 2

The volume of 0.120 M aqueous nitric acid, in millilitres, that is required to neutralise a 25.00 mL aliquot of 0.0840 M sodium carbonate solution is

- A. 35.0 mL.
- B. 35.7 mL.
- C. 17.5 mL.
- D. 8.75 mL.

Question 3

The redox half-equation to describe the oxidation of methanol to carbon dioxide in an aqueous acidic environment is

- A. $\text{CH}_3\text{OH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CO}_2(\text{g}) + 6\text{H}^+(\text{aq}) + 6\text{e}^-$
- B. $\text{CH}_3\text{OH}(\text{aq}) \rightarrow \text{CO}(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$
- C. $\text{CH}_3\text{OH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 6\text{e}^- \rightarrow \text{CO}_2(\text{g}) + 6\text{H}^+(\text{aq})$
- D. $2\text{CH}_3\text{OH}(\text{aq}) + \text{O}_2(\text{aq}) \rightarrow 2\text{CO}_2(\text{g}) + 8\text{H}^+(\text{aq}) + 8\text{e}^-$

Question 4

A 6.924 g sample of a gas occupies a volume of 2.86 L at 348 K and 125 kPa. This gas is most likely to be:

- A. Butane, C_4H_{10} ;
- B. Propanone, $\text{C}_3\text{H}_6\text{O}$;
- C. Butene, C_4H_8 ;
- D. Propane, C_3H_8 .

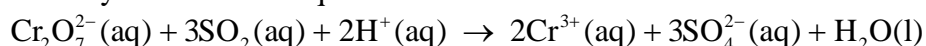
Question 5

The lamp used in an atomic absorption spectrophotometer produces radiation

- A. that will cause an electron in the element being analysed to be excited to a higher energy state.
- B. over a wide range of energies.
- C. with energies in the infra red part of the spectrum that will excite electrons to higher states.
- D. that will cause an electron in the element being analysed to be move to a lower energy state.

Question 6

The reaction between aqueous acidic solutions of potassium dichromate and sulfur dioxide can be described by the chemical equation:



A 20.00 mL sample of an aqueous solution containing sulfur dioxide was titrated with 0.003000 M potassium dichromate solution and required 13.13 mL to reach the end point.

What is the concentration of the sulfur dioxide in the solution?

- A. 1.970×10^{-3} M.
- B. 5.910×10^{-3} M.
- C. 1.182×10^{-4} M.
- D. 3.939×10^{-5} M.

Question 7

The infra-red spectrum of which one of the following compounds will **not** show an absorption in the $1600 - 1750 \text{ cm}^{-1}$ region?

- A. Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$.
- B. Methyl ethanoate, $\text{CH}_3\text{COOCH}_3$.
- C. Diethyl ether, $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$.
- D. Ethanamide, CH_3CONH_2 .

Question 8

A group of students were analysing a set of solutions containing coloured substance using test tubes as cells in a UV-visible spectrophotometer. Initially they used a 10 mm diameter test tube then repeated their measurements using a 12 mm diameter test tube. How would the second set of measurements compare with the initial set, assuming all other variables were the same?

- A. The second set of absorptions would be the same as the cells are about the same size.
- B. The second set of absorptions would be the same as the solutions analysed were the same.
- C. The second set of absorptions would be lower.
- D. The second set of absorptions would be higher.

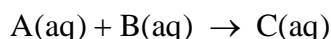
Question 9

A sample of lime used in an industrial process contained a mixture of calcium oxide, CaO, and calcium hydroxide, Ca(OH)₂. A student heated a crucible containing a 22.450 g sample of the lime and found that the mass of the crucible and its contents decreased by 2.564 g. The percentage, by mass, of calcium oxide in the sample is closest to

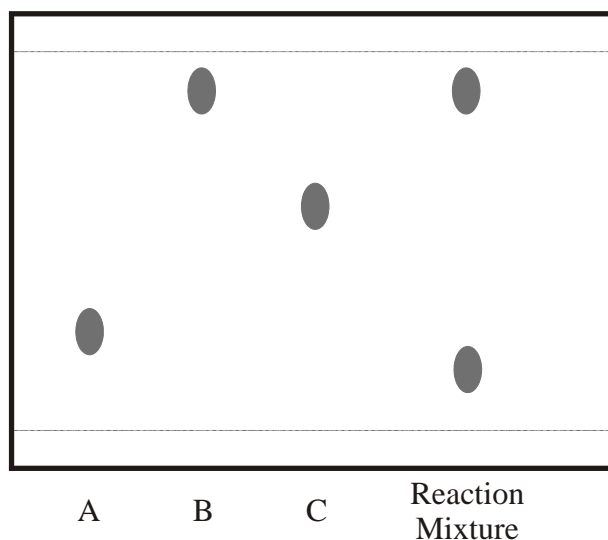
- A. 11 %.
- B. 53 %.
- C. 47 %.
- D. 64 %.

Question 10

A chemist used thin layer chromatography to monitor a chemical reaction that can be symbolically represented by:



In order to find the set of conditions that gave the best yield the chemist altered the conditions being used. Equal molar quantities of A and B were mixed and the reaction was allowed to proceed for a period of time before a sample was withdrawn and analysed using thin layer chromatography. The chromatogram for pure samples of A, B and C together with the reaction mixture is shown below.

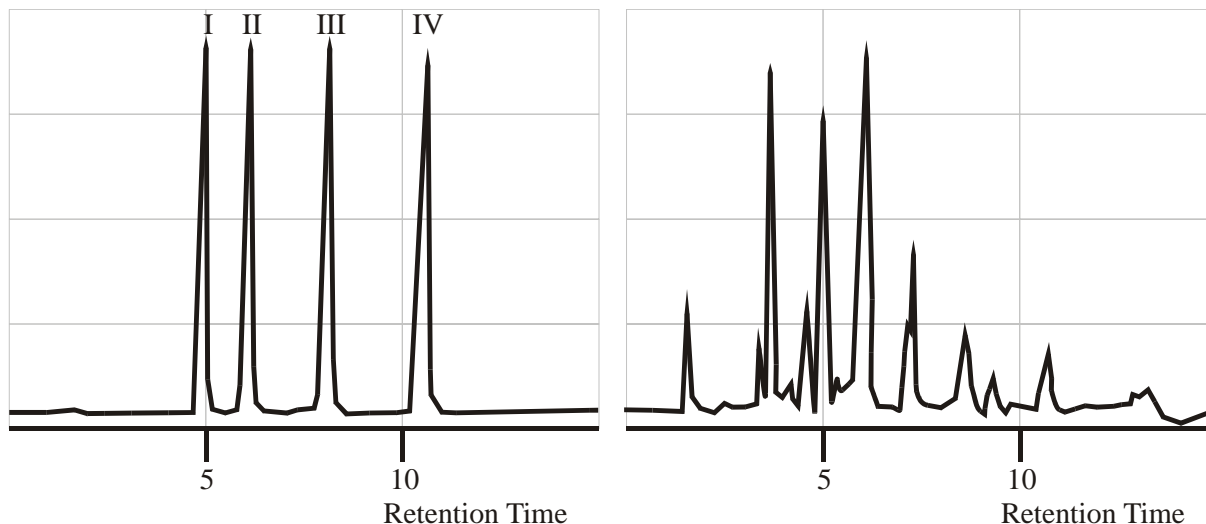


What conclusion could the chemist draw from these results?

- A. Under the new conditions the reaction is proceeding very slowly.
- B. Under the conditions no chemical reactions have occurred.
- C. Under the new conditions reactant A has either decomposed or changed in some way.
- D. Under the new conditions product C has formed, then has either decomposed or changed in some way.

Question 11

The diagram on the left below shows the high performance liquid chromatogram for an equal molar mixture of aldehydes, methanal (I), ethanal (II), propanal (III) and butanal (IV). The diagram on the right is a high performance liquid chromatogram obtained under the same conditions for an extract obtained from cigarette smoke.



Which of the following conclusions **cannot** be obtained from this data?

- A. The extract contains at least three aldehydes.
- B. The extract contains more methanal than ethanal.
- C. The extract contains more methanal than butanal.
- D. The extract contains very little, if any, propanal.

Question 12

The signal with the lowest chemical shift in the ^1H NMR spectrum of 2-methylpropanol, $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$, will have

- A. one peak and a total area six times that of the next signal.
- B. five peaks and a total area three times that of the next signal.
- C. two peaks and a total area three times that of the next signal.
- D. two peaks and a total area six times that of the next signal.

End of Section A

VCE Chemistry 2008 Year 12 Unit 3 – Chemical Analysis

Section B – (30 marks, 36 minutes)

This section contains four Questions, numbered 1 to 4.
All Questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each Question are given.

Question 1 – (6 marks, 7 minutes)

The presence of calcium and some other ions in water can lead to the formation of hard water and this can cause the deposition of insoluble compounds in boiler tubes. The calcium ion concentration in water can be measured using atomic absorption spectrophotometry.

A calcium ion stock solution was prepared by dissolving 0.626 g of calcium carbonate, CaCO_3 , in a small volume of dilute hydrochloric acid in a 500.00 mL volumetric, then diluting this resultant solution to the mark using deionised water.

A set of calcium ion standard solutions were prepared by diluting various aliquots of the stock solution with deionised water in 100.00 mL volumetric flasks. These solutions were then analysed and the data are in the table below. A water sample was analysed using the same equipment and an absorption of 0.191 was recorded.

| Volume of stock solution (mL) | Absorption |
|-------------------------------|------------|
| 0.00 | 0.000 |
| 2.00 | 0.054 |
| 4.00 | 0.107 |
| 6.00 | 0.162 |
| 8.00 | 0.210 |
| 10.00 | 0.262 |
| 12.00 | 0.320 |

- a. Calculate the calcium ion concentration of the stock solution.

(1 mark)

- b. Draw a calibration curve on the grid below using the data provided.

| | | | | | | | |
|--|--|--|--|--|--|--|--|
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(3 marks)

- c. Determine the concentration of the calcium ions in the water sample.

(1 mark)

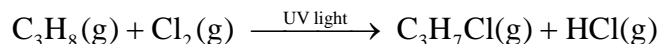
- d. Express the calcium ion concentration in ppm (parts per million or mg L^{-1})

(1 mark)

Question 2 - (8 marks, 10 minutes)

Spectroscopy is a key tool in the identification of various compounds.

- a. The chemical reaction between propane, $\text{CH}_3\text{CH}_2\text{CH}_3$, and chlorine in the presence of ultra violet light can be represented by the chemical equation;



- i. One of the chlorinated compounds that can be formed in this reaction is 2-chloropropane, $\text{CH}_3\text{CHClCH}_3$. What would be three key differences between the ^1H NMR spectra of propane and 2-chloropropane?

(3 marks)

- ii. The other chlorinated hydrocarbon that can be formed in this reaction is 1-chloropropane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$. What would be the key difference between the ^{13}C NMR spectrum of this compound and that of 2-chloropropane?

(1 mark)

- b. The semi-structural formula for hexane can be written as $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$.

- i. What would be the expected m/e ratio for the molecular ion, assuming a +1 charge, in the mass spectrum of hexane?

(1 mark)

- ii. The main peak, that with the highest abundance, in the mass spectrum for hexane occurs at an m/e ratio of 57. What fragment of the molecular ion could explain this m/e ratio?

(1 mark)

- iii. Predict the m/e ratio for another fragment ion that could be present in the mass spectrum of hexane?

(1 mark)

- c. In the UV-Visible spectrum the absorptions are due to the excitation of an electron from a lower energy state to a higher energy state. What is one type of change that gives rise to an absorption in the infra red spectrum?

(1 mark)

Question 3 - (10 marks, 12 minutes)

The label on a bottle of the domestic bleach White King™ states that the active ingredient is sodium hypochlorite, NaOCl, with a concentration of 42 g L^{-1} . A group of VCE chemistry students decided to experimentally verify this by carrying out a volumetric analysis of a 10.00 mL sample from a newly opened bottle of this bleach.

The students diluted the sample in a 200.00 mL volumetric flask. They then took 20.00 mL aliquots of this solution placing these into conical flasks. 5 mL of 1 M aqueous potassium iodide and 10 mL of 1 M aqueous sulfuric acid were added to each conical flask and mixed thoroughly.

The contents of each flask were then titrated with a standardised 0.0936 M sodium thiosulfate solution and adding starch solution to act as the end-point indicator once the colour of the solution had turned pale yellow. The average titre of the concordant titres was 11.79 mL.

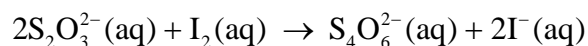
- a. When the hypochlorite ion reacts with the iodide ion, chloride ions and iodine are formed.
- i. Write an appropriate chemical half-equation for the reaction that the hypochlorite ion undergoes.

(1 mark)

- ii. Write an appropriate overall chemical equation for the reaction between the hypochlorite and iodide ions.

(1 mark)

- b. The overall chemical equation for the reaction of iodine with thiosulfate ions can be represented by the chemical equation;



- i. Calculate the number of mole of thiosulfate ions added in the titration.

(1 mark)

- ii. Calculate the number of mole of iodine reduced by the thiosulfate ions.

(1 mark)

- iii. Calculate the number of mole of hypochlorite ions in each 20.00 mL aliquot used in the titrations.

(1 mark)

- iv. Calculate the number of mole of hypochlorite ions present in the original 10.00 mL sample of bleach.

(1 mark)

- v. Express the sodium hypochlorite concentration in g L^{-1} .

(2 marks)

- c. i. Another group of students carried out the same experiment except they added 10 mL of aqueous potassium iodide solution to each flask. What effect, if any, would this have of the expected outcome?

(1 mark)

- ii. Suggest a reason why it was necessary to dilute the bleach solution before carrying out the volumetric analysis.

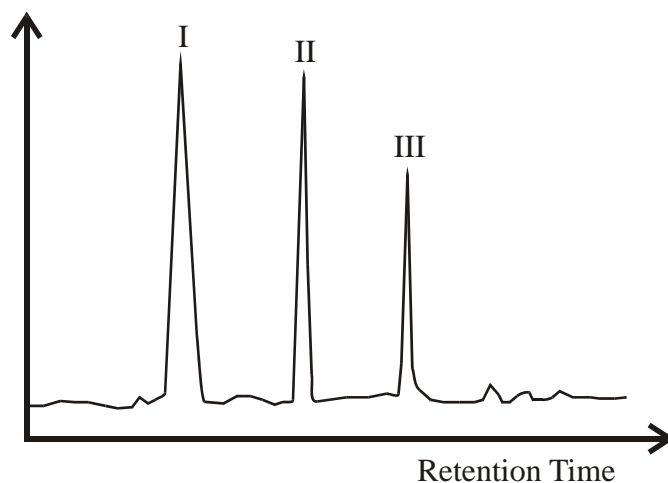
(1 mark)

Question 4 - (6 marks, 7 minutes)

- a. Draw a diagram to show the key components in a gas chromatograph.

(3 marks)

- b. A chemist used a gas chromatograph to analyse a sample of gas containing methane, CH_4 , ethane, C_2H_6 , and propane, C_3H_8 , and obtained the following gas chromatogram.



- i. Which one of the three hydrocarbons is peak II most likely due to, giving a reason for your selection?
- (1 mark)**
- ii. How could the chemist verify the identity of the hydrocarbon that produced each of the peaks?
- (1 mark)**
- c. What is one way that the chemist could alter the retention times observed in the chromatogram?

(1 mark)

End of Trial Exam

Suggested Answers

VCE Chemistry 2008 Year 12 Unit 3 – Chemical Analysis

Multiple Choice Section

Section A – (1 mark per question)

Q1 C The sodium content is 1145 mg per 100 g

$$m(\text{Na}^+) = 1145 \times \frac{20.00}{100} = 229 \text{ mg} = 0.229 \text{ g}$$

$$n(\text{Na}^+) = \frac{m}{M} = \frac{0.229}{23.0} = 9.96 \times 10^{-3} \text{ mol}$$

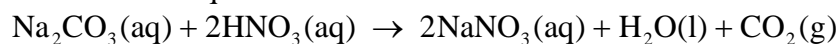
$$n(\text{Cl}^-) = n(\text{Na}^+) = 9.96 \times 10^{-3} \text{ mol}$$

$$n(\text{AgCl}) = n(\text{Cl}^-) = 9.96 \times 10^{-3} \text{ mol}$$

$$M(\text{AgCl}) = 107.9 + 35.5 = 143.4 \text{ g mol}^{-1}$$

$$m(\text{AgCl}) = n \times M = 9.96 \times 10^{-3} \times 143.4 = \mathbf{1.43 \text{ g}}$$

Q2 A The chemical equation:



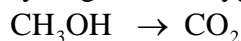
$$n(\text{Na}_2\text{CO}_3) = c \times V = 0.0840 \times (25.00/1000) = 2.10 \times 10^{-3} \text{ mol}$$

$$n(\text{HNO}_3) = 2 \times n(\text{Na}_2\text{CO}_3) = 2 \times 2.10 \times 10^{-3} = 4.20 \times 10^{-3} \text{ mol}$$

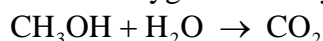
$$V(\text{HNO}_3) = \frac{n}{V} = \frac{4.20 \times 10^{-3}}{0.120} = 3.50 \times 10^{-2} \text{ L} = \mathbf{35.0 \text{ mL}}$$

Q3 A The redox half-equation can be developed using the following steps.

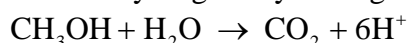
1. Write down the reactants and products and balance elements other than hydrogen and oxygen.



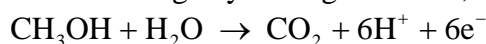
2. Balance oxygen atoms by adding water.



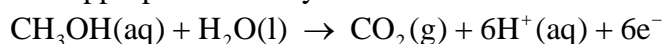
3. Balance hydrogens by adding H^+ ions.



4. Balance charge by adding electrons, e^- .



5. Add appropriate state symbols.



Q4 C Use the general gas equation, $PV = nRT$ to determine the number of mol of gas present.

$$n(\text{gas}) = \frac{PV}{RT} = \frac{125 \times 2.86}{8.31 \times 348} = 1.24 \times 10^{-1} \text{ mol}$$

$$M(\text{gas}) = \frac{m}{n} = \frac{6.924}{1.24 \times 10^{-1}} = 55.8 \text{ g mol}^{-1}$$

$$M(\text{C}_4\text{H}_{10}) = 4 \times 12.0 + 10 \times 1.0 = 58.0 \text{ g mol}^{-1}$$

$$M(\text{C}_3\text{H}_6\text{O}) = 3 \times 12.0 + 6 \times 1.0 + 16.0 = 58.0 \text{ g mol}^{-1}$$

$$\mathbf{M(\text{C}_4\text{H}_8) = 4 \times 12.0 + 8 \times 1.0 = 56.0 \text{ g mol}^{-1}}$$

$$M(\text{C}_3\text{H}_8) = 3 \times 12.0 + 8 \times 1.0 = 44.0 \text{ g mol}^{-1}$$

- Q5 A** The lamp in an atomic absorption spectrophotometer, is a hollow cathode lamp, that produces radiation of a wavelength that can excite an electron in the atoms being analysed from a lower state to a higher energy state.
- Q6 B** $n(\text{Cr}_2\text{O}_7^{2-}) = c \times V = 0.003000 \times (13.13/1000) = 3.939 \times 10^{-5} \text{ mol}$
 From the chemical equation:
 $n(\text{SO}_2) = 3 \times n(\text{Cr}_2\text{O}_7^{2-}) = 3 \times 3.939 \times 10^{-5} = 1.182 \times 10^{-4} \text{ mol}$

$$c(\text{SO}_2) = \frac{n}{V} = \frac{1.182 \times 10^{-4}}{(20.00/1000)} = \mathbf{0.00591 \text{ M}}$$
- Q7 C** Referring to Table 7 in the VCE Data Book the main groups that absorb in the 1600 – 1750 cm^{-1} region are the C=C and the C=O. Since none of the compounds listed is unsaturated then the absence of a C=O unit would not result in an absorption in this region. Only diethyl ether with an ether linkage (C-O-C) fulfils this criterion,
- Q8 D** The **absorbance depends on the amount of substance that the light has to pass through**; therefore this depends on both the **concentration** of the solutions and the **path length**. Since the students increased the path length their second set of absorbances would be greater than those recorded with the smaller (10 mm) diameter test tube.
 This is expressed by Beer's Law: Absorbance = $\epsilon \times c \times l$, where ϵ is the molar extinction constant for the substance at a specific wavelength, c is the concentration and l is the path length.
- Q9 B** Calcium hydroxide will decompose when heated to calcium oxide. $\text{Ca}(\text{OH})_2(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{g})$
 $M(\text{H}_2\text{O}) = 2 \times 1.0 + 16.0 = 18.0 \text{ g mol}^{-1}$
 $n(\text{H}_2\text{O}) = \frac{m}{M} = \frac{2.564}{18.0} = 1.424 \times 10^{-1} \text{ mol}$
 $n(\text{Ca}(\text{OH})_2) = n(\text{H}_2\text{O}) = 1.424 \times 10^{-1} \text{ mol}$
 $M(\text{Ca}(\text{OH})_2) = 40.1 + 2 \times (1.0 + 16.0) = 74.1 \text{ g mol}^{-1}$
 $m(\text{Ca}(\text{OH})_2) = n \times M = 1.424 \times 10^{-1} \times 74.1 = 10.56 \text{ g}$
 $m(\text{CaO}) = 22.450 - 10.56 = 11.89 \text{ g}$

$$\%(\text{CaO}) = \frac{11.89}{22.450} \times \frac{100}{1} = 52.96 \% \approx \mathbf{53 \%}$$
- Q10 C** Comparing the chromatogram for the reaction mixture with those for A, B and C and looking at each of the responses.
 Response A – Very slow reaction, this would require that a spot due to A be present on the chromatogram of the reaction mixture even though C may be not detected. This is not the case therefore this response is not viable.
 Response B – No reaction has occurred, this would also require the presence of a spot due to A on the chromatogram of the reaction mixture. This is not the case therefore this response is not viable.
 Response C – A has changed or decomposed, this would require the spot due to B be present with no spots due to A and C present on the chromatogram of the reaction mixture and another spot due to some unknown be present. This is the case therefore this response is viable.
 Response D – C formed then decomposed, since there is no A and since there was an equal molar mixture of A and B to start with then no spot corresponding to B should be present on the chromatogram of the reaction mixture. Another spot/s due to unknown compounds should be present. This is not the case therefore this response is not viable.

- Q11 B** Comparing the chromatographs it can be seen that compounds with retention times similar to I, II and IV are present, therefore there are at least three aldehydes in the extract. The relative sizes, areas, of the peaks corresponding to I and IV are such that the one due to I is bigger than the one due to IV. The peak corresponding to II is greater than that due to I therefore there is more ethanal than there is methanal. There is no clear peak for III therefore it is either present in small quantities or not present at all.
- Q12 D** The peak with the smallest chemical shift, will be due to the **two equivalent CH₃ groups** in the structure. These are attached to a carbon atom with a single hydrogen, **CH**, therefore the signal for these protons will be **split, using the n+1 rule, into 2 peaks**. The CH unit will be the next signal in the spectrum, therefore the peak area ratio for the **CH₃ groups will be six times that of the CH unit because of the 6 : 1 hydrogen atom ratio**.

SECTION B

Question 1 - (6 marks, 7 minutes)

a. $M(\text{CaCO}_3) = 40.1 + 12.0 + 3 \times 16.0 = 100.1 \text{ g mol}^{-1}$

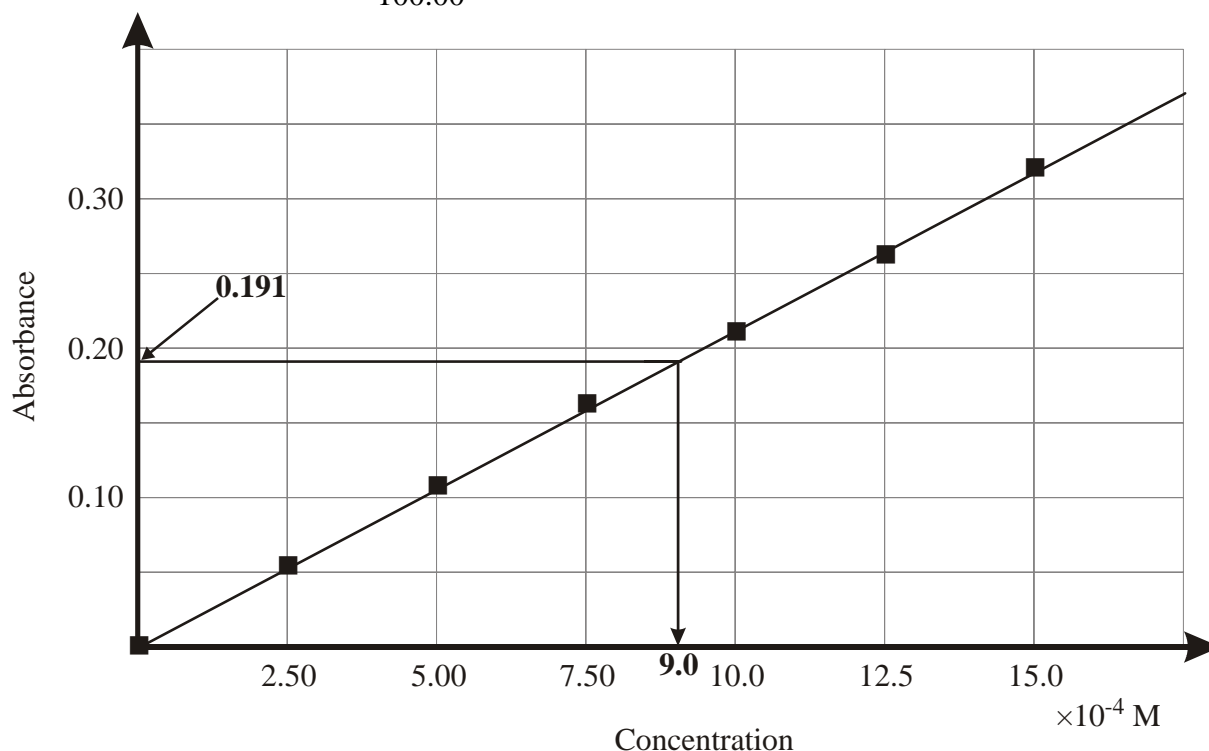
$$n(\text{CaCO}_3) = \frac{m}{M} = \frac{0.626}{100.1} = 6.25 \times 10^{-3} \text{ mol}$$

$$n(\text{Ca}^{2+}) = n(\text{CaCO}_3) = 6.25 \times 10^{-3} \text{ mol}$$

$$c(\text{Ca}^{2+}) = \frac{n}{V} = \frac{6.25 \times 10^{-3}}{(500.00/1000)} = \mathbf{1.25 \times 10^{-2} \text{ M (1 mark)}}$$

- b. The concentrations of the standard solutions can be calculated by multiplying the stock solution concentration by the dilution factor, for example the 2.00 mL aliquot;

$$c(\text{Ca}^{2+}) = 1.25 \times 10^{-2} \times \frac{2.00}{100.00} = 2.50 \times 10^{-4} \text{ M}$$



Axes correctly labelled – (1 mark)

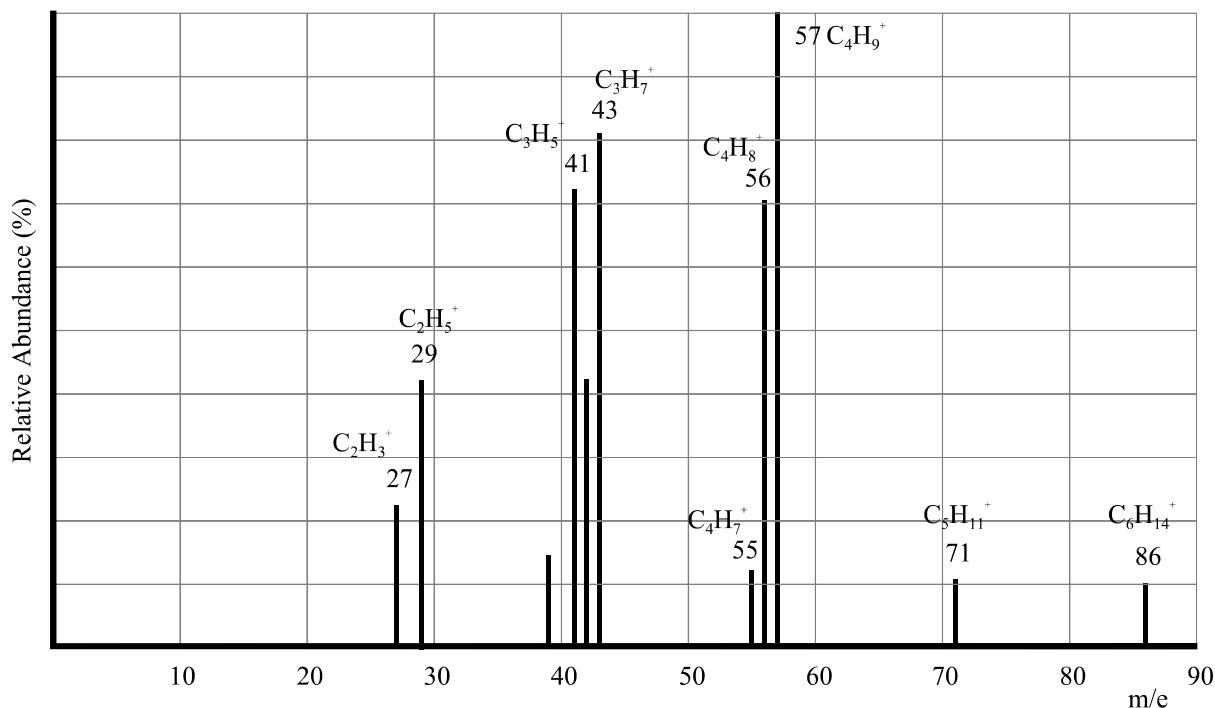
Points plotted accurately – (1 mark)

Best fit line drawn – (1 mark)

- c. From the calibration curve an absorbance of 0.191 corresponds to a concentration of **$9.0 \times 10^{-4} \text{ M}$ (1 mark)**
- d. $c(\text{Ca}^{2+}) = 9.0 \times 10^{-4} \text{ M}$
 $n(\text{Ca}^{2+} \text{ in } 1.00 \text{ L}) = 9.0 \times 10^{-4} \text{ mol}$
 $m(\text{Ca}^{2+} \text{ in } 1.00 \text{ L}) = 9.0 \times 10^{-4} \times 40.1 = 3.6 \times 10^{-2} \text{ g} = 36 \text{ mg}$
 $c(\text{Ca}^{2+}) = 36 \text{ mg L}^{-1} = \mathbf{36 \text{ ppm}}$ (1 mark)

Question 2 - (8 marks, 10 minutes)

- a. i. The ^1H NMR spectra of both compounds will have two signals, however there will be three main differences between the two spectra.
The position of the signals in 2-chloropropane will be shifted down field from TMS due to the presence of the electronegative chlorine atom. This will only have a small affect on the CH_3 protons but a more marked effect on the CH proton. The chemical shifts observed in the spectra for propane are 0.90 and 1.33, and 2-chloropropane 1.14 and 3.75. (1 mark)
 The signals due to the **CH_3 protons** would be seen as a **triplet (3 peaks) in propane** and as a **doublet (2 peaks) in 2-chloropropane** as a result of the **$n+1$ splitting rule**. (1 mark)
The ratio of the areas under the signals will be different **3 : 1 for propane** and **6 : 1 for 2-chloropropane**. (1 mark)
- ii. The major difference between the ^{13}C NMR spectra for 1-chloropropane and 2-chloropropane will be that $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ has three signals while $\text{CH}_3\text{CHClCH}_3$ has two signals due to the differing carbon environments. (1 mark)
- b. i. The molecular ion is the ion due to hexane, $\text{C}_6\text{H}_{14}^+$.
 $M_r(\text{C}_6\text{H}_{14}^+) = 6 \times 12.0 + 14 \times 1.0 = \mathbf{86.0}$ (1 mark)
- ii. The fragmentation ion with a m/e ratio of **57 would have four carbon atoms, C_4H_9^+** , due to a breaking of a carbon-carbon bond and the loss of a C_2H_5 fragment. (1 mark) The C_4H_9^+ ion would be $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2^+$.
- iii. Many fragmentation ions are possible depending on how the various ions fragment. Other possible fragment ions based on simple breaking of carbon-carbon bonds: (1 mark)
- | | |
|---|----------|
| $\text{CH}_3\text{CH}_2\text{CH}_2^+$ | m/e 43 |
| CH_3CH_2^+ | m/e 29 |
| $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2^+$ | m/e 71 |
- The simulated mass spectrum for hexane based on actual mass spectroscopy data is shown together with the formulae assignments for some of the ions.

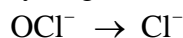


c. Either the **stretching of a bond** or the **bending of a bond** in the molecule. (1 mark)

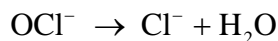
Question 3 - (10 marks, 12 minutes)

a. i. The hypochlorite ion is reduced to the chloride ion. Use the following steps to work out the half-equation for this reduction reaction.

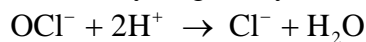
1. Write down the reactants and products and balance elements other than hydrogen and oxygen.



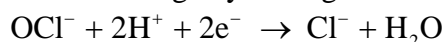
2. Balance oxygen atoms by adding water.



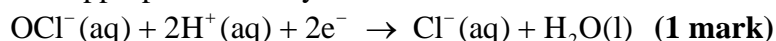
3. Balance hydrogens by adding H⁺ ions.



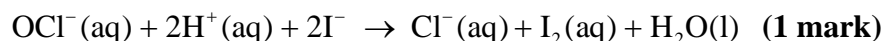
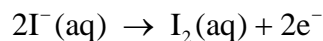
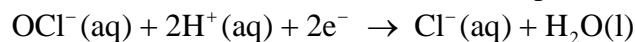
4. Balance charge by adding electrons, e⁻.



5. Add appropriate state symbols.

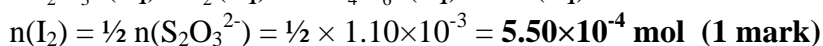
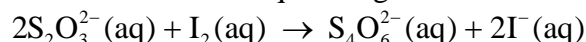


ii. The overall reaction is the obtained by adding the reduction and oxidation reactions so that the number of electrons produced and consumed is the same.

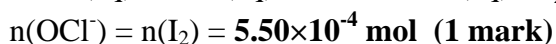
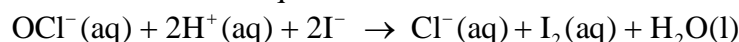


b. i. $n(\text{S}_2\text{O}_3^{2-}) = c \times V = 0.0936 \times (11.79/1000) = 1.10 \times 10^{-3} \text{ mol}$. (1 mark)

ii. From the chemical equation given:



iii. From the chemical equation:



- iv. The 20.00 mL aliquot was taken from the diluted solution which had a total volume of 200.00 mL and all of the hypochlorite in this solution came from the original 10.00 mL sample.

$$n(\text{OCl}^-, \text{ in original sample}) = 5.50 \times 10^{-4} \times \frac{200.00}{20.00} = 5.50 \times 10^{-3} \text{ mol (1 mark)}$$

- v. $M(\text{NaOCl}) = 23.0 + 16.0 + 35.5 = 74.5 \text{ g mol}^{-1}$.
 $m(\text{NaOCl}) = n \times M = 5.50 \times 10^{-3} \times 74.5 = 0.410 \text{ g (1 mark)}$
 This mass of NaOCl is in 10.00 mL therefore in 1 L

$$m(\text{NaOCl in 1 L}) = 0.410 \times \frac{1000}{10} = 41.0 \text{ g}$$

$$c(\text{NaOCl}) = 41.0 \text{ g L}^{-1}. \text{ (1 mark)}$$

- c. i. Since the potassium iodide is in excess and as this has no effect on the amount of hypochlorite added to the conical flask, the results from the two groups should be the same. (1 mark)

- ii. Possible reasons include: (1 mark)

The undiluted bleach would require a very large titre, over 100 mL using a 10 mL aliquot of undiluted bleach, which would require refilling the burette leading to errors.

Safety issues involved in continually using the undiluted bleach solution, these solutions tend to be relatively corrosive.

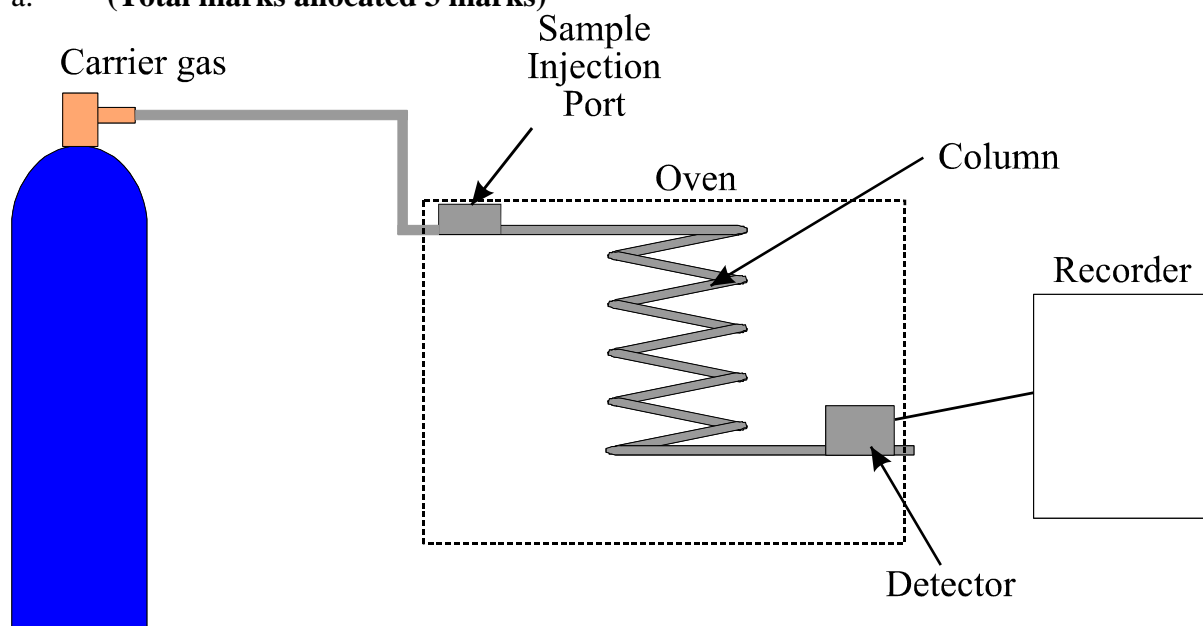
Small variances in the delivery of the bleach solution from the pipette would make it difficult to obtain concordant titres. (A variance of 0.05 mL in the delivery from the pipette would result in about a 0.6 mL variance in the titre.)

The addition of acid to higher concentrations of hypochlorite ion solutions could result in the liberation of some toxic chlorine gas into the classroom if the experiment was not carried out in a fume hood.

Larger volume of potassium iodide and acid would be required.

Question 4 - (6 marks, 7 minutes)

- a. (Total marks allocated 3 marks)



- b. i. Peak II is most likely due to ethane. Since the compounds are all straight chain hydrocarbons the interactions between the hydrocarbons and the stationary phase will be similar, therefore the main factor influencing the retention time will be the molecular mass of the compound. **(1 mark)**
- ii. Two possible methods can be used to identify the origin of each peak. **(1 mark)**
Attach the outlet of the gas chromatograph to a mass spectrometer and obtain the mass spectrum for each compound which will identify the hydrocarbon.
Run gas chromatographs for each of the hydrocarbons under the same conditions and compare the retention times.
- c. There are three main ways that are often used to change the retention times in gas chromatography. **(1 mark)**
Change the length of the column.
Change the flow rate of the carrier gas.
Change the temperature of the oven.
Other methods that can be used are to change either the carrier gas (mobile phase) or the material used in the stationary phase.

End of Suggested Answers