Girraween High School

2013

HIGHER SCHOOL CERTIFICATE

CHEMISTRY

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
- *Write your name and teacher at the top of the Part A Answer Sheet, the Part B Written Answer Booklet and the Section II Answer Booklet*

Total marks - 100

Section I

85 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

Part B – **65 marks**
- Attempt Questions 21 - 34
- Allow about 1 hour and 58 minutes for this part

Section II

15 marks
- Attempt all parts of this question (Question 35)
- Allow about 27 minutes for this section

SECTION I
85 marks

Part A – 20 marks
Attempt all Questions 1-20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet provided to answer Questions 1-20. Follow the procedure outlined below when answering the multiple choice questions.

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 ⬬ (crossed) C ⬭ D ⬭

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

A ⬬ (crossed) B ⬬ (crossed, with arrow) C ⬭ D ⬭

1. Which isotope is radioactive?

(A) helium-4

(B) oxygen-16

(C) calcium-40

(D) iron-52

2. The reaction that is likely to occur would be:

(A) $2Ag(s) + Sn^{2+}(aq) \rightarrow 2Ag^{+}(aq) + Sn(s)$

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

(C) $Pb^{2+}(aq) + 2Fe^{2+}(aq) \rightarrow Pb(s) + 2Fe^{3+}(aq)$

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

3. Consider the following reaction:

$$Cr^{2+}(aq) + [CoCl]^{2+}(aq) \rightleftharpoons [CrCl]^{2+}(aq) + Co^{2+}(aq)$$

What can be said about the change in the chromium and cobalt cations?

(A) Chromium has oxidised and cobalt has reduced

(B) Chromium has oxidised and cobalt has oxidised

(C) Chromium has reduced and cobalt has oxidised

(D) Chromium has reduced and cobalt has reduced

4. Which of the following sets of chemical species could have their concentration measured using atomic absorption spectroscopy?

(A) SO_2, SO_3, CO_2, O_3

(B) NH_4^{+}, Al^{3+}, Cu^{2+}, Sr^{2+}

(C) Cu^{2+}, Hg^{+}, Pb^{2+}, Pb^{4+}

(D) SO_4^{2-}, CO_3^{2-}, Cl^{-}, NO_3^{-}

5. Which of the following would be the best catalyst for the dehydration of ethanol?

(A) dilute sulfuric acid

(B) concentrated sulfuric acid

(C) dilute sodium hydroxide solution

(D) concentrated sodium hydroxide solution

6. What mass of ethanol is obtained when 5.68 g of carbon dioxide is produced during fermentation at 25°C and 100 kPa?

(A) 0.129 g

(B) 2.95 g

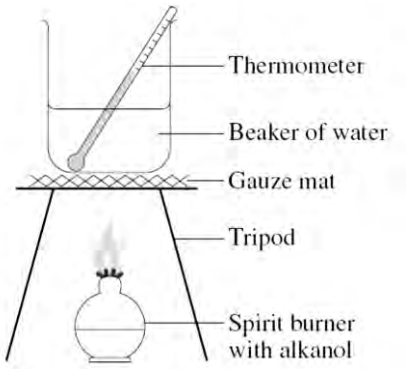
(C) 5. 95 g

(D) 33.6 g

7. What are the volumes of one mole of argon and one mole of fluorine at 0°C and 100 kPa?

	Volume (litres)	
	Ar	F_2
(A)	12.40	24.79
(B)	22.71	22.71
(C)	22.71	45.42
(D)	24.79	24.79

8. The apparatus shown is used in a first-hand investigation to determine and compare the heat of combustion of three different liquid alkanols.



Which is the dependent variable?

(A) Type of alkanol used

(B) Amount of water used

(C) Amount of alkanol used

(D) Temperature change in the water

9. Which of the following reactions may be described as a neutralisation reaction?

(A) $SO_3 + H_2O \rightarrow H_2SO_4$

(B) $Na_2O + 2HCl \rightarrow 2NaCl + H_2O$

(C) $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$

(D) $K_2O + H_2O \rightarrow 2KOH$

10. Which of the following concentrations is consistent with a basic solution?

(A) $[H^+] = 3.2 \times 10^{-3}\ M$
(B) $[OH^-] = 3.6 \times 10^{-9}\ M$
(C) $[H^+] = 9.7 \times 10^{-4}\ M$
(D) $[OH^-] = 3.4 \times 10^{-3}\ M$

11. Consider the following reaction.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -192\ kJ.mol^{-1}$$

What would be the effect of reducing the pressure of the system if it is at equilibrium?

(A) The concentration of PCl_5 will increase.

(B) The equilibrium will not be disturbed.

(C) Heat will be absorbed by the system.

(D) The reverse reaction rate will decrease.

12. What is the correct method of preparing a 250 mL volumetric flask prior to using it to make up a primary standard?

(A) wash, rinse with distilled water three times, then add primary standard

(B) wash, rinse with distilled water three times then completely dry inside

(C) wash, rinse with the solution that is going in the flask three times, then add primary standard

(D) pour the primary standard straight into the flask as the concentration will not be changed

13. In 1884, Svante Arrhenius proposed a definition for acids. His definition was soon accepted as superior to that put forward by earlier chemists. Why was Arrhenius's definition seen as a major breakthrough?

(A) It explained why some acids do not contain oxygen.

(B) It could be used to explain why some acids are strong and others are weak.

(C) It showed the relationship between pH and the concentration of H^+ ions.

(D) It showed how the solvent can affect the strength of an acid.

14. A solid sample was known to contain two calcium salts. In order to determine the anions present, some tests were done on the solid, producing the following results.

Test done	**Results obtained**
Observation of colour	White
Addition of water to solid	Solid partially dissolved
Addition of barium chloride to solution	No precipitate
Addition of silver nitrate to solution	White precipitate
Addition of HCl (aq) to solid	Gas bubbles observed

Which two ions were present in the sample?

(A) PO_4^{3-} and SO_4^{2-}

(B) Cl^- and SO_4^{2-}

(C) CO_3^{2-} and Cl^-

(D) CO_3^{2-} and PO_4^{2-}

15. Where on the Periodic Table would you most likely find elements which form basic oxides?

(A) Group 1

(B) Group 6

(C) Period 2

(D) Period 3

16. A 25.0 mL creek water sample was diluted to 250.0 mL in an appropriate volumetric flask. The diluted sample was found to contain 0.0681 g of NaCl per 250.0 g of solution. What is the concentration of NaCl in ppm in the creek sample?

(A) 2.72

(B) 272

(C) 2720

(D) 3671

17. An industrial chemist discovers that the following reaction is occurring in one part of his process.

$$3CH_4 + 5O_2 \rightarrow CO_2 + 2CO + 6H_2O$$

Which chemical should be carefully monitored and how can its presence be reduced?

	Monitor…	Reduce its presence by…
(A)	CO_2	Reducing the amount of oxygen present.
(B)	CO	Increasing the amount of oxygen present.
(C)	CO	Reducing the amount of oxygen present.
(D)	CO_2	Increasing the amount of oxygen present.

18. What is the catalyst used in the formation of ammonia?

(A) Ag

(B) Cu

(C) Fe_3O_4

(D) MnO_2

19. A student obtained the data in the table below when conducting an investigation on the sulfate content of a particular fertiliser.

Mass of fertiliser used (g)	2.34
Mass of fertiliser that did not dissolve (g)	0.18
Volume of saturated $BaCl_2$(aq) added (mL)	50.0
Mass of glass filter (g)	19.5
Mass of glass filter with dry $BaSO_4$ (g)	21.6

What is the percentage of sulfate in the fertiliser?

(A) 34%

(B) 37%

(C) 40%

(D) 43%

20. A resident discovered and reported on a number of dead fish floating in their local creek. A team of chemists, including an analytical chemist, an organic chemist, and a biochemist, was established to investigate the fish death. What does this example best illustrate?

(A) Collaboration helps chemists solve complex problems.

(B) Validity is improved by increasing the number of people solving a problem.

(C) Reliability is increased when an experiment is done by a group rather than an individual.

(D) Experimental results are more accurate when procedures are undertaken by a team.

Student Name	
Teacher	
Mark /	

Girraween High School **2013 HSC Chemistry Trial Examination**

Write your Name and Class at the top of this Part A Answer Sheet.

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 Name	
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Write your Name and Teacher at the top of this Part B Answer Booklet.

SECTION I (continued)
Part B – 65 Marks

Attempt questions 21-34

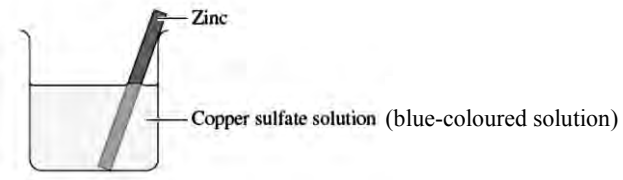
Allow about 1 hour and 58 minutes for this part

Show all relevant working in questions involving calculations

Write your answers in the spaces provided

Question 21 (4 marks)

The following experiment was performed to investigate the relative activity of metals. A piece of cleaned zinc was placed in a beaker that initially contained 250.0 mL of 0.050 mol L^{-1} copper (II) sulfate solution.



(a) Account for any changes that would be observed over the next 48 hours. (2 marks)

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Question 21 *Continued*

(b) A deposit was removed from the piece of zinc metal and dried. It was found to weigh 0.325 g. Calculate the concentration of copper (II) sulfate solution remaining in the beaker. (2 marks)

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Question 22 (4 marks)

Water and ethanol are both used as solvents. Explain the differences and similarities in their solvent behaviour in terms of their molecular structures. Include labelled diagrams in your answer.

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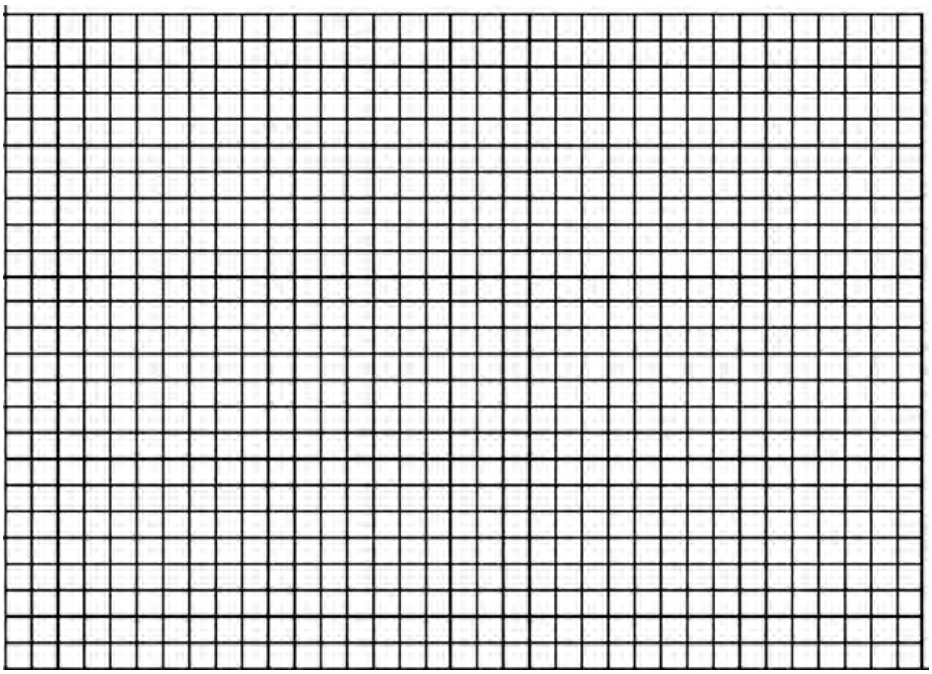
Question 23 (6 marks)

A student conducted a first-hand investigation to determine the molar heat of combustion of some alkanols by heating 10 grams of water with each of the alkanols using a spirit burner. His results are presented in the table below.

Alkanol	Molar heat of combustion (kJ mol^{-1})
Methanol	721
Ethanol	1135
1-Propanol	1821
1-Butanol	2432

(a) On the grid below, construct a graph that shows the relationship between carbon chain length and the molar heat of combustion for the alkanols. (3 marks)



(b) Suppose the mass of the water being heated was doubled to 20 grams. What effect would this have on the molar heat of combustion of the alkanols? Explain your answer. (2 marks)

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(c) Calculate the amount of energy released when 1 g of 1-propanol is completely combusted. (1 mark)

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Question 24 (4 marks)

An electrochemical cell is constructed using two half-cells. One half-cell consists of an inert platinum electrode and an aqueous solution of Fe^{2+} and Fe^{3+}. The other half-cell consists of a lead electrode and an aqueous solution of Pb^{2+}.

Current will flow from one electrode to the other electrode when the cell is completed using a voltmeter and a salt bridge.

(a) Write the relevant half-equations and a balanced net ionic equation for the overall cell reaction. (2 marks)

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(b) Calculate the standard cell potential ($E°$). (1 mark)

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(c) Describe an appropriate salt bridge for this electrochemical cell. (1 mark)

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Question 25 (4 marks)

Polyvinyl alcohol is a water-soluble addition polymer used in adhesives and paints. The monomer used has the following structure:

$$CH_2 = CHOH$$

(a) Draw a structural formula for a 3-unit segment of the polymer. (1 mark)

(b) Explain how bromine water can be used to distinguish between a solution of the monomer and a solution of the polymer. (2 marks)

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(c) State the systematic name for the monomer used in forming polystyrene. (1 mark)

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Question 26 (5 marks)

Pentanoic acid is refluxed with a solution that contains ethanol and a suitable catalyst.

(a) Write a balanced equation using structural formulae for the esterification reaction that occurs. (2 marks)

(b) Identify the catalyst used in the esterification. (1 mark)

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(c) Explain why the boiling point of an ester is lower than the boiling points of straight-chained alkanoic acids and straight-chained primary alkanols of similar molar mass. (2 marks)

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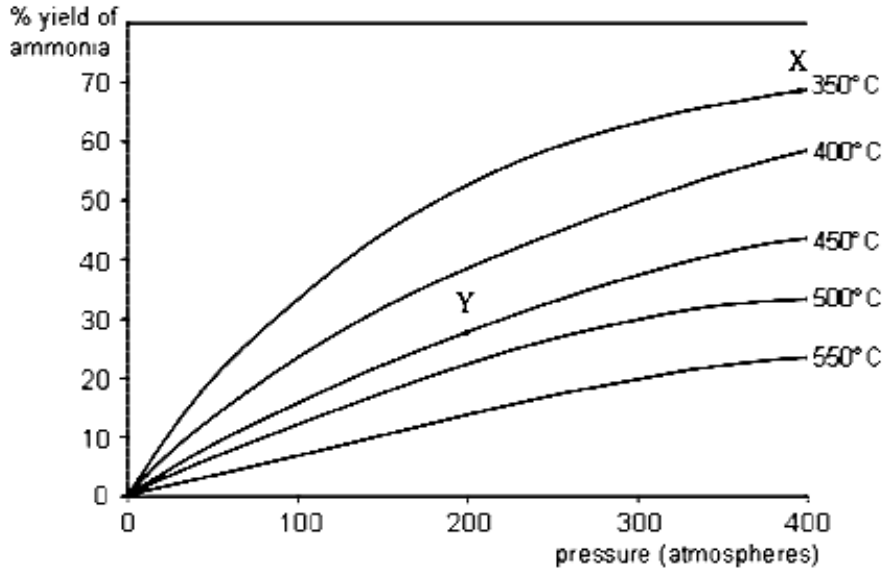
Question 27 (4 marks)

The percentage of ammonia produced under various conditions of temperature and pressure via the Haber process is shown in the graph below.



(a) Write a balanced chemical equation to describe the formation of ammonia via the Haber process. (1 mark)

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(b) Explain why the reaction conditions employed in the Haber process are closer to where the letter "Y" is positioned in the above graph instead of where "X" is positioned. (3 marks)

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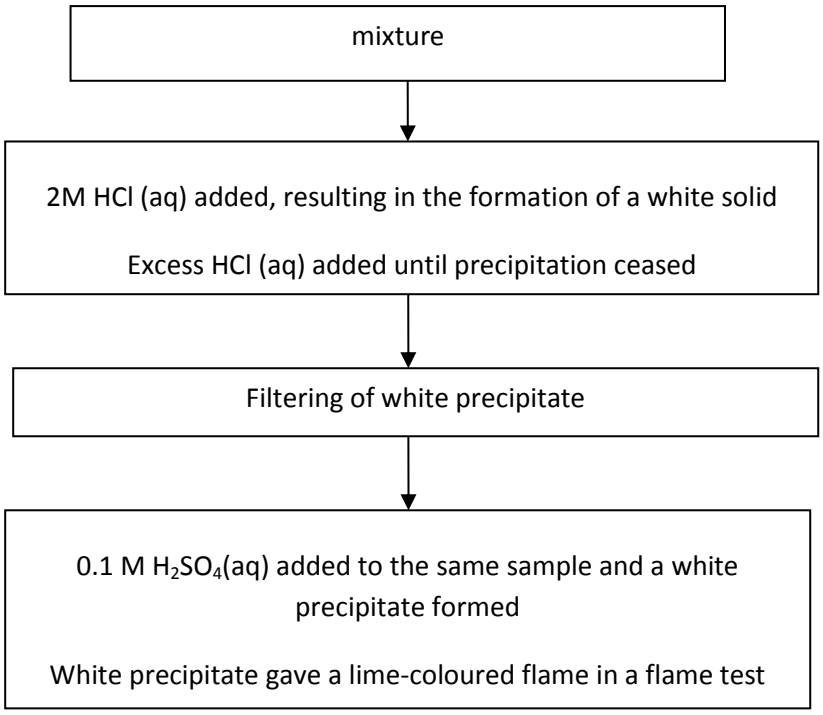
Question 28 (5 marks)

An aqueous solution was known to contain two of the following cations: Ca^{2+}; Ba^{2+}; Cu^{2+}; Pb^{2+}; Fe^{2+}.

The procedure a student used to identify the two cations is shown in the following flowchart.



(a) Identify the cation responsible for the white precipitate formed upon addition of HCl. (1 mark)

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(b) Write a net ionic equation for the reaction which produced the white precipitate upon addition of H_2SO_4. (1 mark)

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(c) Justify the procedure the student followed to identify these two cations. (3 marks)

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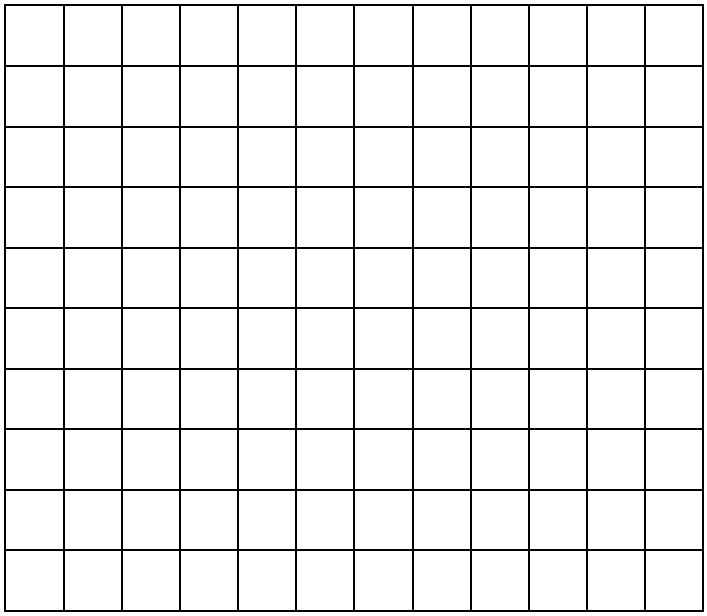
Question 29 (6 marks)

A group of scientists used AAS to investigate the concentration of lead in samples of groundwater taken from three industrial sites. They used samples of known concentration of lead ions to calibrate their instrument and then tested the three samples. The absorbance of the standards are given below:

Standards $[Pb^{2+}]$ (ppm)	1	2	4	6	10	12
Absorbance	0.10	0.15	0.36	0.49	0.83	0.99

(a) Draw a calibration curve of the absorbance versus concentration (ppm) for the lead standards on the grid below. (2 marks)



(b) The absorbance of solutions made from the three industrial sites are given below.

Sites	**A**	**B**	**C**
Absorbance	0.26	0.56	0.39

Use the calibration curve to determine the concentration of lead ions in ppm from the site which has the highest concentration of lead ions. (1 mark)

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Question 29 *Continued*

(c) Discuss the impact of the development of AAS on the monitoring and management of trace elements. (3 marks)

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Question 30 (3 marks)

Calculate the pH after 50.0 mL of 0.500 M barium hydroxide is added to 100.0 mL of 1.0 mol L^{-1} HCl (aq). Include a balanced equation in your answer.

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Question 31 (6 marks)

A standard solution was prepared by dissolving 2.628 g of analytical grade sodium hydrogen carbonate in sufficient distilled water to give a final volume of 500.0 mL.

(a) Describe the correct technique for the preparation of this standard solution. (2 marks)

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(b) The standard solution was then used to determine the concentration of hydrochloric acid. Four 25.00 mL samples of the acid were titrated with the standard sodium hydrogen carbonate solution. The titration results are shown below.

Titration number	Titration endpoint volume (mL)
1	23.40
2	23.55
3	24.75
4	23.35

Determine the concentration of the hydrochloric acid solution. (4 marks)

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Question 32 (3 marks)

Explain the role of the conjugate acid/base pair $H_2PO_4^-$ /HPO_4^{2-} in maintaining the pH of living cells. Include chemical equations in your answer.

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Question 33 (4 marks)

Assess the impact of the recent development of a named biopolymer on society and the environment.

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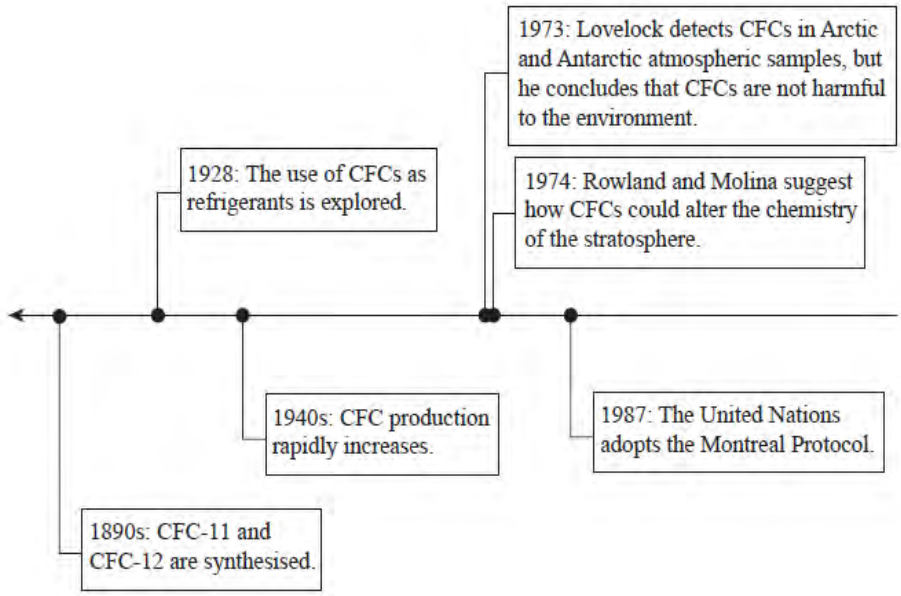
Question 34 (7 marks)

With reference to the timeline shown below, evaluate the impact that human activity and technology have had on the chemistry of the stratosphere.



Write your Name and Class at the top of the Section II Answer Booklet.

SECTION II

15 marks

Attempt ALL parts of Question 35 Industrial Chemistry - Parts (a) – (e)

Allow about 27 minutes for this part

Show all relevant working in questions involving calculations

Answer the question parts in the Section II Answer Booklet

Extra writing booklets are available

Question 35 - Industrial Chemistry (15 Marks)

(a) An important role of chemistry is to provide for our material needs in an environmentally and socially viable way.

(i) Identify a shrinking natural resource which is not a fossil fuel. (1 mark)

(ii) Outline issues associated with the reduction in the availability of this resource and identify a current or potential solution to find a replacement. (2 marks)

(b) Phosgene, $COCl_2$, is considered a chemical weapon and its manufacture is monitored. It is also an industrially important compound, being useful in the synthesis of many carbon compounds.

Phosgene may be formed by reacting carbon monoxide with chlorine as shown in the following reaction. The equilibrium constant for this reaction is 1.2×10^3 at 670 ^oC.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g) \quad \square\square = -108 \text{ kJ/mol}$$

(i) Identify the reaction condition which can change the value of K for this reaction. (1 mark)

(ii) The concentrations of each of the above species in a mixture at 670 ^oC were as follows: [CO] = 0.15M, $[Cl_2]$ = 0.18M, and $[COCl_2]$ = 0.25M. Explain whether the system was shifting to the left or the right to reach equilibrium at the time these measurements were taken. (3 marks)

(c) During your practical work you performed a first-hand investigation to observe the reactions of sulfuric acid acting as an oxidising agent.

(i) Analyse the risks associated with the procedure undertaken. (2 marks)

(ii) Outline a conclusion drawn from the results of this investigation and assess the validity of this conclusion. (2 marks)

(d) "The method of extraction of sulfur by the Frasch process is only possible because of the physical properties of the element sulfur." Assess the accuracy of this statement. (3 marks)

(e) Outline ONE possible environmental issue associated with the extraction of sulfur by the Frasch process. (1 mark)

End of Trial Examination

Girraween High School

2013

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

CHEMISTRY

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Part B – **65 marks**
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15 marks
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85 marks

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A B C D

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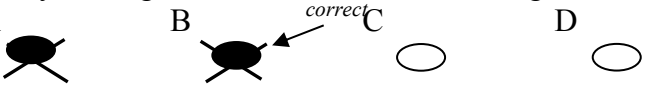

1. Which isotope is radioactive?

(A) helium-4

(B) oxygen-16

(C) calcium-40

(D) iron-52

2. The reaction that is likely to occur would be:

(A) $2Ag(s) + Sn^{2+}(aq) \rightarrow 2Ag^{+}(aq) + Sn(s)$

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

(C) $Pb^{2+}(aq) + 2Fe^{2+}(aq) \rightarrow Pb(s) + 2Fe^{3+}(aq)$

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

3. Consider the following reaction:

$$Cr^{2+}(aq) + [CoCl]^{2+}(aq) \rightleftharpoons [CrCl]^{2+}(aq) + Co^{2+}(aq)$$

What can be said about the change in the chromium and cobalt cations?

(A) Chromium has oxidised and cobalt has reduced

(B) Chromium has oxidised and cobalt has oxidised

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4. Which of the following sets of chemical species could have their concentration measured using atomic absorption spectroscopy?

(A) SO_2, SO_3, CO_2, O_3

(B) NH_4^{+}, Al^{3+}, Cu^{2+}, Sr^{2+}

(C) Cu^{2+}, Hg^{+}, Pb^{2+}, Pb^{4+}

(D) SO_4^{2-}, CO_3^{2-}, Cl^{-}, NO_3^{-}

5. Which of the following would be the best catalyst for the dehydration of ethanol?

(A) dilute sulfuric acid

(B) concentrated sulfuric acid

(C) dilute sodium hydroxide solution

(D) concentrated sodium hydroxide solution

6. What mass of ethanol is obtained when 5.68 g of carbon dioxide is produced during fermentation at 25°C and 100 kPa?

(A) 0.129 g

(B) 2.95 g

(C) 5. 95 g

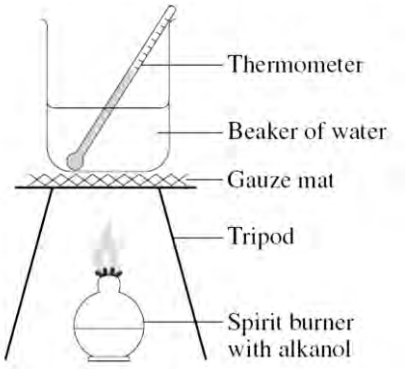
(D) 33.6 g

7. What are the volumes of one mole of argon and one mole of fluorine at 0°C and 100 kPa?

	Volume (litres)	
	Ar	F_2
(A)	12.40	24.79
(B)	22.71	22.71
(C)	22.71	45.42
(D)	24.79	24.79

Answer is B

8. The apparatus shown is used in a first-hand investigation to determine and compare the heat of combustion of three different liquid alkanols.



Which is the dependent variable?

(A) Type of alkanol used

(B) Amount of water used

(C) Amount of alkanol used

(D) Temperature change in the water

9. Which of the following reactions may be described as a neutralisation reaction?

(A) $SO_3 + H_2O \rightarrow H_2SO_4$

(B) $Na_2O + 2HCl \rightarrow 2NaCl + H_2O$

(C) $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$

(D) $K_2O + H_2O \rightarrow 2KOH$

10. Which of the following concentrations is consistent with a basic solution?

(A) $[H^+] = 3.2 \times 10^{-3}\ M$

(B) $[OH^-] = 3.6 \times 10^{-9}\ M$

(C) $[H^+] = 9.7 \times 10^{-4}\ M$

(D) $[OH^-] = 3.4 \times 10^{-3}\ M$

11. Consider the following reaction.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -192\ kJ.mol^{-1}$$

What would be the effect of reducing the pressure of the system if it is at equilibrium?

(A) The concentration of PCl_5 will increase.

(B) The equilibrium will not be disturbed.

(C) Heat will be absorbed by the system.

(D) The reverse reaction rate will decrease.

12. What is the correct method of preparing a 250 mL volumetric flask prior to using it to make up a primary standard?

(A) wash, rinse with distilled water three times, then add primary standard

(B) wash, rinse with distilled water three times then completely dry inside

(C) wash, rinse with the solution that is going in the flask three times, then add primary standard

(D) pour the primary standard straight into the flask as the concentration will not be changed

13. In 1884, Svante Arrhenius proposed a definition for acids. His definition was soon accepted as superior to that put forward by earlier chemists. Why was Arrhenius's definition seen as a major breakthrough?

(A) It explained why some acids do not contain oxygen.

(B) It could be used to explain why some acids are strong and others are weak.

(C) It showed the relationship between pH and the concentration of H^+ ions.

(D) It showed how the solvent can affect the strength of an acid.

14. A solid sample was known to contain two calcium salts. In order to determine the anions present, some tests were done on the solid, producing the following results.

Test done	Results obtained
Observation of colour	White
Addition of water to solid	Solid partially dissolved
Addition of barium chloride to solution	No precipitate
Addition of silver nitrate to solution	White precipitate
Addition of HCl (aq) to solid	Gas bubbles observed

Which two ions were present in the sample?

(A) PO_4^{3-} and SO_4^{2-}

(B) Cl^- and SO_4^{2-}

(C) CO_3^{2-} and Cl^-

(D) CO_3^{2-} and PO_4^{2-}

15. Where on the Periodic Table would you most likely find elements which form basic oxides?

(A) Group 1

(B) Group 6

(C) Period 2

(D) Period 3

16. A 25.0 mL creek water sample was diluted to 250.0 mL in an appropriate volumetric flask. The diluted sample was found to contain 0.0681 g of NaCl per 250.0 g of solution. What is the concentration of NaCl in ppm in the creek sample?

(A) 2.72

(B) 272

(C) 2720

(D) 3671

17. An industrial chemist discovers that the following reaction is occurring in one part of his process.

$$3CH_4 + 5O_2 \rightarrow CO_2 + 2CO + 6H_2O$$

Which chemical should be carefully monitored and how can its presence be reduced?

	Monitor…	Reduce its presence by…
(A)	CO_2	Reducing the amount of oxygen present.
(B)	CO	Increasing the amount of oxygen present.
(C)	CO	Reducing the amount of oxygen present.
(D)	CO_2	Increasing the amount of oxygen present.

18. What is the catalyst used in the formation of ammonia?

(A) Ag
(B) Cu
(C) Fe_3O_4
(D) MnO_2

19. A student obtained the data in the table below when conducting an investigation on the sulfate content of a particular fertiliser.

Mass of fertiliser used (g)	2.34
Mass of fertiliser that did not dissolve (g)	0.18
Volume of saturated $BaCl_2$(aq) added (mL)	50.0
Mass of glass filter (g)	19.5
Mass of glass filter with dry $BaSO_4$ (g)	21.6

What is the percentage of sulfate in the fertiliser?

(A) 34%
(B) 37%
(C) 40%
(D) 43%

20. A resident discovered and reported on a number of dead fish floating in their local creek. A team of chemists, including an analytical chemist, an organic chemist, and a biochemist, was established to investigate the fish death. What does this example best illustrate?

(A) Collaboration helps chemists solve complex problems.
(B) Validity is improved by increasing the number of people solving a problem.
(C) Reliability is increased when an experiment is done by a group rather than an individual.
(D) Experimental results are more accurate when procedures are undertaken by a team.

Marking Criteria for long response

Question 21
(a)

States reason for the change in colour of the solution and the formation of the red-brown(or solid copper) deposit	**2**
States a reason for **EITHER** the change in colour of the solution **OR** the formation of the red-brown deposit	**1**

Sample answer
Copper ions accept electrons from the zinc metal and form solid copper, the red brown (or solid copper) deposit.
The copper ions are blue and as solid copper is formed so they are less and the solution gets lighter. OR Zinc ions go into solution and they are colourless making the solution lighter.

(b)

Correctly calculates the concentration of copper sulfate AND shows working	2
Correctly calculates either the moles of $CuSO_4$ in solution initially or the moles of Cu metal deposited	1

Sample Answer

Moles of copper ions= 0.05X0.250=0.0125 moles

Moles of copper deposited=0.325/63.55=0.005 moles

Copper remaining in solution= 0.0125-0.005= 0.007/0.25==0.029 mol/L OR
$3.0X\ 10^{-2}$mol/L
(Answer must be close to the value)

Question 22

Both water and ethanol dissolve polar solutes because of the ability of water molecules as well as the hydroxyl group in ethanol molecule to form dipole-dipole forces/hydrogen bonding with polar solutes.

Water cannot dissolve non polar solutes because it forms weaker dispersion forces but ethanol can because the hydrocarbon chain in ethanol molecule can form strong dispersion forces with non polar solutes. Strong dispersion forces by hydrocarbon part Polar hydroxyl part form strong dipole –dipole forces with polar solutes

Non polar solutes (hexane)----------C_2H_5OH----------polar solutes (water)

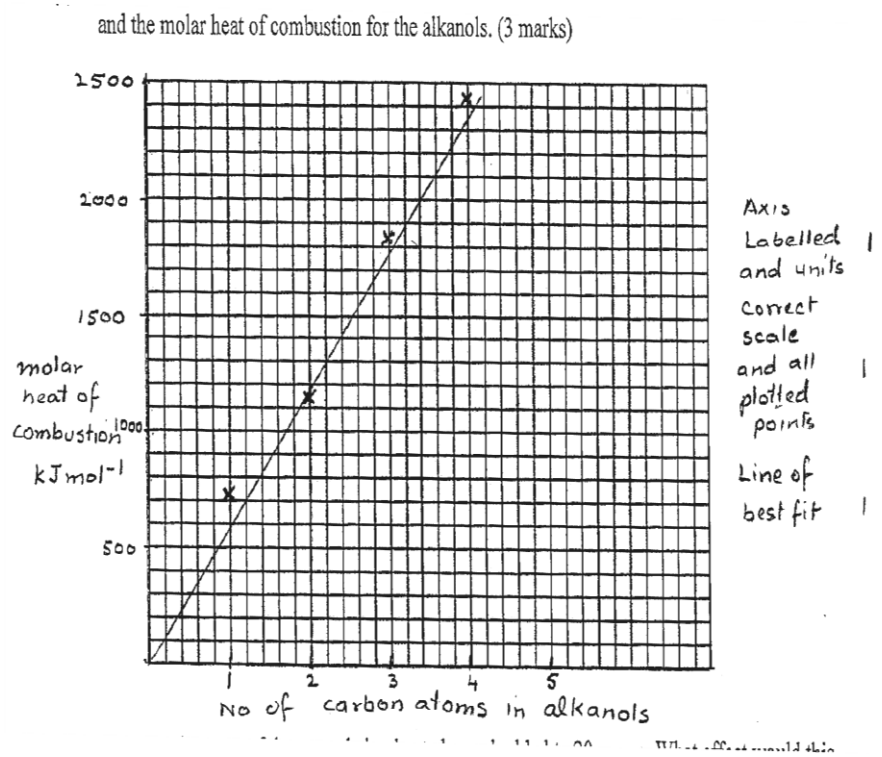
. Weaker dispersion forces by water molecule Polar water molecule form strong dipole –dipole forces with polar solutes

Non polar solutes (hexane)----------H_2O ----------polar solutes (water)

Criteria	marks
Explains that water and ethanol can dissolve polar solutes because of their ability to form strong dipole-dipole forces with polar solutes Explains that non polar hydrocarbon part of ethanol can form strong dispersion forces with nonpolar solutes as such can dissolves non polar solutes while water can not Draw two simple diagrams clearly labelled with the type of forces that form	4
One or more of above is not stated	1-3

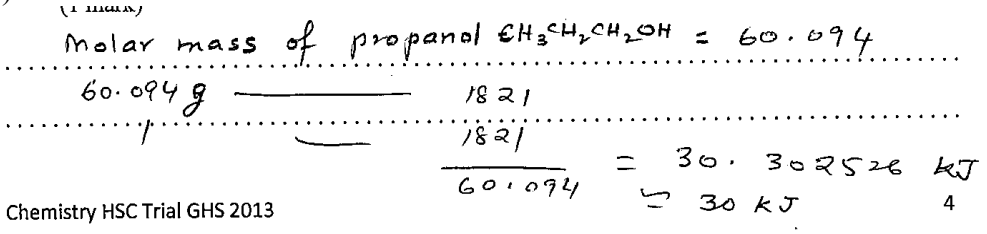
Question 23

(a)



(b) Molar heat of combustion of alkanols will not change (1 mark)
Because Heat produced = mass of water x specific heat capacity x temperature rise (1 mark)
If mass is doubled then temperature rise is halved. The heat produced will be same for same mass of alkanol burnt in each case.(1 mark)

(c)



Question 24

(a) Write relevant half equations and a balanced net ionic equation for the overall cell reaction. (2 marks)

$Pb \rightarrow Pb^{2+} + 2e^-$	0.13V
$2Fe^{3+} + 2e^- \rightarrow 2Fe^{2+}$	0.77V
Overall $Pb(s) + 2Fe^{3+}(aq) \rightarrow Pb^{2+}(aq) + 2Fe^{2+}(aq)$	0.90V

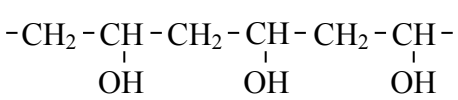
Three equations correct 2 marks
Two equations correct 1 mark
One equation correct (0 mark)

(b) Calculate the standard cell potential ($E^{\ominus}$°). (1 mark)

0.13 + 0.77 = 0.90V

(c) Identify an appropriate electrolyte to use in the salt bridge. (1 mark)
$NaNO_3$/ KNO_3 etc (1 mark)

Question 25

Criteria	Marks
	1

Criteria	Marks
Bromine water is decolourised instantly by the monomer reacting with the double bond. The polymer has single bonds only and reacts very slowly or not at all.	2
Fails to mention that Bromine water reacts with double bond	1

Phenyl Benzene OR Ethenyl Benzene

Question 26

a.

Criteria	Marks
Correct names, structural formula, balanced, correct reactants and products, reversible sign and water as a product. States NOT required	**2**
Some correct information **OR** **Reversible sign missing / water missing/name of ester missing**	**1**

$CH_3CH_2CH_2CH_2COOH + HOCH_2CH_3 \rightleftharpoons CH_3CH_2CH_2CH_2COOCH_2CH_3 + H_2O$

PENTANOIC ACID + EtOH ⇌ ETHYL PENTANOATE +WATER

b) conc. H_2SO_4 - 1 MARK

Q26 (c) (2 marks)

Criteria	Marks
Correct explanation in terms of intermolecular forces in esters, acids and alcohols	2
Some correct information about intermolecular forces in esters, alcohols or acids	1

Esters are polar molecules but **do not exhibit hydrogen bonding**, whereas acids and alcohols have stronger intermolecular forces due to hydrogen bonding.
Hence esters have weaker intermolecular forces than acids or alcohols of similar mass and thus undergo the change of state from liquid to gas more easily (at a lower boiling point).

Question 27

a

Marking Guidelines	Marks
• Writes a correct chemical equation with the correct ▲H	**1**

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$ ▲H= -92kJ/mol

b

Marking Guidelines	Marks
• Explains how the reaction conditions shown in points X and Y impact on the rate and yield of the Haber process, and hence why conditions Y are chosen.	**3**
• Outlines how the reaction conditions at X and/or Y impact on the rate or/and yield.	**2**
• Identifies one correct impact of reaction conditions on the rate or yield.	**1**

The Haber process is an equilibrium reaction and the forward reaction is exothermic. Point X on the graph represents a high pressure (400 atm), and a low temperature (350 ^{0}C). Under these conditions the yield of ammonia is higher than at the higher temperature and lower pressure shown in point Y. But the Haber process is a 'balancing act' of reaction conditions to maximise both rate and yield. At the higher temperature at point Y, the reaction occurs much faster. Unreacted nitrogen and hydrogen are separated from the product (by cooling the mixture to remove ammonia), and recycled. The lower pressure shown at point Y is desirable because the higher pressure shown at point X requires more expensive, thicker walled reaction vessels, and is more dangerous.

Question 28

(a)

Correctly identifies Pb2+	1

Pb^{2+}

(b)

Writes the correct net ionic equation.	1

$Ba^{2+} + SO4^{2-} \rightarrow BaSO_{4(s)}$

(c)

Justifies the order of adding HCl, and H_2SO_4, and the addition of excess HCl to prevent precipitation of $PbSO_4$.	3
Justifies the order of adding HCl and H_2SO_4, and the addition of excess HCl to remove Pb^{2+}	2
Justifies the order of adding HCl and H_2SO_4 OR gives a justification of adding excess HCl.	1

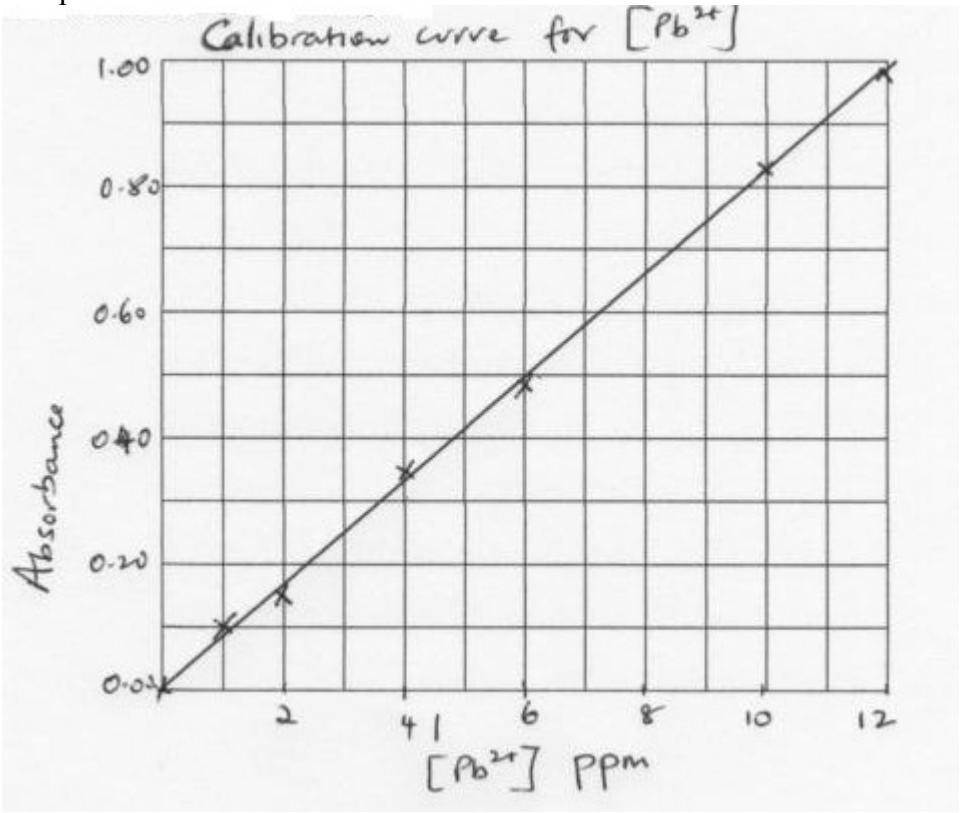
The student knew there were two cations. The HCl was added first because from the list of possible cations, it precipitates only Pb2+. If he had added H2SO4 first, it would have precipitated both the Pb2+ and the Ba2+ and there would have been no way of telling that both cations were in the ppt. HCl was added until ppt of the Pb2+ ceased in order to prevent remaining Pb2+ from precipitating with SO42-, which would have provided a false positive in the sulfate precipitation test. The Pb2+ had to be removed to ensure that any precipitate in the sulfate test was not Pb2+, but rather Ba2+.

Question 29 (6 marks)

(a) (i)

Criteria	Marks
Draws a graph, using appropriate scales, labels on axes and heading AND Plots all points correctly	2
Draws a graph, using appropriate scales, labels on axes and heading OR Plots all points correctly	1

Sample answer



(a) (ii) (1 mark)

Criteria	Mark
Correct answer	1

Sample answer

The site with highest [Pb2+] is B (as the absorbance is greatest).

From the calibration curve, [Pb2+] = 6.7 ppm (range of answers possible, depending on calibration curve drawn).

(b) (3 marks)

Criteria	Marks
Discusses the impact of the development of AAS on the monitoring and management of trace elements AND Recognises that the use of AAS relates to the sensitivity of measurements	3
Outlines the use of AAS on the monitoring and management of trace elements AND Recognises that the use of AAS relates to the sensitivity of measurements	2
Outlines the use of AAS on the monitoring and management of trace elements OR Recognises that the use of AAS relates to the sensitivity of measurements	1

Sample answer

AAS provides a very sensitive, quantitative technique for determining the levels of metal ions, including the ions of trace elements. Trace elements are those needed in very small concentrations (from 1 to 100 ppm) in food or nutrient sources for the essential metabolism of a living organism. For example, zinc, in animals, is used in the metabolism of amino acids and in energy production. Zinc is one of the most important trace elements in the body and is essential as a catalytic, structural and regulatory ion. Deficiencies of zinc in the diet or in the soil can cause health problems.

AAS can measure concentrations of <1 ppm of metal ions in a sample. If light of a frequency known to be absorbed by a particular trace element passes from the light source through the heated sample, atoms of the element in the sample will absorb some of this light. The intensity of the light energy absorbed by the sample (the absorbance) is proportional to the concentration of the metal ion in the sample.

Before the invention and use of AAS ,the presence of trace elements in living things could not be detected, as their extremely low concentrations were too low for the then quantitative or qualitative analytical tests. After AAS was invented, concentrations of metal ions <1 ppm could be detected. This allowed the impact of deficiencies in these metal ions to be investigated and allowed testing of foods to determine the levels of these essential vitamins and minerals. It is essential for scientists to monitor the concentrations of trace elements in foods, to ensure that the claimed amount of an essential element is present and to determine, by experiment, the optimal levels of these trace elements for healthy functioning of the organism.

Without AAS, the amounts of trace elements could not be measured or monitored, so the requirements for trace elements could not be scientifically determined.

Question 30 (3 marks)

Suggested answers and marking guidelines

Criteria	Marks
Writes the correct balanced equation. • Determines the moles of HCl and moles of Ba(OH)2 that are mixed. • Correctly determines the final pH	3
•Writes the correct balanced equation. • Determines the moles of HCl and moles of Ba(OH)2 that are mixed	2
• Writes the correct balanced equation. OR • Determines the moles of HCl and moles of Ba(OH)2 that are mixed.	1

$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$

$n(HCl) = \text{concentration} \times \text{volume} = 1.00 \times 0.100$

$n(HCl) = 0.100 \text{ mole}$

$n(Ba(OH)_2) = \text{concentration} \times \text{volume}$

$n(Ba(OH)_2) = 0.500 \times 0.0500 = 0.0250 \text{ mole}$

(limiting reagent is $Ba(OH)_2$)

$n\text{HCl (in excess)} = 0.100 - 2 \times 0.0250$

$n\text{HCl (in excess)} = 0.0500 \text{ mole}$

$$[HCl] \text{ (in mixture)} = \frac{0.0500}{0.150}$$

$[HCl] \text{ (in mixture)} = 0.333 \text{ mol } L^{-1}$

$pH = -\log 10[0.333] = 0.48$

Note: barium hydroxide give 2 moles of hydroxide ions per mole.

Question 31
a)

Criteria	Marks
• Correctly identifies the **equipment** (analytical balance and standard flask) that must be used to prepare a standard solution. • Correctly **outlines the steps** that must be followed (rinse the flask with water, quantitatively transfer the weighed sample and then make up to the mark with water)	**2**
• Correctly identifies the **equipment** (analytical balance and standard flask) that must be used to prepare a standard solution. **OR** • Correctly **outlines the steps** that must be followed (rinse the flask with water, quantitatively transfer the weighed sample and then make up to the mark with water) .	**1**

Suggested answer

- A volumetric) flask is washed and rinsed with distilled water.
- An electronic balance is used to accurately weigh the sodium hydrogen carbonate.
- The weighed sample is then dissolved into a little distilled water and transferred into the volumetric flask.
- Distilled water is added to the volumetric mark on the volumetric flask.

b)

Criteria	Marks
Writes a correctly balanced equation. • Correctly determines average titration volume& ignores the outlier • Correctly determines moles of $NaHCO_3$. • Correctly determines the concentration of acid	**4**
Any three of the above	**3**
Any two of the above	**2**
Only one of the above	**1**

- **$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$**
- 23.40 + 23.55 + 23.35/ 3 = 23.43 mL
- = *n* $NaHCO_3$ = 0.02343 × 0.06256 = 0.001466 mole

  n(HCl)= *n* NaHCO3 = 0.001466 mole

- [HCl] = 0.001466/ 0.02500 **= 0.05864 mol L^{-1}**

Question 32

Criteria	Marks
• States the role of $H_2PO_4^-/HPO_4^{2-}$ as a buffer system in the cell • Provides TWO correct equations	3
• States the role of $H_2PO_4^-/HPO_4^{2-}$ as a buffer system in the cell **AND** provides ONE correct equation OR • Provides TWO correct equations	2
• States the role of $H_2PO_4^-/HPO_4^{2-}$ as a buffer system in the cell OR • Provides ONE correct equation	1

Sample answer:

$H_2PO_4^-/HPO_4^{2-}$ is a buffer system in the cell. This means it can neutralise both an acid or a base in the cell, therefore maintaining the pH.

$$HPO_4^{2-} + H_3O^+ \rightarrow H_2PO_4^- + H_2O$$

$$H_2PO_4^- + H_2O \rightarrow HPO_4^{2-} + H_3O^+$$

Question 33

Criteria	Marks
• Names a recent development of a named biopolymer • States desirable properties of biopolymers • Identifies properties of biopolymers that allow an impact on society and environment • Makes a judgement about the impact of the biopolymer on both society and the environment	3–4
• Names a recent biopolymer • Identifies a property of a biopolymer that differentiates it from a synthetic polymer • States an impact on society or the environment	2
• Names a recent biopolymer OR • States a desirable property of a biopolymer (eg biodegradable) OR • States an impact on either society or the environment	1

Question 34

	Marks
Identifies that CFCs were initially thought to be chemically inert. AND • Discusses the advances in technology that were needed to determine the very small concentrations of CFCs in the atmosphere. AND • Writes an equation showing the photochemical formation of chloride atoms (radicals) from CFCs. AND • Writes two equations showing that chlorine atoms (radicals) catalyse the decomposition of ozone. AND • States that the Montreal Protocol was an international agreement to phase out CFCs. AND • Nominates a replacement chemical (HCFCs or HFCs) for CFCs. AND • Concludes by evaluating the impact human activity has had on the chemistry of the stratosphere	**7**
All of the above except conclusion	**6**
Any five of the above	**5**
Any four of the above	**4**
Any three of the above	**3**
Any two of the above	**2**
Any one of the above	1

Human activity and technology have had a big impact on the concentration of ozone in the stratosphere. CFCs, or chlorofluorocarbons, were known a long time before they were used commercially. Research in 1928 suggested that CFCs were a safe replacement for refrigerants as they were non-toxic to humans and chemically

inert and much safer to use than ammonia (the refrigerant used at that time). CFCs are unreactive and water insoluble, so they persist in the atmosphere. The development of sensitive analytical tools (such as the electron capture detector and spectrophotometers) in the early 1970s meant that it became possible to measure trace amounts of halogenated compounds in air. It was realised that CFCs were present in all air samples, however it was initially believed that CFCs were not impacting on the environment.

Rowland and Molina recognised that CFCs were not entirely chemically inert and that in the stratosphere CFCs could interact with UV light to produce chlorine radicals.

$CF_3Cl \longrightarrow CF_3\bullet + Cl\bullet$

Chlorine radicals (Cl•) react with ozone in a process that regenerates the chlorine radical (a catalytic cycle).

$O_3 + Cl\bullet \longrightarrow OCl\bullet + O_2$

$OCl\bullet + O_3 \longrightarrow Cl\bullet + 2O_2$

One CFC molecule can destroy thousands of ozone molecules.

A series of satellite measurements and weather balloon measurements demonstrated the extent of ozone depletion over the Antarctic in the spring of each year, resulting in global reductions of ozone concentration in the stratosphere. This confirmation of the damage that CFCs were causing to the environment lead to the Montreal Protocol, in which nations agreed to phase out CFCs and replace them with HCFCs (hydrochlorofluorocarbons), HFCs (hydrofluorocarbons), and more recently, hydrocarbons. The ozone concentrations in the stratosphere are slowly returning to their previous levels, indicating that the Montreal Protocol is working.

In conclusion, human activity and technology have had a huge impact on ozone concentration – causing its depletion, and more recently, allowing its depletion to be halted.

Marking Criteria for Industrial Chemistry

(a)

Marking guidelines	Marks
Identifies a shrinking natural resource. Eg. Wood ,Rubber,Guano	1

(b)

Marking guidelines	Marks
Outlines two associated issues and identifies a current or potential solution	2
Identifies one associated issue and a solution.	1

(c) (i)

Marking guidelines	Marks
Identifies temperature	1

(ii)

Marking guidelines	Marks
Identifies that the system is shifting to the right by calculating a value for the reaction quotient and correctly comparing this to the value of K given, showing working.	3
Correctly calculates the value of the reaction quotient and gives the correct direction without explanation.	2
Correctly calculates the value of the reaction quotient	1

The equilibrium constant expression is $K = [COCl_2]/[CO][Cl_2]$.
The concentration values give a value of the reaction quotient, $Q = 0.25/(0.15x0.18) = 9.3$.
Because this is less than the value of K, the proportion of $COCl_2$ in the mixture is lower than the equilibrium value at this temperature. Thus, the system is shifting to the right to produce more $COCl_2$.

(d)

Marking guidelines	Marks
• Analyses two risks associated with an appropriate procedure (details of procedure not required). • Indicates a method of minimising (controlling) each.	2
• Analyses one risk associated with an appropriate procedure (details of procedure not required). • Indicates a method of minimising this risk.	1

This experiment required the use of concentrated sulphuric acid, which is extremely corrosive and can damage the skin and eyes. If an accident occurred it would be severe. As such, careful handling was needed to minimise the risk of an accident. To minimise the risk, safety gloves, safety glasses and protective clothing were worn.
The experiment produced SO2(*g*) which can be a respiratory irritant. To minimise the risk of irritation the experiment was carried out in a well-ventilated room and only small quantities of materials were used, minimising the production of SO2(*g*).

Marking Guidelines	Marks
• Outlines the results of the procedure. • Gives one specific conclusion from these results. • Assesses the conclusion based on one criterion	3
• Outlines the results of the procedure. • Gives one specific conclusion from these results. OR • Gives one specific conclusion from the results (unspecified). • Assesses the conclusion based on one criterion.	2
• Gives one (general) conclusion from an appropriate investigation. OR • Identifies one result from an appropriate investigation	1

(d)

Criteria	**Marks**
• Assessment of the statement AND • Thorough discussion of the method of extraction of sulfur by the Frasch process, relating the process to specific physical properties of sulfur	3
• Assessment of the statement AND • Sound discussion of the method of extraction of sulfur by the Frasch process, relating the process to physical properties of sulfur	2
• Describes the method of extraction of sulfur by the Frasch process AND • Describes some physical properties of sulfur	1

Sample answer

In the Frasch process, superheated water at 160°C is forced down the outer of 3 concentric pipes into the sulfur deposit. This melts the sulfur (because sulfur has a low melting point at 113°C) and forms an emulsion of sulfur and water.

Compressed air is blown down the inner pipe and the sulfur-water mixture is forced up the middle pipe to the surface.

The low melting point of sulfur, its low density (which means that the compressed air can push it to the surface) and its insolubility in water (which means it can be easily separated from the water once it has been collected at the surface) are all physical properties of sulfur which permit this method of extraction.

Assessment

The statement is correct, as it is only possible to use this method of extraction because of the physical properties of sulfur - its insolubility in water, its low density and its low melting point.

(ii)

Criteria	Marks
• Identifies ONE environmental issue	2

Sample answer
Sulfur dioxide (an acidic pollutant gas, produced when hot sulfur combines with oxygen in the air) is an issue if the gas is released into the atmosphere. OR
Ground subsidence in the area mined is an issue, as the material extracted leaves underground caverns which are not easily backfilled after the extraction process