

2016

TRIAL HSC

EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of the response sheet on page 11 and on the Elective answer booklet.
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided.

Total Marks – 100

Section I Pages 2 – 21

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1– 20
- Allow about 35 minutes for this part

Part B – 55 marks

- Attempt Questions 21 – 31
- Allow about 1 hour and 40 minutes for this part

Section II Page 22

25 marks

- Attempt Question 32
- Allow about 45 minutes for this section

Mark your answers on the ANSWER grid on page 11

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

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9
 A ☐ B ☒ C ☐ D ☐

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ☒ B ☒ C ☐ D ☐

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

A ☒ B ☒ C ☐ D ☐
 correct
 ↙

1. How are radioisotopes prepared in a nuclear reactor?
 - (A) Fusion reactions.
 - (B) Fission reactions.
 - (C) Bombardment with alpha particles.
 - (D) Bombardment with neutrons.

2. What products would result from the catalytic cracking of a 15-carbon alkane?
 - (A) One alkane and one alkene.
 - (B) One alkanoic acid and one alkanol.
 - (C) Two alkanes.
 - (D) Two alkenes.

3. In the petrochemical industry, cellulose has been identified as a potential raw material.

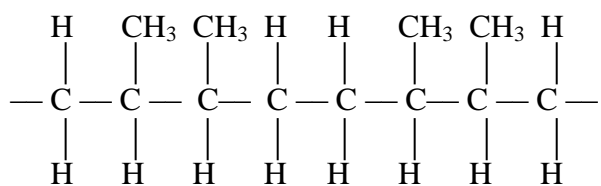
Which of the following statements best justifies this choice of cellulose?

- (A) Cellulose is a major component of biomass.
- (B) There is a need for alternative sources of the compounds obtained from fossil fuels.
- (C) Cellulose contains the basic carbon-chain structures needed to build petrochemical products and comes from renewable sources.
- (D) Cellulose is a condensation polymer produced from glucose, where both reactants and products are naturally occurring materials, so will not increase environmental pollution.

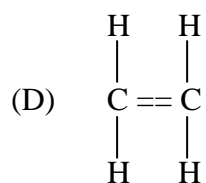
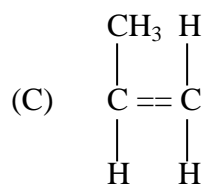
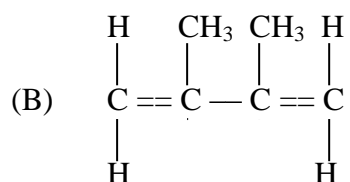
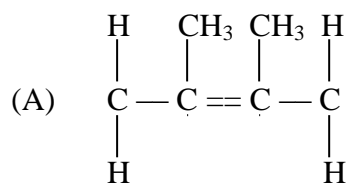
4. What is the catalyst used in the Haber process?

- (A) Vanadium oxide
- (B) Iron oxide
- (C) Zeolite
- (D) Concentrated sulfuric acid

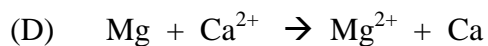
5. A section of a polymer is represented below.



Which monomer can be used to prepare this polymer?



6. Which reaction will occur spontaneously?



7. Ethane undergoes complete combustion in the presence of excess oxygen.

What is the ratio of ethane to oxygen to ensure complete combustion occurs?

(A) 1:1

(B) 1:2

(C) 2:5

(D) 2:7

8. What causes eutrophication in streams?

(A) a decrease in the amount of phosphates and nitrates available.

(B) an increase in the amount of phosphates and nitrates available.

(C) a decrease in the total dissolved oxygen level of the stream.

(D) an increase in the total dissolved oxygen level of the stream.

9. Which of the following ions contributes to heavy metal pollution?

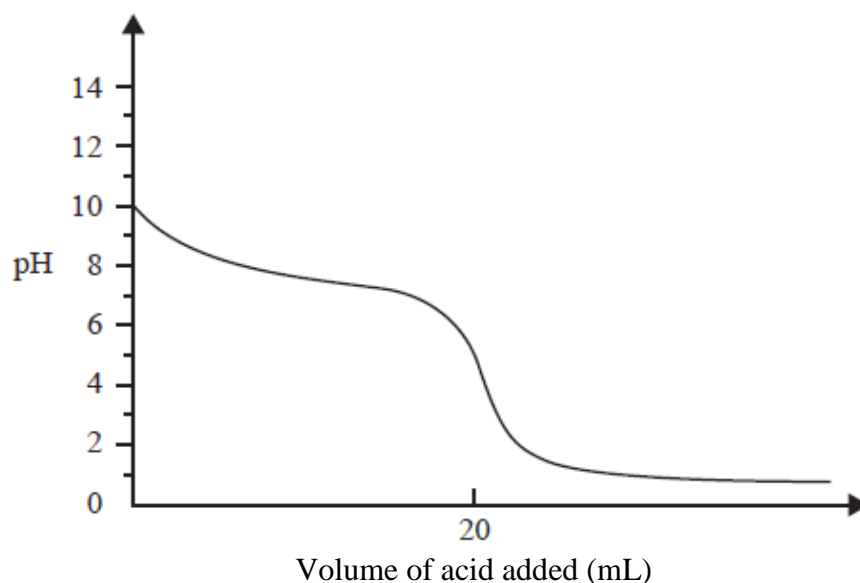
(A) Ca^{2+}

(B) Pb^{2+}

(C) Na^+

(D) Fe^{3+}

10. The following titration curve was obtained by measuring the pH in a reaction flask during an acid-base titration.



Which one of the following is a suitable indicator for this titration?

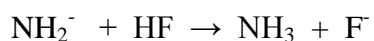
- (A) Methyl orange
 - (B) Universal
 - (C) Phenolphthalein
 - (D) Bromothymol blue
11. Due to the industrial revolution there is a higher proportion of nitrogen monoxide in our atmosphere. Different quantities of nitrogen monoxide are listed below.

Which one contains the least number of molecules of nitrogen monoxide?

- (A) 6×10^2 L at 0°C and 100kPa
- (B) 6×10^{23} molecules
- (C) 6×10^2 g
- (D) 6 mol

12. What happens to the pH of a buffer solution when it is diluted by a factor of 10?
- (A) The buffer pH increases by 1 unit.
 - (B) The buffer pH decreases by 1 unit.
 - (C) The pH does not change significantly.
 - (D) The change in pH depends on the weak acid/base conjugate pair used to prepare the buffer solution.
13. Which statement best explains the solubility of ethanol in 2-methylheptane?
- (A) Ethanol forms dispersion forces with 2-methylheptane.
 - (B) Ethanol forms dipole-dipole forces with 2-methylheptane.
 - (C) Ethanol forms hydrogen bonds with 2-methylheptane.
 - (D) Ethanol and 2-methylheptane are both non-polar.
14. Which of the following does NOT form sulfur dioxide in the atmosphere?
- (A) Decaying organic matter.
 - (B) Burning coal.
 - (C) Breaking down of ozone.
 - (D) Erupting volcanos.

15. Identify a base and its conjugate acid in the following reaction?



	<i>Base</i>	<i>Conjugate acid</i>
(A)	HF	F ⁻
(B)	NH ₂ ⁻	NH ₃
(C)	NH ₃	NH ₂ ⁻
(D)	NH ₂ ⁻	F ⁻

16. What volume of carbon dioxide will be produced if 15.2 g of glucose is fermented at 25 °C and 100 kPa?

- (A) 1.89 L
(B) 2.06 L
(C) 3.78 L
(D) 4.13 L

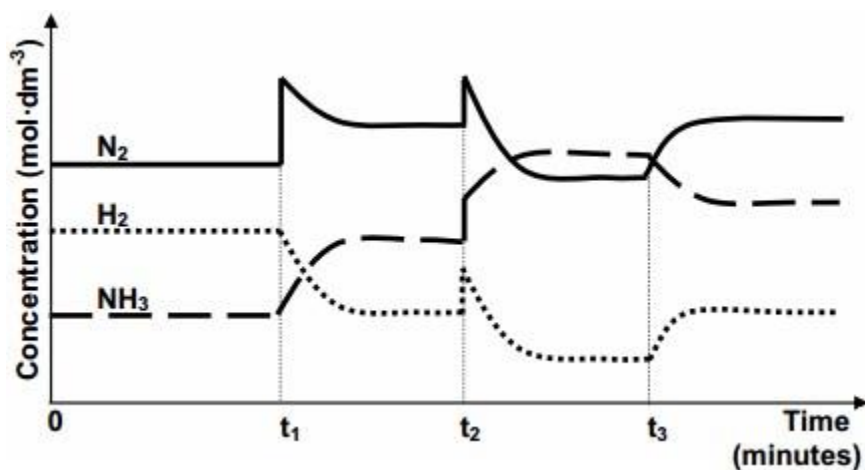
17. Which row shows the correct test result for the ion shown?

	<i>Ion</i>	<i>Test</i>	<i>Result</i>
(A)	barium	add potassium iodide	yellow precipitate forms
(B)	chloride	add calcium nitrate	white precipitate forms
(C)	carbonate	flame test	brick red colour
(D)	copper	flame test	blue/green colour

18. 50.0 mL of a 0.020 mol L^{-1} sodium hydroxide solution was added to 50.0 mL of a 0.040 mol L^{-1} hydrochloric acid solution. The solution was then diluted in a 250.0 mL volumetric flask.

What is the pH of the final solution?

- (A) 0.2
(B) 1.7
(C) 2.4
(D) 6.2
19. The graph shows the changes in concentration of the reactants and products for the equilibrium reaction in the Haber process.



Which option best describes the changes to the conditions at times 1, 2 and 3?

	t_1	t_2	t_3
(A)	Nitrogen is added	Pressure is decreased	Temperature is decreased
(B)	Hydrogen is removed	Pressure is decreased	Temperature is decreased
(C)	Nitrogen is added	Pressure is increased	Temperature is increased
(D)	Hydrogen is removed	Pressure is increased	Temperature is increased

20. During the tests for biochemical oxygen demand (BOD), a sample of water is kept in the dark for 5 days before being tested for its dissolved oxygen levels.

What is the purpose of keeping the sample in the dark?

- (A) To prevent photosynthesis occurring and adding oxygen to the water.
- (B) To prevent photosynthesis occurring and removing oxygen from the water.
- (C) To prevent respiration occurring and adding oxygen to the water.
- (D) To prevent respiration occurring and removing oxygen from the water.

Student Number

Mark.....

Section I Part A

Multiple Choice Answer Sheet

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|-----|-------------------------|-------------------------|-------------------------|-------------------------|
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| 18. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |
| 19. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |
| 20. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |

Part B. 55 marks

Attempt questions 21 - 31

Allow about 1 hour and 40 minutes for this part

► *Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response*

► *Show all relevant working in questions involving calculations*

Question 21 (2 marks)

Marks

Element 112 copernicium, was first synthesised in 1996.

- (a) What is the term used to describe elements occurring after element 92 in the Periodic Table? **1**

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- (b) Is element 112 stable? Suggest a reason for your answer. **1**

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Question 22 (3 marks)

Account for THREE conditions necessary for the fermentation of glucose. **3**

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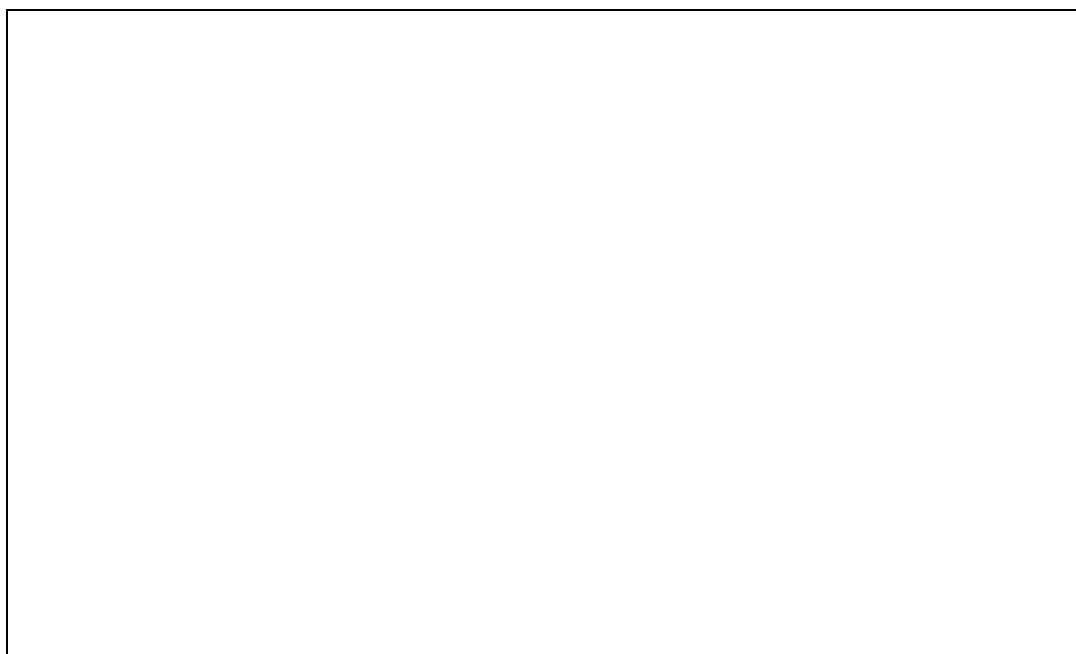
Question 23 (8 marks)

A student performed a first-hand investigation to measure the difference in potential of various combinations of metals in electrolytes. He tested manganese, iron and tin and three electrolyte solutions manganese nitrate, iron(II) nitrate and tin(II)nitrate.

- (a) Which metals tested would give the highest potential difference. **1**
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- (b) Draw and label an experimental set-up with the combination of metals identified in part(a).

Identify the anode, cathode and the direction of electron flow on the diagram. **5**



- (c) Write a net ionic equation for the reaction of the metals identified in part (a) **1**
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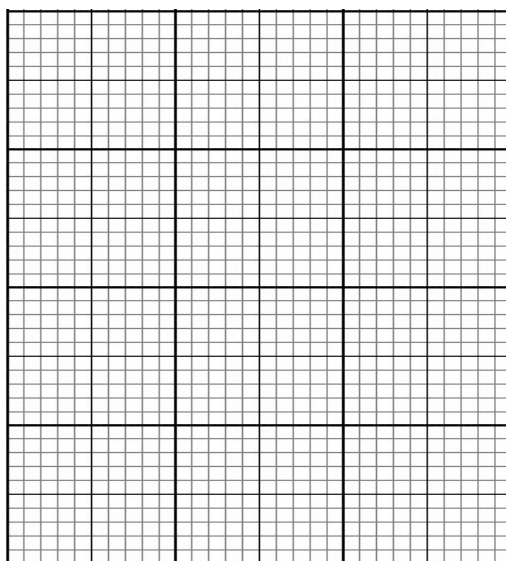
- (d) Calculate the net potential difference for the reaction in part (a) **1**
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Question 24 (7 marks)

The table below contains calibration data from an atomic absorption spectrometer used for detecting mercury.

Concentration of mercury (ppm)	Absorbance
0.0	0.00
1.0	0.12
2.0	0.26
3.0	0.38
4.0	0.50
5.0	0.65

- (a) Plot a graph of the data on the grid below and draw a line of best fit

4

- (b) A 5.0 mL river water sample was tested for mercury and the absorbance measured was 0.45.

Calculate the mass of mercury in the river water sample tested.

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Question 25 (4 marks)

In your study of chemistry, you used computer simulations, molecular model kits or multimedia resources to model chemical processes.

Discuss a model you used to demonstrate the polymerisation of ethylene. **4**

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Question 26 (4 marks)

Justify the use of sodium hydrogen carbonate to minimise damage from acid spills. **4**

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Question 27 (6 marks)

Volumetric analysis can be used to determine the concentration of citric acid in lemon juice.

25.00 mL of lemon juice was extracted then diluted to 250.0 mL with demineralized water.

25.00 mL aliquots of this solution were titrated with $0.1013 \text{ mol L}^{-1}$ sodium hydroxide solution. The results are given below.

Trial number	Titre (mL)
1	25.15
2	24.85
3	24.95
4	24.90

Assume that the lemon juice contains only citric acid.

Calculate the concentration of citric acid in the undiluted lemon juice.

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Question 28 (5 marks)

Explain the use of the two acids involved in the production of butyl ethanoate .

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Question 29 (6 marks)

Since the start of the industrial age, most of the energy used by humans has come from the burning of coal and oil. In that time the amount of CO₂ in the air has increased from 0.42% by mass to 0.58% by mass.

- (a) Assume that the total mass of the Earth's atmosphere is 5.15×10^{18} kg.

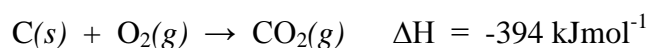
Calculate the additional mass of CO₂, in kg, that has been added to the Earth's atmosphere, by the burning of coal and oil, since the start of the industrial age. **1**

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- (b) If half of this additional CO₂ has come from the burning of coal, calculate the total amount of energy, in kJ, that has been produced by burning all this coal, given that



For the purposes of this calculation, assume that coal is pure carbon. **2**

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- (c) Explain the formation, and ONE effect of acid rain caused by an increase in carbon dioxide in the atmosphere. **3**

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Question 30 (5 marks)

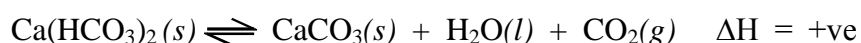
Water is a natural resource. Drinking water in some regions of Australia is soft, but in other regions, drinking water is hard because of the limestone blended within ground soils.

There are two types of hard water, permanent hard water and temporary hard water.

Permanent hard water can be caused by calcium ions dissolved in the water.

Temporary hard water can be caused by calcium hydrogen carbonate dissolved in the water.

Temporary hard water causes the formation of ‘limescale’, a deposit of calcium carbonate, on heating elements that can be found in kettles.



a new heating element



a heating element with ‘limescale’ deposit

- (a) Explain how ‘limescale’ forms on heating elements in kettles.

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- (b) Outline how the addition of sodium carbonate could ‘soften’ permanent hard water. Give an equation to support your answer.

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Question 31 (5 marks)

The population in an industrial town near Lake Nakuru in Kenya has become bigger since 1996. One effect of this is an increase in the volume of sewage that flows into Lake Nakuru.

Explain how this sewage pollution might affect the organisms in the lake.

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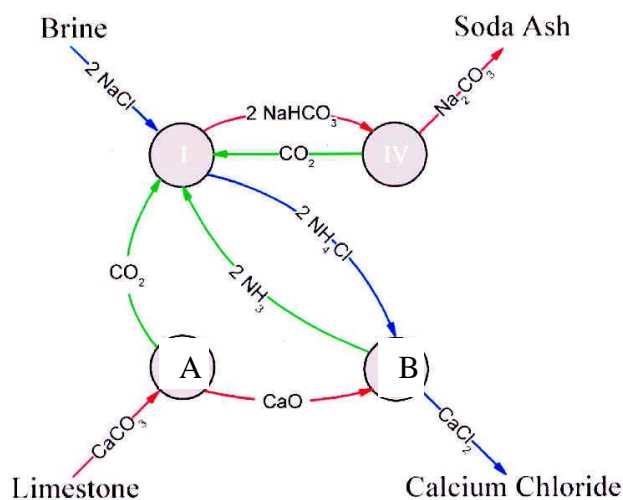
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End of Part B

Question 32 – Industrial Chemistry (25 marks) (a) – (e)**Marks**

- (a) The diagram shows the Solvay process used in the production of sodium carbonate (soda ash).



- (i) Outline one use of sodium carbonate. **1**
- (ii) Write an equation for the production of sodium carbonate from raw materials. **1**
- (iii) Explain the relationship between steps A and B on the diagram. **3**
- (b) 0.020 mol of colourless phosphorous pentachloride gas was placed in a 2.0 L evacuated flask and was heated to 800°C . The gas decomposed forming colourless phosphorous trichloride gas and green chlorine gas. The concentration of the chlorine gas was found to be $8.0 \times 10^{-3} \text{ mol L}^{-1}$ at equilibrium.
- (i) Give an expression for the equilibrium constant. **1**
- (ii) Calculate the equilibrium constant for this reaction at 800°C . **3**
- (iii) When the temperature is increased to 1000°C , the colour of the gas mixture intensifies. Identify the forward reaction as exothermic or endothermic and explain the effect of this change on the equilibrium constant. **2**
- (c) Justify the industrial conditions used to produce sulfuric acid from sulfur dioxide. **7**
- (d) Analyse the changes made to anionic detergents in response to their impacts on the environment. **4**
- (e) Explain the different products formed in the electrolysis of dilute and molten sodium chloride. **3**

Part B extra writing space

If you use this space, clearly indicate which question you are answering.

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End of exam

Trial Chemistry answers 2016

Multiple Choice Answer Sheet

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| 18. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 19. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 20. | A <input checked="" type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |

1. How are radioisotopes prepared in a nuclear reactor?

- (A) fusion reactions
- (B) fission reactions
- (C) bombardment with alpha particles
- (D) bombardment with neutrons**

Outcomes: H3

2. What products would result from the catalytic cracking of a 15-carbon alkane?

- (A) One alkane and one alkene**
- (B) One alkanoic acid and one alkanol
- (C) Two alkanes
- (D) Two alkenes

Outcomes: H6, H9

3. In the petrochemical industry, cellulose has been identified as a potential raw material. Which of the following statements best justifies this choice of cellulose?

- (A) Cellulose is a major component of biomass.
- (B) There is a need for alternative sources of the compounds obtained from fossil fuels.
- (C) Cellulose contains the basic carbon-chain structures needed to build petrochemical products and comes from renewable sources.**
- (D) Cellulose is a condensation polymer produced from glucose, where both reactants and products are naturally occurring materials, so will not increase environmental pollution.

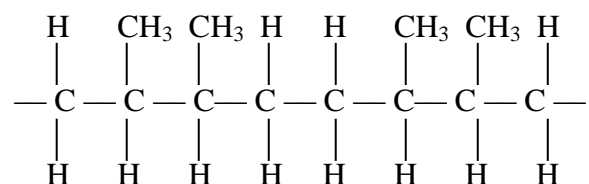
Outcomes: H1, H5

4. What is the catalyst used in the Haber process?

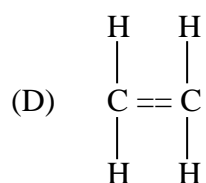
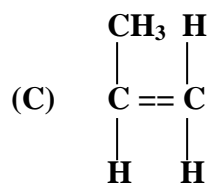
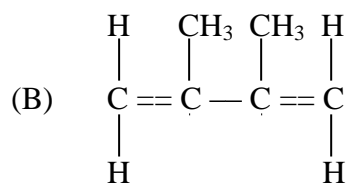
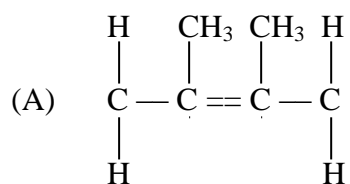
- (A) vanadium oxide
- (B) activated iron oxide**
- (C) zeolite
- (D) concentrated sulfuric acid

Outcomes:H8

5. A section of a polymer is represented below.

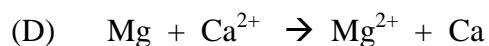
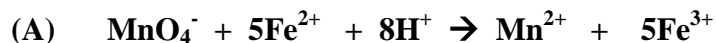


Which monomer can be used to prepare this polymer?



Outcomes: H6, H9

6. Which reaction will occur spontaneously?



Outcomes: H7, H8

7. Ethane undergoes complete combustion in the presence of excess oxygen.

What is the ratio of ethane to oxygen to ensure complete combustion occurs?

(A) 1:1

(B) 1:2

(C) 2:5

(D) 2:7

Outcomes: H10, H9

8. What causes eutrophication in streams?

(A) a decrease in the amount of phosphorus and nitrogenous nutrients available.

(B) **an increase in the amount of phosphorus and nitrogenous nutrients available.**

(C) a decrease in the total dissolved oxygen level of the stream.

(D) an increase in the total dissolved oxygen level of the stream.

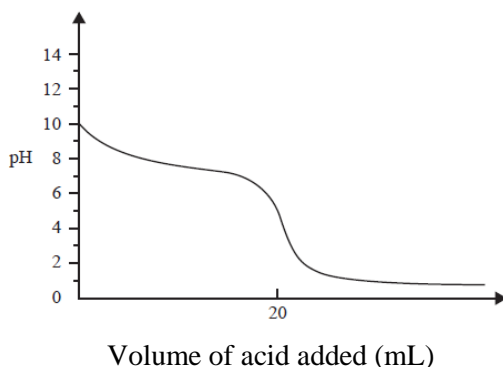
Outcomes: H4

9. Which of the following ions contributes to heavy metal pollution?

- (A) Ca^{2+}
- (B) **Pb^{2+}**
- (C) Na^{+}
- (D) Fe^{3+}

Outcomes: H4

10. The following titration curve was obtained by measuring the pH in a reaction flask during an acid-base titration.



Which one of the following is a suitable indicator for use in this titration?

- (A) **methyl orange**
- (B) universal
- (C) phenolphthalein
- (D) bromothymol blue

Outcomes: H8

11. Due to the industrial revolution there is a higher proportion of nitrogen monoxide in our atmosphere. Different quantities of nitrogen monoxide are listed below.

Which one contains the least number of molecules of nitrogen monoxide?

- (A) 6×10^2 L at 0°C and 100kPa
- (B) **6×10^{23} molecules**
- (C) 6×10^2 g
- (D) 6 mol

Outcomes: H10

12. What happens to the pH of a buffer solution when it is diluted by a factor of 10?
- (A) The buffer pH increases by 1 unit.
 - (B) The buffer pH decreases by 1 unit.
 - (C) **The pH does not change significantly.**
 - (D) The change in pH depends on the weak acid/base conjugate pair used to prepare the buffer solution.

Outcomes: H10

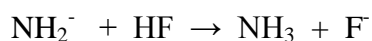
13. Which statement best explains the solubility of ethanol in 2-methylheptane?
- (A) **Ethanol forms dispersion forces with 2-methylheptane.**
 - (B) Ethanol forms dipole-dipole forces with 2-methylheptane.
 - (C) Ethanol forms hydrogen bonds with 2-methylheptane.
 - (D) Ethanol and 2-methylheptane are both non-polar.

Outcomes: H4

14. Which of the following does not form sulfur dioxide in the atmosphere?
- (A) Decaying organic matter
 - (B) The burning of coal
 - (C) **Breaking down of ozone**
 - (D) Erupting volcanos

Outcomes: H4

15. Identify a base and its conjugate acid in the following reaction.



	<i>Base</i>	<i>Conjugate acid</i>
(A)	HF	F ⁻
(B)	NH₂⁻	NH₃
(C)	NH ₃	NH ₂ ⁻
(D)	NH ₂ ⁻	F ⁻

Outcomes:, H9

16. What volume of carbon dioxide will be produced if 15.2 g of glucose is fermented at 25 °C and 100 kPa?
- (A) 1.89 L
- (B) 2.06 L
- (C) 3.78 L
- (D) 4.18 L**

Outcomes:H10, H9

17. Which row shows the correct test result for the ion shown?

	<i>Ion</i>	<i>Test</i>	<i>Result</i>
(A)	barium	add potassium iodide	yellow precipitate forms
(B)	chloride	add calcium nitrate	white precipitate forms
(C)	carbonate	flame test	brick red colour
(D)	copper	flame test	blue/green colour

Outcomes:H8

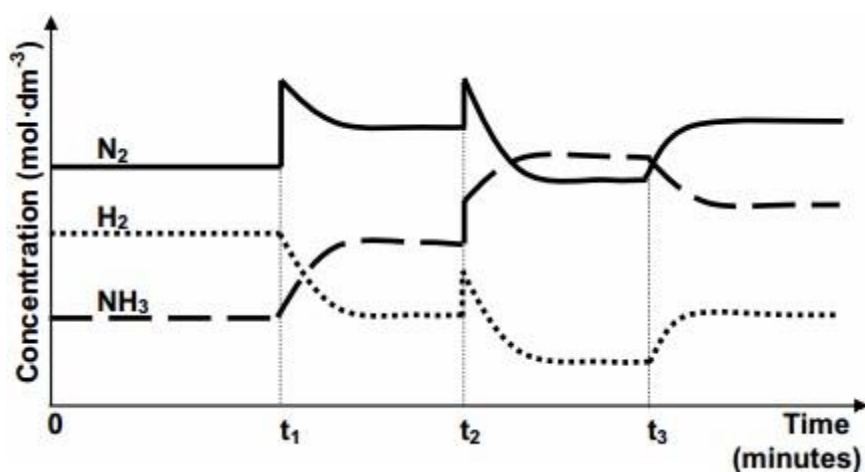
18. 50.0 mL of a 0.020 mol L^{-1} sodium hydroxide solution was added to 50.0 mL of a 0.040 mol L^{-1} hydrochloric acid solution. The solution was then diluted in a 250.0 mL volumetric flask.

What is the pH of the final solution?

- (A) 0.2
(B) 1.7
(C) 2.4
(D) 6.2

Outcomes:H8

19. The graph shows the changes in concentration of the reactants and products for the equilibrium reaction in the Haber process.



Which option best describes the changes to the conditions at times 1, 2 and 3?

	t_1	t_2	t_3
(A)	Nitrogen is added	Pressure is decreased	Temperature is decreased
(B)	Hydrogen is removed	Pressure is decreased	Temperature is decreased
(C)	Nitrogen is added	Pressure is increased	Temperature is increased
(D)	Hydrogen is removed	Pressure is increased	Temperature is increased

Outcomes:H8

20. During the tests for biochemical oxygen demand (BOD), a sample of water is kept in the dark for 5 days before being tested for its dissolved oxygen levels. What is the purpose of keeping the sample in the dark?
- (A) To prevent photosynthesis occurring and adding oxygen to the water.
 - (B) To prevent photosynthesis occurring and removing oxygen from the water.
 - (C) To prevent respiration occurring and adding oxygen to the water.
 - (D) To prevent respiration occurring and removing oxygen from the water.

Outcomes:H4

Question 21 (3 marks)

Marks

Element 112 copernicium, was first synthesised in 1996.

- (a) What is the term used to describe elements occurring after element 92 in the Periodic Table? **1**
- (b) Is element 112 stable? Suggest **a reason** for your answer. **1**

(a) transuranic element

(b) Unstable as it has a very heavy nucleus with very high proton to neutron ratio thus will be energetically stable if it emits radioactive particles and energy.

Marking Criteria	Marks
(a) identify correct term	1
(b) Correct identification and reason	1

Outcomes:H6

Question 22 (3 marks)

Account for THREE conditions necessary for the fermentation of glucose. **3**

- *alcohol-tolerant yeast (Saccharomyces ellipsoideus) used as a biological catalyst.*
- *pH: 3.7–4.6 (low pH prevents pathogens from growing)*
- *temperature: ~37°C (rapid bulk fermentation of sugars derived from molasses or grainstarch) too low and the reaction is slow, too high and the yeast will cease to function*
- *anaerobic conditions (closed vessels; absence of air) to prevent oxidation of the ethanol to ethanoic acid*

<i>Marking Criteria</i>	<i>Marks</i>
Correctly accounts for THREE conditions necessary for successful fermentation	3
Correctly accounts for at least ONE conditions necessary for successful fermentation OR Identifies three conditions	2
Identifies at least one condition	1

Outcomes:H9, H7, H8

Question 23 (8 marks) **Outcomes:H7, H11**

A student performed a first-hand investigation to measure the difference in potential of various combinations of metals in electrolytes. He tested manganese, iron and tin and three electrolyte solutions manganese nitrate, iron(II) nitrate and tin(II)nitrate.

- (a) Which metals tested would give the highest potential difference. **1**

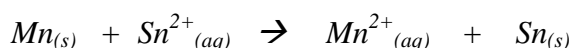
manganese and tin

- (b) Draw and label an experimental set-up with the combination of metals identified in part(a). **5**

Identify the anode, cathode and the direction of electron flow on the diagram.

One half-cell with manganese electrode labelled anode in manganese nitrate solution and other half-cell with tin electrode labelled cathode in tin nitrate solution ; salt bridge connecting 2 half-cells and connecting wire between 2 electrodes with a voltmeter to measure potential difference; direction of electron flow from manganese to tin labelled.

- (c) Write a net ionic equation for the reaction of the metals identified in part (a) **1**



- (d) Calculate the net potential difference for the reaction in part (a) **1**

$$1.18 \text{ V} + (-0.14\text{V}) = 1.04 \text{ V}$$

<i>Marking Criteria</i>	<i>Marks</i>
(a) Correct identification of metals	1
(b) Correct labelled diagram showing all components	5
One component incorrect or missing	4
Two components incorrect or missing	3
Three components incorrect or missing	2
Four components incorrect or missing	1
(c) Correct balanced net ionic equation with states	1
(d) Correct calculation of net potential showing working	1

Question 24 (7 marks) **Outcomes:**H4,H10

The table below contains calibration data from an atomic absorption spectrometer used for detecting mercury.

Concentration of mercury (ppm)	Absorbance
0.0	0.00
1.0	0.12
2.0	0.26
3.0	0.38
4.0	0.50
5.0	0.65

(a) Plot a graph of the data on the grid below. Draw a line of best fit.

4

(a) *correct labels and scales for axes and appropriate plotted points and line of best fit .*

<i>Marking Criteria</i>	<i>Marks</i>
Correctly completed graph with labelled scales and axes	4
One error in graph	3
Two errors in graph	2
Three errors in graph	1

(b) A 5.0 mL river water sample was tested for mercury and the absorbance measured was 0.45. Calculate the mass of mercury in the river water sample.

3

The absorbance reading from the graph gives a concentration of 3.5 ppm

$$3.5 \text{ ppm} = 3.5 \text{ mgL}^{-1} = 3.5 \times 10^{-3} \text{ g L}^{-1}$$

$$3.5 \times 10^{-3} \text{ g in } 1000 \text{ mL}$$

$$x \text{ g in } 5 \text{ mL}$$

$$x = 5 \times 3.5 \times 10^{-3} / 1000 = 0.018 \times 10^{-5} \text{ g}$$

<i>Marking Criteria</i>	<i>Mark(s)</i>
• Correct calculation showing all relevant working	3
• Shows some calculation	2
• Shows a basic understanding of the chemistry	1

Question 25 (4 marks)

In your study of chemistry, you used computer simulations, molecular model kits or multimedia resources to model chemical processes.

Discuss a model you used to demonstrate the polymerisation of ethylene.

4

Plastic balls of different colours depicting different elements were joined together by rigid or flexible plastic sticks.

Initiation

The bond between the two oxygens of a hydrogen peroxide molecule was broken (resulting in two radicals), and one of the sticks in an ethene molecule was removed. These two molecules were connected by using a stick to join the oxygen atom from one half of the hydrogen peroxide molecule to one of the carbon atoms in the ethene molecule. Hence form a longer molecular radical.

Propagation

The molecular radical was then joined to more ethene molecules by removing one of the sticks in the ethene molecules, and using the stick to join one carbon atom with another carbon atom, until you achieve a chain.

Both Initiation and Propagation steps were repeated to form another similar chain.

Termination

The two chains were joined together by removing one of the sticks from one of the carbons, and using only one stick to join the two carbon ends.

Molymods

<i>Advantage</i>	<i>Limitation</i>
<ul style="list-style-type: none"><i>This resource enabled students to demonstrate the breaking of double bonds within each monomer, then the formation of single bonds between each monomer.</i><i>The model showed that in the polymerisation process there is no gain or loss of atoms, the whole monomer becomes a part of the polymer (Addition polymerisation).</i>	<ul style="list-style-type: none"><i>There was difficulty in illustrating the transfer of a lone electron or the radical component of the molecules.</i><i>Does not illustrate the extent of polymer chain lengths.</i>

Flash video (.flv) file

<i>Advantage</i>	<i>Limitation</i>
<ul style="list-style-type: none">• The file illustrated clearly the breaking of double bonds within each monomer, then the formation of single bonds between each monomer.• The video also showed the transfer of a lone electron by showing where the radical component is in the molecule.	<ul style="list-style-type: none">• The video did not clearly show the conservation of matter (where there is the same number of atoms before and after polymerisation occurs), because a new monomer 'appears' once the previous monomer is bonded.• The video also did not show the termination step.

Both models are useful in developing conceptual understanding of additional polymerisation of ethylene.

<i>Marking Criteria</i>	<i>Marks</i>
<ul style="list-style-type: none">• Describes the model clearly.• Identify that it is an addition polymerisation/ the product is polyethene.• States an advantage• AND limitation.	4
<ul style="list-style-type: none">• The answer includes THREE of the above points.	3
<ul style="list-style-type: none">• Describes the model clearly.• Identify that it is an addition polymerisation/ the product is polyethene. OR <ul style="list-style-type: none">• States an advantage AND limitation. OR <ul style="list-style-type: none">• A COMBINATION OF THE TWO.	2
<ul style="list-style-type: none">• Describes the model clearly. OR <ul style="list-style-type: none">• Identify that it is an addition polymerisation/ the product is polyethene. OR <ul style="list-style-type: none">• State an advantage/ limitation.	1

Outcomes: H2, H9

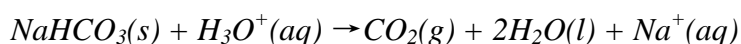
Question 26 (4 marks) **Outcomes: H7**

Justify the use of sodium hydrogen carbonate to minimise damage from acid spills.

MUST INCLUDE:

Neutralisation reactions are exothermic reactions and have the potential to release large amounts of heat, burning the surface where the spill is. Weak bases produce less heat, although the addition of water will also help disperse the heat produced.

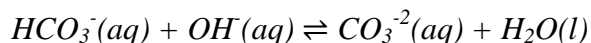
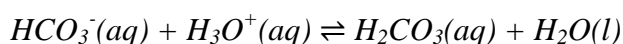
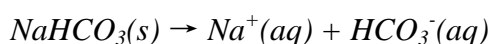
NaHCO₃ is a weak base hence if used will reduce further damage/harm from the acid.



Sodium hydrogen carbonate also comes as a solid powder which will not add to the acid spills when used, rather help absorb the spill.

Additional:

NaHCO₃ is also an amphiprotic substance (shown in the equations below) which will form a buffer, so this substance can be used in excess.



The reaction of carbonates and acids produces carbon dioxide gas which can be used as an indicator for the progression of neutralisation. When there are no longer any bubbles forming, then it is a good approximation that the reaction is close to complete neutralisation.

Hence NaHCO₃ is very effective in neutralising acids spills with minimal damage/harm.

Marking Criteria	Mark(s)
<ul style="list-style-type: none">Provides a thorough justification for the use of sodium hydrogen carbonate in minimising the damage from acid spills.Gives at least one relevant balanced equation	4
<ul style="list-style-type: none">Provides a thorough justification for the use of sodium hydrogen carbonate in minimising the damage from acid spills. ORProvides a thorough explanation of the use of sodium hydrogen carbonate in minimising the damage from acid spills.Gives at least one relevant balanced equation.	3
<ul style="list-style-type: none">Outlines the use of sodium hydrogen carbonate in minimising the damage from acid spills.	2
<ul style="list-style-type: none">Demonstrates a limited knowledge of the use of sodium hydrogen carbonate in minimising the damage from acid spills	1

Question 27 (6 marks)

Volumetric analysis can be used to determine the concentration of citric acid in lemon juice.

25.00 mL of lemon juice was extracted then diluted to 250.0 mL with demineralized water.

25.00 mL aliquots of this solution were titrated with $0.1013 \text{ mol L}^{-1}$ sodium hydroxide solution. The results are given below.

Trial number	Titre (mL)
1	25.15
2	24.85
3	24.95
4	24.90

Assume that the lemon juice contains only citric acid.

Calculate the concentration of citric acid in the undiluted lemon juice.

6

Average titre = $24.85 + 24.95 + 24.90 = 24.90 \text{ mL}$ (1 mark)

$3\text{NaOH} + \text{citric acid} \rightarrow \text{sodium citrate} + 3 \text{H}_2\text{O}$

$\text{mol NaOH} = c \times V = 0.1013 \times 0.02490 = 2.522 \times 10^{-3}$ (1 mark)

$\text{mol citric acid is } 1/3 \text{ the moles of sodium hydroxide} = 2.522 \times 10^{-3} / 3 = 8.4079 \times 10^{-4}$

in the diluted solution. (1 mark recognising 3: 1 ratio)

$[\text{citric acid}]_{\text{diluted}} = \text{mol}/v = 8.4079 \times 10^{-4} / 0.02500 = 0.03363$ (1 mark)

$[\text{citric acid}]_{\text{lemon juice}} = 0.03363 \times 10 = 0.3363 \text{ mol L}^{-1}$ (2 marks with correct sig figs)

Marking criteria	Marks
<ul style="list-style-type: none"> Shows all relevant working and gives final answer in 4 significant figures 	6

Outcomes:H10,H9

Question 28 (5 marks)

Explain the use of the two acids involved in the production of butyl ethanoate

5

Concentrated sulfuric acid(H_2SO_4) and ethanoic acid (CH_3COOH)are used to produce the ester butyl ethanoate.

The ethanoic acid is the organic acid used to prepare the ester as an ester is made from the combination of an alkanol and an alkanoic acid.

Butanol + ethanoic acid \rightleftharpoons butyl ethanoate + water

The concentrated sulfuric acid is used as a catalyst to speed up the reaction by lowering the activation energy, as esterification is slow to come to equilibrium.

- ***Describe the purpose of using acid in esterification for catalysis***

<i>Marking Criteria</i>	<i>Mark(s)</i>
<ul style="list-style-type: none">• Correctly identifies the two acids as concentrated sulfuric acid and ethanoic acid.• Explains the use of ethanoic acid as a component of esters• Explains the use of sulfuric acid as a catalyst and its purpose• Shows some chemistry (relevant equation or formulae written)	5
<ul style="list-style-type: none">• Correctly identifies the two acids as concentrated sulfuric acid and ethanoic acid.• Explains the use of both of the acids in esterification OR• Correctly identifies the two acids as concentrated sulfuric acid and ethanoic acid.• Explains the use of one and outlines the other OR• Outlines the use of the two identified acids and shows some relevant chemistry	4
<ul style="list-style-type: none">• Correctly identifies one acid and explains its use AND• Outlines the use of the other acid.OR• Correctly identifies one acid and explains its use AND• Gives some relevant chemistry	3
<ul style="list-style-type: none">• Correctly identifies one acid and explains its use OR• Identifies the two acids	2
<ul style="list-style-type: none">• Identifies butyl ethanoate as an ester OR• Correctly identifies one acid	1

JS, JE, C, I, I

Question 29 (6 marks)

Since the start of the industrial age, most of the energy used by humans has come from the burning of coal and oil. In that time the amount of CO₂ in the air has increased from approximately 0.42% by mass to 0.58% by mass.

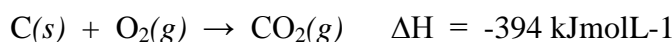
- (a) Assume that the total mass of the Earth's atmosphere is 5.15×10^{18} kg.

Calculate the additional mass of CO₂, in kg, that has been added to the Earth's atmosphere, by the burning of coal and oil, since the start of the industrial age. **1**

$$\begin{aligned} m(\text{CO}_2) &= [(0.58 - 0.42) / 100] \times 5.15 \times 10^{18} \\ &= 8.24 \times 10^{15} \text{ kg} \end{aligned}$$

Marking Criteria	Mark
Correctly calculates the mass of carbon dioxide produced	1

- (b) If half of this additional CO₂ has come from the burning of coal, calculate the total amount of energy, in kJ, that has been produced by burning all this coal, given that



For the purposes of this calculation, assume that coal is pure carbon. **2**

$$\begin{aligned} n(\text{CO}_2) &= 8.24 \times 10^{15} / 2 \\ &= 4.12 \times 10^{15} \times 10^3 / 44.01 \\ &= 9.4 \times 10^{16} \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Energy produced} &= 9.4 \times 10^{16} \times 394 \\ &= 3.68 \times 10^{19} \text{ (kJ)} / 3.7 \times 10^{19} \text{ (kJ)} \end{aligned}$$

Marking Criteria	Marks
Correctly calculates the number of moles released AND the amount of energy released	2
Correctly calculates the number of moles released OR the amount of energy released if error carried forward	1

- (c) Explain the formation, and ONE effect of acid rain caused by an increase in carbon dioxide in the atmosphere. **3**

Sample answer

Acid rain forms when carbon dioxide dissolves in water in the atmosphere.

CO_{2(g)} + H₂O_(l) ⇌ H₂CO_{3(aq)} This acid rain can cause damage to buildings made from limestone.

Then, H₂CO₃ + H₂O_(l) ⇌ H₂CO_{3(aq)} + H₃O⁺_(aq) when it releases hydronium ions into the environment

The calcium carbonate is dissolved by the acid, eroding the structure.

<i>Marking Criteria</i>	<i>Marks</i>
Gives the correct balanced equation for the formation of carbonic acid Explains the formation of acid rain Explains one effect of acid rain caused by increased CO ₂ levels	3
Explains the formation of acid rain caused by an increase in CO ₂ Describes one effect of acid rain caused by increased CO ₂ levels	2
Gives some relevant information about aid rain	1

Outcomes:H9, H10

Question 30 (5 marks) **Outcomes:**H9, H8

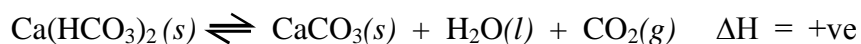
Water is a natural resource. Drinking water in some regions of Australia is soft, but in other regions, drinking water is hard because of the limestone blended within ground soils.

There are two types of hard water, permanent hard water and temporary hard water.

Permanent hard water can be caused by calcium ions dissolved in the water.

Temporary hard water can be caused by calcium hydrogen carbonate dissolved in the water.

Temporary hard water causes the formation of ‘limescale’, a deposit of calcium carbonate, on heating elements that can be found in kettles.



a new heating element



a heating element with ‘limescale’ deposit

(a) Explain how ‘limescale’ forms on heating elements in kettles.

2

On heating, the calcium hydrogen carbonate decomposes to form increased levels of the insoluble CaCO₃ as it is in an equilibrium reaction which shifts to the left.

The reaction which is endothermic in the forward direction. Heating the water forces the equilibrium to move to the right to minimise the temperature change disturbance, as per Le Chatelier’s Principle.

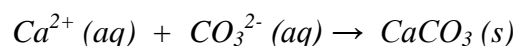
<i>Marking Criteria</i>	<i>Marks</i>
Identifies the solid precipitate by name formed AND why there is a movement in the equilibrium position to the left ‘endothermic’	2
ONE correct entry level response	1

- (b) Outline how the addition of sodium carbonate could 'soften' permanent hard water.
Give an equation to support your answer. **3**

The sodium carbonate / carbonate ions react with calcium / magnesium ions, forming a precipitate of calcium carbonate / magnesium carbonate.

The precipitate will then sink to the bottom and is easily filtered from the water

Therefore the water is softened because this removes the calcium / magnesium ions, which cause hardness, from the water now allowing it to readily lather up with soap.



<i>Marking criteria</i>	<i>Marks</i>
Correctly identifies the carbonate ions will form a ppt with the Ca ions AND explains how the water is softened by the removal of these two 2^+ ions Gives a correct balanced equation with correct states	3
Correctly identifies the carbonate ions will form a ppt with the Ca ions AND explains how the water is softened by the removal of these two 2^+ ions Gives a balanced equation	2
Correctly identifies the carbonate ions will form a ppt with the Ca ions OR e explains how the water is softened by the removal of these two 2^+ ions OR gives an equation	1

Question 31 (5 marks)

An industrial town near Lake Nakuru in Kenya human population has become bigger since 1996. One effect of this is an increase in the volume of sewage that flows into Lake Nakuru.

Explain how this sewage pollution might affect the organisms in the lake.

5

ANSWER: TWO or more clear causes of pollution and THREE or more related problems that link in sequence associated with the increased sewage associated with a larger population size

Causes:

- i. Increase in organic matter / effluent run-off from increased human waste from increased human population
- ii. Increase in turbidity / TSS
- iii. Increase in dissolved nutrients (phosphates and nitrates) / TDS – need to be specific

Problems:

- i. Increases the BOD as microorganisms need to use more O₂ to breakdown the increase organic matter
Lead to decrease in DO
Lead to increased distress of aquatic fauna decreasing survival rates due to lack of oxygen
Lead to decrease in biodiversity of organisms that cannot cope with reduced DO levels in the lake
- ii. Decrease in light intensity reaching flora in the lake environment
Lead to a decrease in photosynthetic rate
Lead to a decrease in DO
Lead to increased distress of aquatic fauna to obtain oxygen for survival
Lead to decrease in biodiversity of organisms that cannot cope with reduced DO levels in the lake
OR
Lead to an increase in plants at the bottom of the lake die and start to decompose
The decomposers will then use further DO in the water
Lead to the water becoming anoxic
Lead to increased distress of aquatic fauna to obtain oxygen for survival
Lead to decrease in biodiversity of organisms that cannot cope with reduced DO levels in the lake
- iii. this can cause an algal bloom and
Lead to eutrophication of the lake because
Algae will block the sunlight from the plants at the bottom of the lake/river
the plants at the bottom cannot photosynthesise
the plants on the bottom die and start to decompose
decomposers respire while decomposing the dead plants
the decomposers use the oxygen in the water
the water becomes anoxic
aquatic organisms such as fish will die
due to lack of oxygen

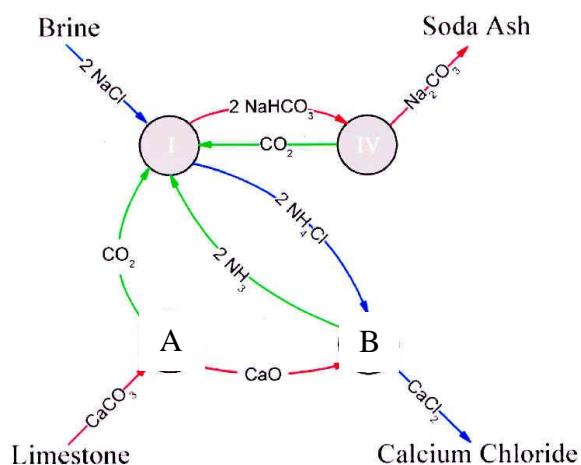
Marking Criteria	Mark(s)
<ul style="list-style-type: none"> • a detailed explanation including TWO or more statements of new causes due to an increased population • a detailed explanation of THREE or more of the associated problems that arise from increased sewage into the system from an increased human population • the steps are identified AND are in a sequential order • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately 	5
<ul style="list-style-type: none"> • a simple explanation including TWO or more statements of new causes that have arisen due to an increased human population • some of the steps will be missing OR not in a sequential order but lack depth • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately 	3/4
<ul style="list-style-type: none"> • a limited explanation including one statement of how eutrophication occurs or the problems of eutrophication • the answer communicates ideas using simple language and uses limited scientific terminology 	2
<ul style="list-style-type: none"> • provides entry level statement related to the increase in sewage on the lake 	

Outcomes: H4, H7, H8

Question 32 – Industrial Chemistry (25 marks) (a) – (e)

Marks

- (a) The diagram shows the Solvay process used in the production of sodium carbonate (soda ash).



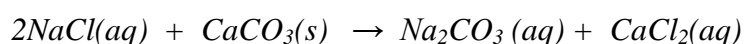
- (i) Outline one use of sodium carbonate. 1

Sodium carbonate is used in glassmaking. It reduces the melting point of sand that is the major component of glass.

Marking Criteria	Mark
<ul style="list-style-type: none"> Outlines a use of sodium carbonate (more than identify) 	1

Outcomes: H4

- (ii) Write an equation for the production of sodium carbonate from raw materials. 1

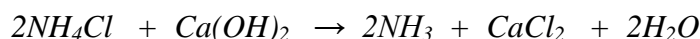


Marking Criteria	Mark
<ul style="list-style-type: none"> Correct balanced equation (no states required) 	1

Outcomes: H10

- (iii) Explain the relationship between steps A and B on the diagram. 3

Step A is the decomposition of limestone to make carbon dioxide for the solvay tower and calcium oxide that is used in ammonia recovery. In step B ammonia is recovered and returned to the solvay tower by reacting ammonium chloride with lime (calcium hydroxide) produced from the limestone.



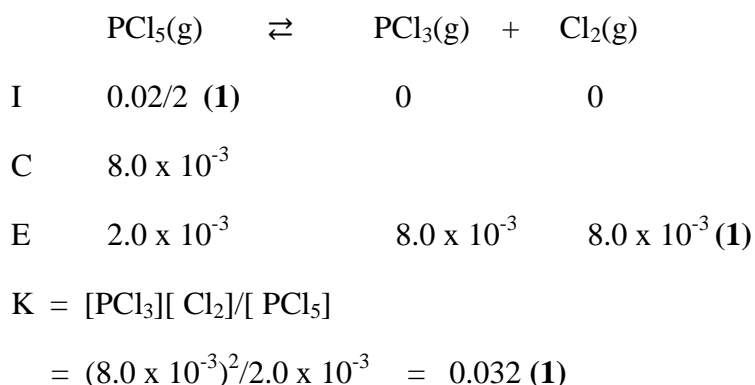
Marking Criteria	Mark(s)
<ul style="list-style-type: none"> Explains the relationship between A and B by identifying each process and showing some relevant chemistry. 	3
<ul style="list-style-type: none"> Explains the relationship between A and B and identifies each process 	2
<ul style="list-style-type: none"> Gives some relevant information about A or B 	1

Outcomes: H4, H8

- (b) 0.020 mol of colourless phosphorous pentachloride gas was placed in a 2.0 L evacuated flask and was heated to 800°C. The gas decomposed forming colourless phosphorous trichloride gas and green chlorine gas. The concentration of the chlorine gas was found to be $8.0 \times 10^{-3} \text{ mol L}^{-1}$ at equilibrium.

- (i) $K = [\text{PCl}_3][\text{Cl}_2]/[\text{PCl}_5]$ 1

- (ii) Calculate the equilibrium constant for this reaction at 800°C. 3



Marking Criteria	Mark(s)
• Correct answer with relevant working shown	3
• Correct answer with some relevant working shown	2
• Some relevant working	1

- (ii) When the temperature is increased to 1000 °C, the colour of the gas mixture intensifies. Identify the forward reaction as exothermic or endothermic and explain the effect of this change on the equilibrium constant.

As temperature increases more chlorine gas has formed (more green), therefore the forward reaction is favoured so the reaction must be endothermic (uses heat) (Le Chatelier). The numerator is larger so K is larger.

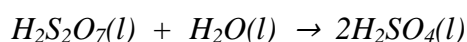
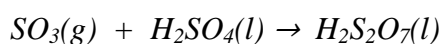
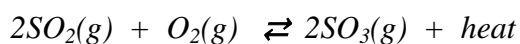
Marking Criteria	Mark(s)
• Identifies the forward reaction as endothermic and explains the change in K	2
• Identifies the forward reaction as endothermic OR • Explains the change in K	1

Outcomes: H8,H10

- (c) Justify the industrial conditions used to produce sulfuric acid from sulfur dioxide. 7

Outcomes: H3, H7, H8

Sample answer



The industrial conditions for the contact process include

2atm pressure 450°C compromise temperature V₂O₅ catalyst

The contact process starts with an equilibrium between sulphur dioxide and sulfur trioxide. The reaction conditions are used to produce a reasonable yield at a reasonable rate.

Although high pressure would push the equilibrium to the right (LeChatelier) as there are fewer gas molecules (3:2), there is a sufficient yield of sulphur trioxide without the added expense of high pressure vessels so a pressure of 2 atm is sufficient to push the gases through the system.

The catalyst of V₂O₅ is used to speed up the reaction so that equilibrium is achieved faster and to allow the reaction to proceed at a lower temperature.

The temperature is a compromise between rate and yield. The forward reaction is exothermic so would be favoured by a lower temperature (Le Chatelier). However, this reaction would be too slow. Industrially, the first catalytic bed is at 550°C. This is for a fast rate and achieves 70% yield. The next beds are at 400°C, the equilibrium shifts right for more yield and the reaction slows.

The final condition is creating oleum, H₂S₂O₇, an intermediate product, as the reaction of sulphur trioxide with water is strongly exothermic and would produce an acidic mist, boiling the water. The SO₃ is added to sulfuric acid to make oleum and then this is reacted with water to make sulfuric acid.

<i>Marking criteria</i>	<i>Marks</i>
<ul style="list-style-type: none">• Demonstrates a thorough knowledge of the industrial conditions including the final oleum step.• Uses correct and relevant chemistry• Justifies the conditions through examples• Articulates a concise, coherent and logical progression with relevant information and includes correct use of scientific principles.	6-7
<ul style="list-style-type: none">• Demonstrates a sound knowledge of the industrial conditions including the final oleum step.• Uses some correct and relevant chemistry• Communicates some scientific principles and ideas in a clear manner	4-5
<ul style="list-style-type: none">• Demonstrates a basic knowledge of the industrial conditions• Identifies some industrial conditions.• Communicates ideas in a basic form using general scientific terms.	2-3
<ul style="list-style-type: none">• Demonstrates a limited knowledge of the process.• Communicates simple ideas	1

TT, TC, TP, TO E, E

- (d) Analyse the changes made to anionic detergents in response to their impacts on the environment. **Outcomes: H4, H9** **4**

Sample answer

Anionic detergents have a long nonpolar alkyl tail and a polar sulfonate head forming the anion, the cation is a spectator ion. They are made from petrochemicals.

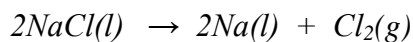
Early anionic detergents had branched alkyl tails that made them non-biodegradable. This would cause build ups of detergents in the environment causing streams to be covered with foaming suds and having a negative impact on the health of the waterway by preventing light from entering and photosynthesis occurring. Detergents were changed to have straight alkyl tails that can be broken down by microorganisms and so improved the health of the waterway.

Early anionic detergents also included phosphate builders for more effective cleaning. A build-up of phosphates in waterways can help promote eutrophication and this can have a devastating effect on the waterway causing organisms to die and reducing the oxygen content of the waterway. These phosphates were replaced with zeolites that didn't cause eutrophication.

<i>Marking Criteria</i>	<i>Mark(s)</i>
<ul style="list-style-type: none">Identifies at least two changes made to anionic detergents and gives an analysis of the reasons for the changes made and the consequences of the change	4
<ul style="list-style-type: none">Identifies at least two changes made to anionic detergents and gives an outline of the reasons for the changes made.	3
<ul style="list-style-type: none">Identifies at least one change made to anionic detergents and gives a reason for the change ORIdentifies two changes ORIdentifies two impacts	2
<ul style="list-style-type: none">Demonstrates a limited knowledge of anionic detergents and their impacts on the environment	1

- (e) Explain the different products formed in the electrolysis of dilute and molten sodium chloride. **Outcomes: H11, H7, H** **3**

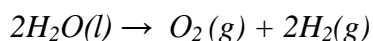
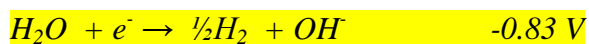
The products of electrolysis of molten sodium chloride are liquid sodium and chlorine gas as chloride and sodium ions are the only species in the liquid.



In dilute sodium chloride there are sodium ions, chloride ions and water.

As the water requires less energy to be oxidised and reduced than the other ions in solution, the water will be electrolysed producing hydrogen and oxygen.

Hydrogen is produced at the cathode and oxygen is produced at the anode.



<i>Marking Criteria</i>	<i>Mark(s)</i>
• Identifies the products correctly and explains the differences	3
• Outlines the different products with some relevant chemistry	2
• Identifies one correct product	1