



**Kincoppal-Rose Bay
School of the Sacred Heart**

Year 12 TRIAL EXAMINATIONS

JULY 2008

Chemistry

General Instructions

- Reading time – five minutes
- Working time – three hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formula sheets and Periodic Table are provided separately
- Write your name at the top of the Answer Booklet and Multiple Choice Answer Sheet

Total Marks (100)

This paper has two parts, Part A and Part B

Part A

Total Marks (15)

- Attempt Question 1 to 15
- Allow about 25 minutes for this part

Part B

Total Marks (85)

- Questions 16 to 34
- Attempt ALL Questions
- Allow about two and a half hours for this part

Part A – 15 marks

Attempt Questions 1-15

Allow about 25 minutes for this part

Record answers on the multiple choice answer sheet.

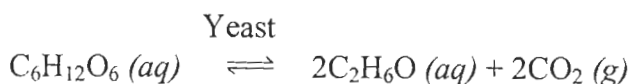
- 1 The heats of combustion of four alkanols are shown below.

<i>alkanol</i>	<i>heat of combustion (kJ/mol)</i>
methanol	715
ethanol	1371
1-propanol	2010
2-butanol	2673

The alkanol which produces the greatest amount of heat in kJ/g is

- (A) methanol
(B) ethanol
(C) 1-propanol
(D) 2-butanol
- 2 When cyclohexene undergoes an addition reaction with bromine, what is / are the organic product(s) formed?
(A) bromocyclohexane
(B) a mixture of bromocyclohexanes
(C) 1, 2-dibromocyclohexene
(D) 1, 2-dibromocyclohexane
- 3 Which of the following species would have the greatest ability to gain electrons from a reducing agent in solution?
(A) magnesium ions
(B) copper ions
(C) magnesium
(D) copper

- 4 A student carried out an investigation to monitor the mass changes during fermentation of glucose to produce ethanol.

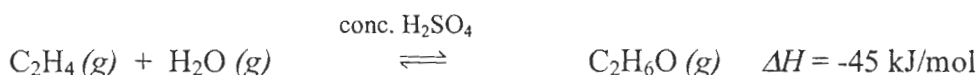


She connected the fermentation flask to a conical flask fitted with a cork and delivery tube. The conical flask contained limewater. She recorded the mass of the flask containing limewater every day for 5 days and noted that the mass increased.

<i>Limewater flask</i>	
<i>Day</i>	<i>Mass (g)</i>
1	503.12
2	505.68
3	509.88
4	512.16
5	515.67

The mass of ethanol produced over the 5-day period would be closest to

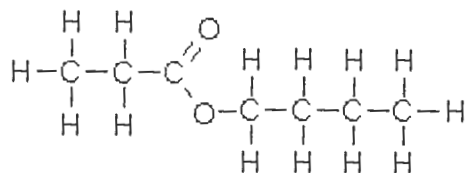
- (A) 12.55 g
(B) 13.15 g
(C) 25.01 g
(D) 26.30 g
- 5 The reversible reaction to form ethanol from ethylene is represented:



Identify the INCORRECT statement.

- (A) the highest yield of ethanol is achieved at low temperature and high pressure.
(B) the dehydration of ethanol is an endothermic reaction.
(C) the highest yield of ethylene from ethanol is achieved when excess $\text{H}_2\text{O}_{(g)}$ is present in the reaction vessel.
(D) sulfuric acid acts as a catalyst for both the backward and forward reactions.

6 Identify the following compound.



- (A) Heptanoic acid
- (B) 1-butyl propanoate**
- (C) 1-propyl butanoate
- (D) 1-propyl pentanoate
- 7 When 1 mole of zinc is reacted with 250 mL of 1.0 mol L⁻¹ hydrochloric acid, what is the closest value of the volume of the hydrogen gas formed, at 25°C and 100 kPa?
- (A) 24.8 L
- (B) 12.4 L
- (C) 6.2 L
- (D) 3.1 L**
- 8 Some salts, when dissolved in water, produce acidic or alkaline solutions, while others produce neutral solutions. Which is the CORRECT statement?
- (A) when sodium chloride is added to water, the pH increases slightly.
- (B) when sodium ethanoate is added to water, the concentration of hydrogen ions increases.
- (C) when sodium carbonate is added to water, the pH decreases.
- (D) when ammonium nitrate is added to water, the concentration of the hydroxide ions decreases.**

- 9 What is an indication that an oxide should be classed as acidic?
- (A) reacts with water to form a base or with a salt to form an acid.
(B) reacts with water to form an acid or with a base to form a salt.
(C) reacts with a base to form an acid.
(D) turns red litmus to a blue colour.
- 10 A solution of HCl is changed from a pH of 1 to a pH of 3. What could be stated about the concentration of H_3O^+ ions?
- (A) decreased by a factor of 100.
(B) decreased by a factor of 2.
(C) increased by a factor of 100.
(D) increased by a factor of 2.
- 11 A student analysed a sample of water from a local creek which was suspected of being contaminated with a metallic ion. The student added dilute hydrochloric acid to the sample and noted that no reaction occurred. Addition of sulfuric acid caused the formation of a white precipitate. He then carried out a flame test and noticed a distinctive orange colour in the flame.

What could the metallic ion in the water be?

- (A) Pb^{2+}
(B) Ba^{2+}
(C) Ca^{2+}
(D) Fe^{2+}
- 12 What statement applies to molecules known as CFCs?
- (A) CFCs are very stable, generally unreactive compounds.
(B) CFCs are highly active and dangerous chemicals in the troposphere.
(C) CFCs dissolve readily in water so cause pollution of rivers and dams.
(D) CFCs only react with active metals such as the Group 1 and 2 elements.

- 13 What is the chemical added to water supplies to ensure that the water is alkaline so that precipitation can occur?
- (A) chlorine
 - (B) sodium fluoride
 - (C) lime**
 - (D) iron (III) chloride
- 14 In which molecule below does co-ordinate covalent bonding occurs?
- (A) ammonia, NH_3
 - (B) ethylene, C_2H_2
 - (C) the hydronium ion, H_3O^+**
 - (D) methane, CH_4
- 15 Water quality is often monitored for organic matter by determining the concentration of dissolved oxygen that is needed for the complete breakdown of the organic matter by aerobic bacteria.
- What aspect of water quality is being determined?
- (A) dissolved oxygen
 - (B) aerobic bacteria levels
 - (C) biochemical oxygen demand**
 - (D) nitrogen-to-phosphorus ratio

END OF PART A

Student Number

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Kincoppal-Rose Bay

Year 12 Chemistry Trial Examination 2008

Part B Attempt all Questions 16 to 34 (85 marks)

Write all answers in the space provided.

Show all relevant working in questions involving calculations.

Allow about 2 and a half hours for this section

Question 16 (3 marks)

- (a) The element thorium forms TWO radioactive isotopes, thorium-234 and thorium-230. **Marks**
Which of these isotopes is more likely to be a beta emitter? **1**
Explain your answer.

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- (b) A student classified thorium as a radioactive metal, as an actinide and as a transuranic element. **2**
Is the student's classification of thorium correct?
Explain your answer.

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Question 18 (5 marks)

A student has been provided with the following chemical substances and equipment to carry out experiments involving galvanic cells:

- 1 mol/L solutions of lead (II) nitrate, magnesium nitrate and zinc nitrate
- strips of lead, magnesium and zinc
- a voltmeter and electrical wires
- a solution of potassium nitrate and tissues to use as a salt bridge
- beakers

(a) Predict the combination of metals and solutions that will produce a galvanic cell with the largest voltage? **Marks**
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(b) Write half-equations for the reactions in part (a). **1**

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(c) Calculate the largest voltage produced from this galvanic cell. **1**

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(d) Explain why the half-cells in any galvanic cell must be linked by a salt bridge or porous membrane. **2**

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Question 19 (7 marks)

Ethylene is an important resource for chemical industries. It can be converted into other useful substances, such as addition polymers and ethanol.

(a) State two methods in which ethylene can be produced.

Marks
2

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(b) Draw a diagram to show the structure of an addition polymer produced from ethylene.

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(c) Compare and contrast the difference in properties of high density polyethylene (HDPE) and low density polyethylene (LDPE) and relate these properties to their different uses.

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Question 20 (5 marks)

Marks

5

“According to the work of Davy and Arrhenius on the theory of acids, all acids contain hydrogen atoms. However, there are many compounds which contain hydrogen atoms which are not classified as acids.”

Use the following examples to explain this statement.

- methane, CH₄
- ethanoic acid, CH₃COOH
- hydrogen chloride, HCl (*g*)

Relate your answer to the bonding of the hydrogen atoms in the THREE compounds.

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Question 21 (6 marks)

The terms amphiprotic and amphoteric are both used in relation to the acid/base properties of substances.

(a) Identify: **Marks**
2

an amphiprotic species

an amphoteric species

(b) Explain why the substance you identified as amphiprotic is classified in this way. **4**
Include equations in the explanation.

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Question 22 (5 marks)

A titration was performed in order to determine the concentration of a solution of ethanoic acid. Sodium hydroxide solution was used to neutralise 25.0 mL of the ethanoic acid (acetic acid) solution. Excess sodium hydroxide was added so that a curve could be drawn, to show the pH changes before and after the end point.

- (a) Write a balanced equation for this reaction. Marks

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- (b) State the name of a suitable indicator for use in this titration. 1

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- (c) Explain why this indicator is suitable for use in this titration. 1

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- (d) The sodium hydroxide solution used had a concentration of 0.142 mol/L. Express this concentration as a percentage by mass (% (w/w)). 2

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Question 23 (5 marks)

Marks

100.0 mL of a solution of 0.150 mol/L sulfuric acid was added to a solution containing 100.0 mL of 0.200 mol/L sodium hydroxide.

- (a) Would the resulting solution be acidic, alkaline or neutral?
Explain your answer.

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- (b) Calculate the pH of the resulting solution (assuming that the sulfuric acid is completely ionised).

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Question 24 (2 marks)

Marks

Explain why esters have lower boiling points than alcohols or acids of the same molecular mass.

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Question 25 (4 marks)

Combustion reactions are important in industry and for society. Scientists must monitor and manage combustion reactions.

(a) Write an equation for the **incomplete** combustion of octane, C_8H_{18} .

Marks

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(b) Justify the need for the monitoring and management of combustion reactions.

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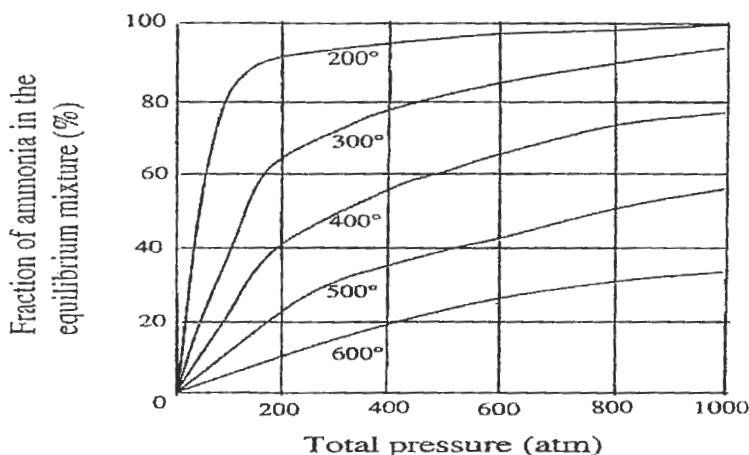
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Question 26 (5 marks)

The graphs below show the fraction of ammonia present at equilibrium when nitrogen and hydrogen react under varying conditions of temperature and pressure.



- (a) Use the information from the graphs to identify the conditions of temperature and pressure which would give the highest yield of ammonia. Marks
1

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- (b) Explain why the Haber process is carried out industrially under compromise conditions of both temperature and pressure. **2**

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- (c) Iron on the surface of magnetite is the catalyst used for this process. Explain the impact of the catalyst on the rate and/or yield of this industrial process. **2**

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Question 28 (5 marks)

- (a) Identify a heavy metal that can be found in the environment due to pollution. **Marks**
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- (b) Explain the effects of this heavy metal on the environment. **2**

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- (c) Explain why analytical laboratories now use atomic absorption spectroscopy (AAS) rather than precipitation reactions for identification and measurement of lead (II) ions in water samples. **2**

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Question 30 (5 marks)

- (a) Aluminium reacts with dilute sulfuric acid according to the equation

Marks

3

Calculate the maximum volume of hydrogen, measured at 25°C and 100 kPa, which can be produced when 5.4 g of aluminium is reacted with excess sulfuric acid.

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- (b) The concentration of argon in the atmosphere is 0.93% (v/v). Calculate its concentration in ppm.

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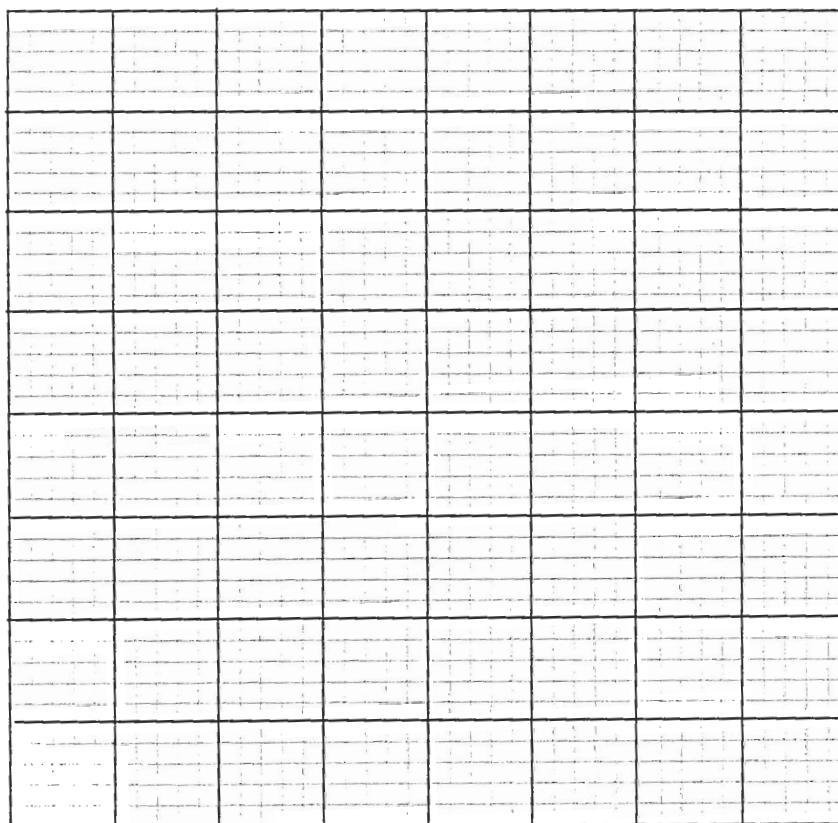
Question 31 (5 marks)

The boiling points of alkanols and alkanolic acids versus molecular weight are listed in the table below.

Molecular weight	46	60	74	88
Alkanols boiling point (°C)	78	97	117	138
Alkanolic acid boiling point (°C)	100	118	141	164

- (a) Draw a line of best fit graphs for each of these organic molecules of boiling point against molecular weight.

Marks
3



Molecular weight

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Question 31 (continued)

(b) Explain the difference in boiling points BETWEEN the organic groups.

Marks

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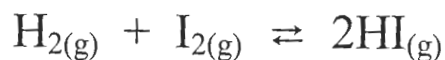
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Question 33 (3 marks)**Marks**

The equilibrium reaction in which hydrogen iodide is formed from iodine gas and hydrogen gas is indicated in the equation:



Concentration of $\text{H}_{2(\text{g})}$ (molL^{-1})	Concentration of $\text{I}_{2(\text{g})}$ (molL^{-1})	Concentration of $\text{HI}_{(\text{g})}$ (molL^{-1})
1.2	1.2	0.8

Table of concentration of reactants and products at equilibrium.

- (a) Write the equilibrium constant expression for this reaction. **1**

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- (b) Calculate the equilibrium constant (value) for this reaction using the data supplied in the table above. **1**

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- (c) At equilibrium is there a greater concentration of products or reactants? Justify your answer. **1**

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Question 34 (3 marks)

Marks

Blood is a natural buffer in living organisms.

- (a) Define the term buffer. 1

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- (b) Describe how blood acts as a buffer in human beings. 2

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END OF EXAMINATION

2008 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY – MAPPING GRID

Part A – 15 marks

Attempt Questions 1-15 (1 mark each)

Allow about 25 minutes for this part

Record answers on the multiple choice answer sheet.

Question	Correct Response	Outcomes Assessed	Suggested performance bands
1	D	H9, H10	3-4
2	D	H9	3-4
3	B	H8, H13	3-4
4	B	H9, H10	5-6
5	C	H7, H8, H9	3-4
6	B	H9, H13	2-3
7	D	H10	4-5
8	D	H8	5-6
9	B	H8, H13	3-4
10	A	H10	4-5
11	C	H8, H14	2-3
12	A	H4, H13	3-4
13	C	H3, H8	2-3
14	C	H6, H13	3-4
15	C	H3, H8	3-4

Part B Attempt all Questions 16 to 34 (85 marks)**Write all answers in the space provided.**

Show all relevant working in questions involving calculations.

Allow about 2 and a half hours for this section**Question 16 (3 marks)**

16 (a) (1 mark)

Outcomes Assessed: H6**Targeted Performance Bands: 3-4**

Criteria	Marks
• Correct answer with explanation	1

Sample answer

Thorium-234 has a higher neutron/proton ratio than thorium-230, so is more likely to emit beta particles by the breakdown of a neutron to form a proton and electron (the beta particle).

16 (b) (2 marks)

Outcomes Assessed: H6, H13**Targeted Performance Bands: 2-4**

Criteria	Marks
• Explanation of the classification of thorium as radioactive, as a metal and as an actinide but NOT as a transuranic element	2
• Partially correct explanation of the classification of thorium	1

Sample answer

The classification of thorium as radioactive is correct as thorium has an Atomic Number >82, so will emit radiation from the unstable nucleus.

Thorium is a metal and is an actinide. It is on the left hand side of the Periodic Table and is classified with the transition metals, in the series called the actinides (elements 89-103).

However, thorium is NOT classified as a transuranic element. Transuranic elements are those after element 92, uranium. Thorium has an atomic number of 90.

Question 17 (5 marks)**Outcomes Assessed:** H1, H3, H4, H5, H9, H13**Targeted Performance Bands:** 2-6

Assess the potential of ethanol as a chemical raw material for use in industry.

Include any relevant chemical equations to support your answer.

Criteria	Marks
<ul style="list-style-type: none"> • Assesses the potential of ethanol as a chemical raw material for use in industry AND <ul style="list-style-type: none"> • Explains how ethanol is currently used as a source of raw materials AND <ul style="list-style-type: none"> • Explains how ethanol as a chemical raw material for use in industry could be used in the future OR reasons why it is not likely this will happen. AND <ul style="list-style-type: none"> • Uses at least ONE appropriate equation 	4-5
<ul style="list-style-type: none"> • Three of the criteria 	3
<ul style="list-style-type: none"> • Two of the criteria 	2
<ul style="list-style-type: none"> • One of the criteria 	1

Sample answer

Ethanol's major uses are as a motor fuel supplement and as a solvent. Ethanol or ethanol-water mixtures are also used as solvents in cosmetics and toiletries, medications, antiseptics and perfumes. Ethanol is an industrial solvent for lacquers, paints, resins, oils and fatty acids. Its wide use as a solvent is related to the polar nature of the molecule.

Ethanol-water mixtures are often used to dissolve various natural oils and organic substances that are normally insoluble in water. Iodine solutions in ethanol-water mixtures have antiseptic properties. The solvent used is a mixture of ethanol and water as non-polar iodine has only a limited solubility in water.

Ethanol produced from fermentation is said to be renewable as it is produced from carbohydrate-rich crops such as sugarcane and thus does not depend on a supply of crude oil. However, over past decades and in many countries today, the source of ethanol, for uses other than for human consumption, has been mainly the hydration of ethylene.

The ethylene was manufactured from petroleum, using the processes of fractional distillation and catalytic cracking. The chemical energy was originally derived from photosynthesis – millions of years ago.

Ongoing research has identified possible methods of production of ethanol from cellulosic feed stocks such as cornfield residues and waste paper.

However it is not completely renewable because considerable amounts of non-renewable fossil fuel go into making ethanol; energy from fossil fuel is used to make fertiliser that is needed to grow the plants and to drive the machinery used to cultivate and harvest the crops.

Fermentation produces only about a 15% aqueous solution of ethanol and generally large amounts of fossil fuel are used to distil ethanol from this mixture.

Ethanol does not in the long term have the potential to become a significant replacement as a transport fuel because of the impact on food production. It will remain as an important raw material for use in industry in the production of industrial solvents, and as solvents for cosmetics and toiletries, medications, antiseptics and perfumes. Increasing population will place demands on the production of ethanol and fermentation could become an increasing method for the production of ethanol.

Question 18 (5 marks)**Outcomes Assessed:** H7, H8**Targeted Performance Bands:** 2-4

18 (a) (1 marks)

Criteria	Marks
• Correct answer	1

Sample answer

The student should use magnesium and magnesium nitrate in the anode half-cell and lead and lead (II) nitrate in the cathode compartment.

The combination which produces the greatest voltage must be the strongest reducing agent (magnesium), with the strongest oxidising agent (lead(II) ions).

18 (b) (1 marks)

Criteria	Marks
• Correct answer	1

Sample answer

18 (c) (1 marks)

Criteria	Marks
• Correct answer	1

Sample answer

Overall predicted voltage: +2.23 V

18 (d) (2 marks)

Outcomes Assessed: H8**Targeted Performance Bands:** 2-3

Criteria	Marks
• States that the salt bridge is necessary for the transfer of charge (completes the circuit)	2
• Explains why build-up of charge is a problem OR the salt bridge specially allows ions to move from one cell to the other	
• One of the above	1

Sample answer

The purpose of a galvanic cell is to create a flow of electrons through an external circuit. The salt bridge contains ions which can move between the half-cells in the galvanic cell. Ions must move to ensure the electrical neutrality of each half-cell. If build-up of charge were to occur, the excess positive charge on the anode side and excess negative charge on the cathode side would prevent the flow of electrons through the external wire.

Question 19 (7 marks)

19 (a) (2 marks)

Outcomes Assessed: H9, H13**Targeted Performance Bands:** 2-4

Criteria	Marks
• Both correct methods: dehydration of ethanol and cracking (either catalytic or thermal cracking) of long-chain hydrocarbons	2
• One correct method	1

Sample answer

1) dehydration of ethanol

(Ethylene is still produced by ethanol dehydration in some modern plants. The dehydration of the ethanol is achieved by passing the ethanol vapour over a bed of alumina and phosphoric acid in a reactor. The reaction occurs in two steps, during which an intermediate 'ether' is formed:



This process has a typical ethylene yield of 94%.

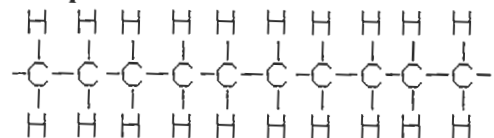
OR

(2) Long-chain hydrocarbons can be broken down into smaller chains by a process called *cracking*.

19 (b) (1 mark)

Outcomes Assessed: H9, H13**Targeted Performance Bands:** 2-3

Criteria	Marks
• Draws correctly the polymer produced from ethylene	1

Sample answer

Polyethylene – showing 5 repeating units

19 (c) (4 marks)

Compare and contrast the difference in properties of high density polyethylene (HDPE) and low density polyethylene (LDPE) and relate these properties to their different uses.

Outcomes Assessed: H4, H9

Targeted Performance Bands: 3-6

Criteria	Marks
<ul style="list-style-type: none"> • Compare and contrast at least two different properties of HDPE and LDPE • AND • Relate these two different properties to their different uses 	4
<ul style="list-style-type: none"> • Compare and contrast at least two different properties of HDPE and LDPE • OR • Relate these two different properties to their different uses 	3
<ul style="list-style-type: none"> • Statement of correct properties of two of the polyethylenes 	2
<ul style="list-style-type: none"> • Statement of correct properties of one of the polyethylenes 	1

Sample answer

HDPE uses a catalyst which ensures that the chains do not branch during the polymerisation process. Long straight chains can get close to each other and can form stronger dispersion forces than branched structures.

As a result, HDPE has higher density, is less flexible and the materials made from it are more rigid (e.g. lunch boxes) than materials made from LDPE (e.g. food wrap).

Low-density polyethylene (LDPE) is an example of a polymer in which branching side chains are present. These branches may be short or long and their presence causes disruption in the packing of the polymer chains in the lattice.

As a consequence there are fewer crystalline regions present in such polymers. About 40–55% of LDPE consists of crystalline regions. LDPE molecules are softer and more flexible than HDPE molecules owing to the weaker dispersion forces between the polymer chains.

LDPE polymers are also more transparent because there is less scattering and refraction of light that passes through the solid.

LDPE polymers typically have melting points that are lower than those of HDPE molecules.

LDPE has a typical melting point of 80°C. Low-density polyethylene is commonly used to make plastic bags, squeeze bottles, electrical insulation and the plastic cling-wrap used for protecting food. LDPE film can also be used to waterproof cardboard food and drink containers.

Question 20 (5 marks)

“According to the work of Davy and Arrhenius on the theory of acids, all acids contain hydrogen atoms. However, there are many compounds which contain hydrogen atoms which are not classified as acids.”

Use the following examples to explain this statement.

- methane, CH₄
- ethanoic acid, CH₃COOH
- hydrogen chloride, HCl (g)

Relate your answer to the bonding of the hydrogen atoms in the THREE compounds.

Outcomes Assessed: H2, H6, H8

Targeted Performance Bands: 2-6

Criteria	Marks
<ul style="list-style-type: none"> • Thorough explanation of the statement using the THREE examples in the explanation AND <ul style="list-style-type: none"> • Correctly relates the classification of acids to the polarity of bonding of hydrogen atoms 	5
<ul style="list-style-type: none"> • Sound explanation of the statement using the THREE examples in the explanation (methane and hydrogen chloride are gases) AND <ul style="list-style-type: none"> • Correctly links acidic properties to the polarity of bonding of hydrogen atoms 	3-4
<ul style="list-style-type: none"> • Some correct information about classification of the THREE examples (identifies acetic acid as a weak acid) OR <ul style="list-style-type: none"> • Correctly links acidic properties to the polarity of bonding of hydrogen atoms 	1-2

Sample answer

The Lowry-Brønsted theory defines acids as proton donors. As a result, only those compounds containing hydrogen atoms which are bonded to an electronegative element can potentially be classified as acids. The bond between hydrogen and the electronegative atom must be sufficiently polar for the hydrogen to be donated as a proton (H⁺) to the electron pair of a base and hence for the substance to be classified as an acid by the Lowry-Brønsted theory.

Methane contains 4 hydrogen atoms but these are not acidic, in that the bonds to the central carbon are non-polar (since carbon and hydrogen have identical electronegativity) – so methane is not classified as an acid.

Ethanoic acid has 3 hydrogen atoms (those bonded in the methyl -CH₃ group) which are not acidic because these bonds are non-polar, as in methane. However, the O-H bond in ethanoic acid (part of the -COOH carboxylic acid functional group) is polar, with the electrons in the bond attracted to the very electronegative oxygen atom. This hydrogen atom can be lost as a proton, so ethanoic acid is classified as a monoprotic acid, in that it can lose 1 of its 4 hydrogens.

Hydrogen chloride gas is also classified as a Lowry-Brønsted acid, as it is capable of donating a proton, even in the gaseous state. The H-Cl bond is polar, with the electrons attracted strongly to the electronegative chlorine atom. The hydrogen is lost as H⁺ to a base, such as ammonia – so hydrogen chloride is classified as an acid.

Question 21 (6 marks)

21 (a) (2 marks)

*Outcomes Assessed: H8, H13**Targeted Performance Bands: 2-3*

Criteria	Marks
• TWO correct species identified (either by name or formula)	2
• ONE correct species identified (either by name or formula)	1

Sample answerAmphiprotic species: hydrogen carbonate ion, HCO_3^- Amphoteric species: aluminium oxide, Al_2O_3

21 (b) (4 marks)

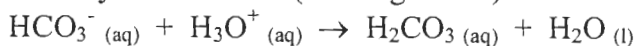
*Outcomes Assessed: H8, H13**Targeted Performance Bands: 3-5*

Criteria	Marks
• Thorough explanation, with correct equation(s)	4
• Sound explanation, with correct equation(s)	3
• Correct explanation, with correct equation(s)	2
• Correct explanation only	1

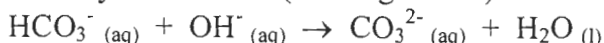
Sample answer

An amphiprotic species is one which can act both as a proton donor and a proton acceptor. Hence the amphiprotic species can accept a proton from a stronger acid and donate a proton to a stronger base.

With hydronium ions (a stronger acid):

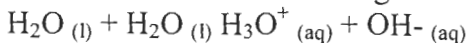


With hydroxide ions (a stronger base):



OR

Water is capable of both gaining and donating a proton. As a result, it is amphiprotic and 2 water molecules can react together to form hydronium and hydroxide ions.



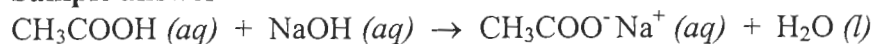
The molecules are in equilibrium with their ions. The equilibrium lies to the left, with only a very small fraction of the water molecules ionised at any time.

Question 22 (5 marks)

22 (a) (1 mark)

Outcomes Assessed: H8, H13**Targeted Performance Bands:** 2-3

Criteria	Marks
• Correct answer	1

Sample answer

22 (b) (1 mark)

Outcomes Assessed: H8, H11**Targeted Performance Bands:** 3-4

Criteria	Marks
• Suitable indicator identified	1

Sample answer

Phenolphthalein is suitable.

22 (c) (1 mark)

Outcomes Assessed: H8, H11**Targeted Performance Bands:** 3-4

Criteria	Marks
• Correct explanation	2

Sample answer

Phenolphthalein is suitable, as it changes colour from colourless to pink from pH 8 to pH 10, which is the pH at the equivalence point of a weak acid-strong base titration.

22 (d) (2 mark)

Outcomes Assessed: H10**Targeted Performance Bands:** 3-4

Criteria	Marks
• Correct answer suitable calculations	1
• Correct answer	1

Sample answer

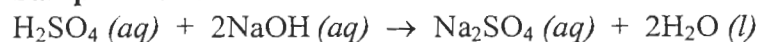
$$\begin{aligned} [\text{NaOH}] &= 0.142 \text{ mol/L} \\ &= 0.142 \times 40.00 \text{ g/L} \\ &= 5.68 \text{ g/L} \\ &= 0.568 \text{ g/100 mL} \\ &= 0.568 \text{ g/100 g water} \\ &= 0.568 \% \text{ (w/w)} \end{aligned}$$

Question 23 (5 marks)

23 (a) (2 marks)

Outcomes Assessed: H8, H10**Targeted Performance Bands:** 3-5

Criteria	Marks
<ul style="list-style-type: none"> Correct explanation based on the correct calculation of the moles of sulfuric acid AND sodium hydroxide which react AND	2
<ul style="list-style-type: none"> The identification of excess moles of sulfuric acid remaining after neutralisation 	1

Sample answer

$$\text{Moles H}_2\text{SO}_4 \text{ added} = 0.150 \times 0.100 = 0.0150 \text{ mol}$$

$$\text{Moles NaOH added} = 0.200 \times 0.100 = 0.0200 \text{ mol}$$

Since 0.0200 moles of NaOH are needed to neutralise 0.0100 mole of H_2SO_4 , all the NaOH will be neutralised and excess moles of sulfuric acid will remain.

Hence the resulting solution will be acidic.

23 (b) (3 marks)

Outcomes Assessed: H10**Targeted Performance Bands:** 3-5

Criteria	Marks
<ul style="list-style-type: none"> Calculates the pH of the resulting solution to 3 decimal places 	3
<ul style="list-style-type: none"> Calculates concentration of hydrogen ions 	2
<ul style="list-style-type: none"> Calculates the moles of hydrogen ions in excess 	1

Sample answer

$$\begin{aligned} \text{Moles of sulfuric acid in excess} &= (0.0150 - 0.0100) \text{ mol} \\ &= 0.0050 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Moles of hydrogen ions in excess} &= 2 \times \text{moles H}_2\text{SO}_4 \text{ (assumed to be completely ionised)} \\ &= 2 \times 0.0050 \text{ mol} \\ &= 0.0100 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Concentration of hydrogen ions} \quad c &= n/v \\ &= 0.0100/0.2000 \text{ mol L}^{-1} \\ &= 0.0500 \text{ mol L}^{-1} \text{ (to 3 significant figures)} \end{aligned}$$

$$\begin{aligned} \therefore \text{pH} &= -\log_{10} [\text{H}^+] \\ &= 1.301 \text{ (to 3 decimal places)} \end{aligned}$$

Question 24 (2 marks)**Outcomes Assessed:** H9**Targeted Performance Bands:** 3-5

Criteria	Marks
• Correct explanation in terms of intermolecular forces in esters AND alcohols OR acids	2
• Some correct information about the intermolecular forces in esters OR alcohols OR acids	1

Sample answer

Esters are polar molecules but they do not have hydrogen bonding (only weaker dipole-dipole forces) between neighbouring molecules. Alcohols and acids have stronger hydrogen bonding between neighbouring molecules. Hence if esters, alcohols and acids of the same (or similar) molecular mass are heated, the esters will boil at lower boiling points than alcohols and acids, as less energy needs to be applied to separate the molecules and change the state.

Question 25 (4 marks)

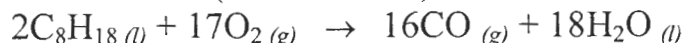
25 (a) (1 mark)

Outcomes Assessed: H9, H13**Targeted Performance Bands:** 2-3

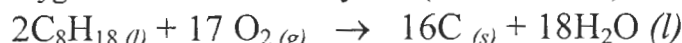
Criteria	Marks
• Correctly balanced equation	1

Sample answer

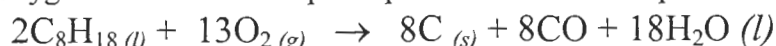
Incomplete combustion, to form carbon monoxide instead of carbon dioxide, occurs if the oxygen-to-fuel ratio is lower (17 : 2 or 8.5 : 1).



Incomplete combustion, to form carbon (soot) instead of carbon dioxide or carbon monoxide, occurs if the oxygen-to-fuel ratio is very low (9 : 2 or 4.5 : 1).



Hence different oxygen-to-fuel ratios impact upon the nature of the products.



25 (b) (3 marks)

Outcomes Assessed: H4, H9**Targeted Performance Bands:** 2-4

Criteria	Marks
• Justifies the need for monitoring and management of combustion reactions	4
• Explains the problems associated with incomplete combustion in terms of production of pollutants AND inefficient use of a fuel	
• Explains the problems associated with incomplete combustion in terms of EITHER production of pollutants OR inefficient use of a fuel	3
• Explains the problems associated with incomplete combustion in terms of EITHER production of pollutants OR inefficient use of a fuel	2
• States the problems associated with incomplete combustion in terms of EITHER production of pollutants OR inefficient use of a fuel	1

Sample answer

Monitoring and management of combustion reactions is justified, on the basis of both pollution control and energy efficiency, to ensure that complete rather than incomplete combustion occurs.

The management of combustion reactions involves ensuring that excess oxygen is available so that carbon dioxide, rather than carbon monoxide or carbon, is formed and that the maximum amount of energy is released from a given amount of fuel.

Incomplete combustion produces carbon monoxide (toxic) and carbon (visual pollutant and respiratory problems). Less energy is released per mole or gram of the fuel, so the efficiency of the combustion process is reduced, with negative financial effects.

Question 26 (5 marks)

26 (a) (1 mark)

Outcomes Assessed: H8, H14**Targeted Performance Bands:** 2-3

Criteria	Marks
<ul style="list-style-type: none"> Correct answer, using specific pressure and temperature conditions 	1

Sample answer

The highest yield would be produced at 1000 atm pressure and at 200°C.

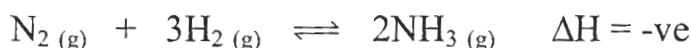
26 (b) (2 marks)

Outcomes Assessed: H3, H4**Targeted Performance Bands:** 3-6

Criteria	Marks
<ul style="list-style-type: none"> Explains why the Haber process is a compromise between rate and yield of production by explaining the impact of changing temperature on the rate and yield Explains the impact of changing pressure on the rate and yield 	2
<ul style="list-style-type: none"> Identifies an impact of changing temperature OR changing pressure on rate OR yield of production OR explains the impact of changing temperature and pressure on the rate and yield 	1

Sample answer

The maximum yield of ammonia would be achieved at the highest pressure and at the lowest temperature, as these conditions drive the equilibrium towards the right and maximise the yield of ammonia.



The maximum rate is achieved at the highest pressure and highest temperature, as the gas molecules are closest and have greatest kinetic energy at these conditions and thus have greatest chance of successful collisions.

High pressure therefore favours both high yield and high rate of production but the higher costs of maintaining high pressure and the risks associated with operating an industrial process at very extreme pressure mean that a compromise lower pressure (of 250 atmospheres rather than 1000 atmospheres) is used.

High temperature favours high rate but low temperature favours high yield. A compromise temperature of 400°C is used (moderate by industrial standards).

26 (c) (2 mark)

Outcomes Assessed: H3, H8**Targeted Performance Bands:** 2-3

Criteria	Marks
<ul style="list-style-type: none"> Identifies that the catalyst affects the rate (but not the yield) of reaction AND provides an explanation 	2
<ul style="list-style-type: none"> Identifies that the catalyst affects the rate (but not the yield) of reaction 	1

Sample answer

The catalyst increases the rate of reaction by providing an alternate lower activation energy pathway for the reaction. In an equilibrium reaction, the catalyst will increase the rate of both the backward and forward reactions equally, so the reaction reaches equilibrium faster but the amount of product (the yield) does not change.

Question 27 (4 marks)*Outcomes Assessed: H11**Targeted Performance Bands: 2-4*

Criteria	Marks
<ul style="list-style-type: none"> • Identifies specific relevant chemicals AND <ul style="list-style-type: none"> • Use specific quantities in the description AND <ul style="list-style-type: none"> • Includes all significant processes/steps in a logical sequence AND <ul style="list-style-type: none"> • Includes procedures taken to ensure safety. 	4
<ul style="list-style-type: none"> • Three of the criteria only 	3
<ul style="list-style-type: none"> • Two of the criteria only 	2
<ul style="list-style-type: none"> • One of the criteria only 	1
<ul style="list-style-type: none"> • Confusing / incorrect procedure without significant steps 	0

Sample answer

Gravimetric analysis is a way of determining the sulfate content in lawn fertiliser. In lawn fertiliser sulfate is usually available as soluble sulfate of ammonia (ammonium sulfate). This can be converted to insoluble barium sulfate, which can be collected, dried and weighed.

1. Weigh out accurately approximately 5.62 g of the powdered lawn fertiliser into a clean 250 mL beaker. Record the mass of fertiliser. Add 25 mL of warm water from a measuring cylinder. Stir to dissolve the crystals.
2. Add 10 drops of concentrated hydrochloric acid to the solution. (Take care. Use safety glasses.) Acidification is performed to remove any carbonate, hydrogen carbonate or sulfide ions that may precipitate with barium ions.
3. Use a hotplate to heat the mixture until it just boils.
4. Add from a burette the 7% barium chloride solution slowly to the hot sulfate solution until no further white precipitate forms. Stir with a glass rod after each addition. (You will need to allow the precipitate to settle and then add further drops of barium chloride to ensure that all the sulfate has precipitated.)
5. Gently re-boil the mixture for a further 5 minutes to coagulate the precipitate. Let stand on a fibre board for 5–10 minutes to cool. (Boiling is necessary to coagulate the fine particles into larger particles that will be trapped in the filter during filtration. No precipitate must pass through the pores of the filter.)
6. Meanwhile, weigh a circle of quantitative filter paper on an electric balance. Weigh a clock glass and record this weight.
7. Fold the filter paper into a cone and set up the apparatus for filtration.
8. Pour the warm supernatant and then the suspension of barium sulfate through the filter paper. Ensure that all the solid is transferred from the beaker to the filter using small amounts of warm washing water. (Washing is needed to remove any occluded or adhering ions. If these remain, the precipitate will be heavier than it should be.)

9. When filtration is complete, carefully transfer the opened filter paper to the weighed clock glass and allow drying in a low temperature oven.

10. When they are dry, weigh the clock glass and filter. Calculate the mass of barium sulfate collected. (There must be no moisture left in the barium sulfate, otherwise the precipitate will weigh more than it should. By using cycles of drying and weighing the correct weight of the precipitate can be established.)

Additional HSC Notes for another question:

Repeating the experiment several times and averaging the results will improve reliability. Wash the precipitate several times with warm, distilled water to remove any soluble particles, then thoroughly dry in a desiccator.

The assumption on which validity relies is that all the barium sulfate, and only the barium sulfate particles will precipitate. That is, there no other particles that will precipitate out with the added barium.

Question 28 (5 marks)

28 (a) (1 mark)

Outcomes Assessed: H11, H13**Targeted Performance Bands:** 3-5

Criteria	Marks
• Correct identification of a heavy metal	1

Sample answer

Heavy metals are metals of high atomic weight that are toxic to humans in relatively low concentrations.

Heavy metals include the transition metals, plus lead and the semi-metal arsenic. The heavy metals that are of concern because of their detrimental health effects are mercury, lead, cadmium, chromium and arsenic.

28 (b) (2 marks)

Outcomes Assessed: H11, H13**Targeted Performance Bands:** 3-5

Criteria	Marks
• Two effects OR One effect and a consequence	2
• One effect Or a consequence	1

Sample answer

Contamination of water supplies and natural waterways by mercury, lead, cadmium, chromium and arsenic are of concern because of their detrimental health effects on humans and animals. Many metal ions (like mercury) bioaccumulate and can pass up the food chain.

Lead is a poison. It retards intellectual development in children, causes brain damage and can lead to neurological disorders. Lead can cause neurological disorders even in low concentrations.

Mercury is a serious pollutant of water due to its toxic and bio-accumulative properties. It damages the nervous system and can cause death of fish and other animals up the food chain who depend on fish for their diets. Unborn children are most at risk of nervous disorders if their mothers eat contaminated fish. In aquatic systems, mercury is often converted by bacteria to methylmercury (the organic form of mercury) which can be magnified up the aquatic food chain hundreds of thousands of times, posing a potential risk to humans and wildlife that consume fish.

28 (c) (2 marks)

Outcomes Assessed: H1, H4**Targeted Performance Bands: 3-5**

Criteria	Marks
ANY TWO OF THE CRITERIA <ul style="list-style-type: none"> • Explanation in terms of the accuracy • Explanation involving sensitivity of AAS when compared with precipitation reactions • Explanation in terms of the efficient time taken to perform a test 	2
ANY ONE OF THE CRITERIA	1

Sample answer

AAS is an extremely sensitive analytical technique which gives accurate readings of the concentration of lead (II) ions (or other metallic ions) in a sample. Because lead (II) ions absorb energy of particular “fingerprint” frequencies, a unique frequency energy source, which is only absorbed by lead (II) ions, is passed through the sample and the reduction in intensity of the energy (or absorbance) is used as a measure of the concentration of ions present. Thus the presence of lead (II) ions can be detected and their concentration (even at concentrations below 1ppm) measured.

Precipitation is much less sensitive – by a factor of 1000. Low concentrations of ions might not be detected as precipitates may not form in dilute solutions. Amounts of precipitate may be too small for quantitative analysis. Precipitation is not as specific (in that many reactions may be needed to positively identify a sample) and is more time-consuming, so less efficient.

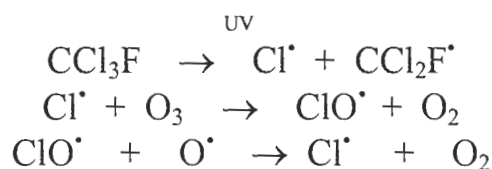
AAS can be used, not only to detect the presence of heavy metals in the environment, but to determine their concentrations.

Question 29 (4 marks)**Outcomes Assessed:** H1, H4, H8**Targeted Performance Bands:** 2-5

Criteria	Marks
<ul style="list-style-type: none"> Explains the relationship between the level of ozone and the concentration of chlorine free radicals in the stratosphere AND Explains why HCFCs and HFCs produce fewer chlorine free radicals than do CFCs AND Explains that CFCs from past decades will still remain in the atmosphere into the future Use of relevant chemical equation/s 	4
ANY 3 OF THE CRITERIA	3
ANY 2 OF THE CRITERIA	2
ANY 1 OF THE CRITERIA	1

Sample answer

The problem with the use of CFCs is associated with the atoms of chlorine they contain. When the CFC molecule reaches the stratosphere, the UV light breaks the carbon-chlorine bond, releasing chlorine free radicals. These in turn react with ozone and reduce the concentration of ozone.



The free radical, Cl^\bullet , has not been consumed and is available to react with another ozone molecule. CFCs are very stable in the troposphere, take a long time to diffuse up to the stratosphere and hence CFCs from past decades will remain in the stratosphere for some decades into the future.

HCFCs are much less stable than CFCs and are mostly decomposed as they pass through the troposphere. They still contain chlorine atoms, so can produce chlorine free radicals if they do reach the stratosphere.

HFCs do not contain chlorine, so do not produce chlorine free radicals in the stratosphere. HFCs do not destroy ozone.

Thus the replacement of CFCs by HCFCs and HFCs will eventually stop the destruction of the “ozone layer” and the levels of ozone will increase. However, the remaining CFC and HCFC molecules still diffusing through the troposphere and remaining in the stratosphere will mean that the levels of ozone will improve only gradually in the years ahead.

Question 30 (a) (3 marks)

Outcomes Assessed: H1, H4, H8

Targeted Performance Bands: 2-5

Criteria	Marks
• Correct number of moles of aluminium	1
• Correct number of moles of hydrogen	1
• Correct answer for volume of hydrogen	1

Suggested answer:

$$\text{Number of moles of aluminium} = \frac{\text{mass}}{\text{mol wt}} = \frac{5.4}{27} = 0.2 \text{ mol}$$

$$\text{Number of moles of hydrogen} = \frac{3}{2} \times \text{mol Al} = 0.3 \text{ mol}$$

$$\begin{aligned} \text{Volume of hydrogen} &= \text{number of moles} \times \text{volume per mole} \\ &= 0.3 \times 24.79 = \mathbf{7.44 \text{ L}} \end{aligned}$$

Question 30 (b) (2 marks)

Outcomes Assessed: H1, H4, H8

Targeted Performance Bands: 2-5

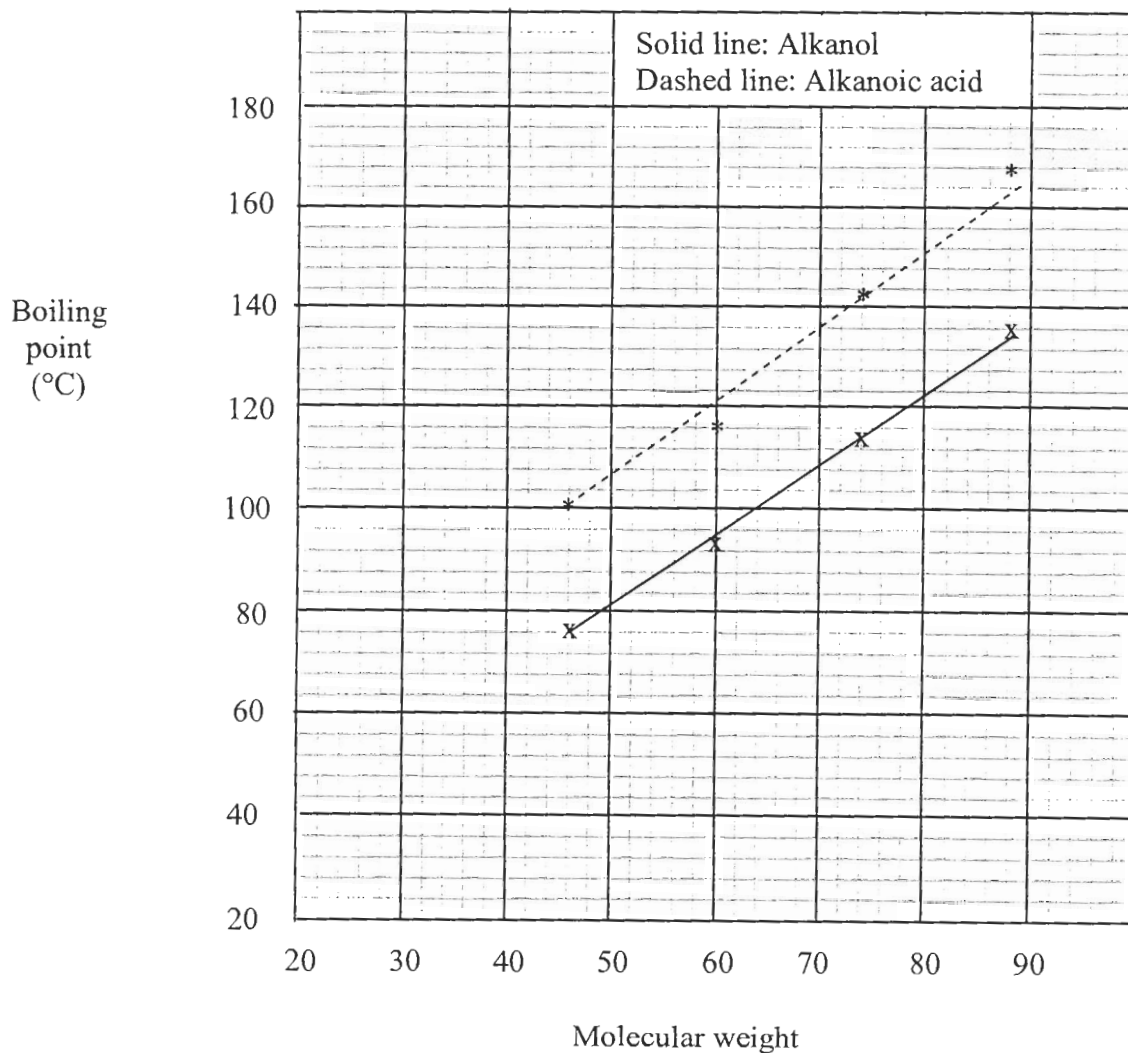
Criteria	Marks
• $0.935 \text{ (v/v)} = 0.93 \text{ mL/100 mL}$	1
• Correct answer	1

Suggested answer:

$$0.935 \text{ (v/v)} = 0.93 \text{ mL/100 mL} = 0.93 \times 10\,000 \text{ mL/kL} = \mathbf{9300 \text{ ppm}}$$

Question 31(a) (3 marks)**Outcomes Assessed: H1, H4, H8****Targeted Performance Bands: 2-5**

Criteria	Marks
• Correct units and labels X and Y axes	1
• Correct placements of points on graph	1
• Correct drawing of lines of best fit	1

Suggested answer:

Question 31(b) (2 marks)**Outcomes Assessed: H1, H4, H8****Targeted Performance Bands: 2-5**

Criteria	Marks
ANY TWO OF THE CRITERIA <ul style="list-style-type: none"> • Thorough explanation that includes Alkanoic acids have higher boiling point • Molecules with same molecular weight have similar dispersion / intermolecular forces • More polarity in alkanolic acids 	2
ANY ONE OF THE CRITERIA	1

Suggested answer:

When alkanols and alkanolic acids of the same molecular weight are compared, the alkanolic acids have the higher boiling points than the alkanolic acids.

The strength of the dispersion forces will be similar in molecules of the same molecular weight however there is a difference in the strength in the intermolecular forces of alkanolic acids and alkanols.

The alkanolic acids and the alkanols both contain the C–O and O–H bonds which result in the molecules being polar.

The alkanolic acids also have a third polar C=O bond; the O–H bonds in each are able to form hydrogen bonds.

Question 32 (a) (1 mark)**Outcomes Assessed:****Targeted Performance Bands: 3-5**

Criteria	Marks
<ul style="list-style-type: none"> Valid example of a depleting natural resource other than a fossil fuel, that currently can be replaced by a synthetic material 	1

Sample answer

Valid example of a depleting natural resource other than a fossil fuel, that currently can be replaced by a synthetic material.

Rubber, Vanilla is a flavoring derived from orchids, animal fats (are animals depleting or do want to stop using animals?) etc.

Question 32 (b) (3 marks)**Outcomes Assessed:****Targeted Performance Bands: 3-5**

Criteria	Marks
<ul style="list-style-type: none"> Evaluation the properties of a synthetic material that make it suitable as a replacement of this natural resource named in (a) 	3
<ul style="list-style-type: none"> Description of the properties of a synthetic material that make it suitable as a replacement of this natural resource named in (a) 	2
<ul style="list-style-type: none"> States/outlines some correct information about the properties of the synthetic material. 	1

Sample answer

Synthetic rubbers had been manufactured in the last quarter of the 19th century but the demands of war led to industrial production of synthetic rubber based on butadiene and styrene (products derived from crude oil).

Synthetic rubber is a white, crumbly, plastic mass which can be processed and vulcanized in the same way as natural rubber. Synthetic rubber can be made from the polymerization of a variety of monomers including butadiene and styrene (products derived from crude oil).

Synthetic rubber has all the properties of natural rubber. These properties include natural elasticity and thermoplastic (A thermoplastic is a plastic that melts to a liquid when heated and freezes to a brittle, very glassy state when cooled sufficiently.)

These and other monomers can be mixed in various desirable proportions to be copolymerized for a wide range of physical, mechanical, and chemical properties. The monomers can be produced pure and addition of impurities or additives can be controlled by design to give optimal properties. Polymerization of pure monomers can be better controlled to give specific desired properties.

In future decades, limitations on the availability of crude oil may force society to change the materials used for production of synthetic rubber. Already, the use of synthetic rubber is diminishing, as Asian countries expand their agricultural production of natural rubber, using cheap labour. Indonesia, China, India and Thailand have replaced Brazil, Malaysia and Burma as the major suppliers of natural rubber.

Research into the use of polymers based on lactic acid derived from crops (wheat, sugar beet) indicates that rubbers based on biopolymers, rather than on petroleum, may be used in future decades.

Question 33 (a) (1 mark)**Outcomes Assessed: H9****Targeted Performance Bands: 3-5**

Criteria	Marks
• Correct equilibrium expression	1

Sample answerFor this equation $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$

$$K = [\text{HI}]^2 / [\text{H}_2] [\text{I}_2]$$

Question 33 (b) (1 mark)**Outcomes Assessed: H9****Targeted Performance Bands: 3-5**

Criteria	Marks
• Correct VALUE (units or derivation of units not necessary not required)	1

Sample answer

$$K = [\text{HI}]^2 / [\text{H}_2] [\text{I}_2] ; K = (0.8)^2 / (1.2) (1.2)$$

$$K = 0.44 \text{ (mol}^2\text{L}^{-2} / \text{mol}^2\text{L}^{-2} = \text{no units)}$$

Question 33 (c) (1 mark)**Outcomes Assessed: H9****Targeted Performance Bands: 3-5**

Criteria	Marks
• Correct answer	1

Sample answer

There is a greater concentration of reactants as indicated in the table of concentration of each species at equilibrium.

Note for future study

If K is large—say greater than 10^3 —then the equilibrium lies well to the right; it favours products.

If K is small—say less than 10^{-3} —then the equilibrium lies well to the left; it favours reactants.

In other words, if K is large, the reaction goes almost to completion, but if K is small the reaction hardly goes at all. If K

Question 34 (a) (1 mark)**Outcomes Assessed:** H1, H4, H8**Targeted Performance Bands:** 3-5

Criteria	Marks
• Correct answer	1

Sample answer

Buffers are equilibrium solutions which contain similar concentrations of moderately weak acids and their conjugate bases (which are moderately weak bases). The conjugate acid/base pair prevents large pH change when small amounts of strong acids or strong bases enter the equilibrium system.

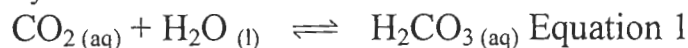
Question 34 (b) (2 mark)**Outcomes Assessed:** H1, H4, H8**Targeted Performance Bands:** 3-5

Criteria	Marks
• Thorough explanation involving equilibrium, with reference to species / equation(s)	2
• Explanation only	1

Sample answer

Blood must remain in the pH range 7.35 – 7.45. The blood contains a carbonic acid / hydrogen carbonate buffer system.

Carbonic acid forms by the reaction of carbon dioxide in water.



The carbonic acid is a weak acid, reacting with water to form hydrogen ions.



High concentration of carbon dioxide in the blood leads to an abnormal medical condition. A healthy person prevents this condition through the carbonic acid / hydrogen carbonate buffer system.

Normally, in a healthy person, the excess hydronium ions react with the hydrogen carbonate ions which are present in the blood in ample amounts, and the reverse reaction of equation 2 reduces the build-up of hydronium ions and prevents the pH dropping too low.

Additional Information for study purposes

(The hydrogen phosphate/dihydrogen phosphate system buffers the kidneys)

The hydrogen carbonate ion/carbonate ion combination in the blood acts as a natural buffer system. The hydrogen phosphate/dihydrogen phosphate system buffers the kidneys, where urine is produced. It is important that the kidney tissue does not get too acidic despite the excretion of an acidic compound. $\text{HPO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{OH}^-(\text{aq}) + \text{H}_2\text{PO}_4^-(\text{aq})$

If small quantities of a strong acid are added to the buffer mixture, the equilibrium shifts to the right. If the mixture were to receive small quantities of a strong base (unlikely), then the equilibrium would shift to the left to absorb this extra OH^- .

Note: the Syllabus dot point states:

- qualitatively describe the effect of buffers with reference to a specific example in a natural system