Name: Teacher:

SECTION I
75 marks

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

Use the multiple-choice answer sheet provided for Questions 1-20.

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

A ⊗ B ⊗ ← C ○ D ○

1. The extraction of zinc from zinc sulphide produces sulphur dioxide as a by-product according to the equation:

$ZnS(s) + O_2(g) \quad Zn(s) + SO_2(g)$

What volume of sulphur dioxide gas will be released at 25^0C & 100kPa when 3.2g of ZnS is reacted.

A. 745.7ml
B. 814ml
C. 0.814ml
D. 2.10ml

Name: Teacher:

2. Chromate and dichromate ions form an equilibrium mixture as represented in the equation:

$2CrO_4^{2-}\ (aq) + 2H^+\ (aq) \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$

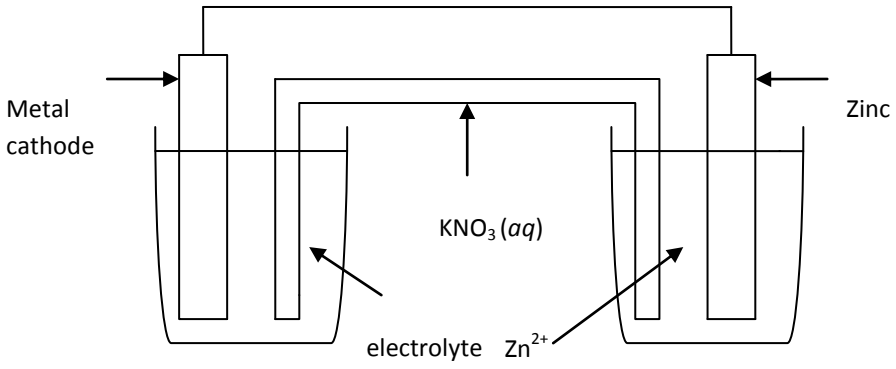
Which of the following solutions, when added to the equilibrium mixture, would decrease the concentration of the dichromate ions?

A. Sodium chloride
B. Hydrochloric acid
C. Acetic acid
D. Sodium acetate

3. The volume of gas produced when 6.0 g magnesium ribbon reacts with 400 mL of 0.50 mol L^{-1} hydrochloric acid at 25°C and 100 kPa pressure is closest to

A. 2.3L
B. 2.5L
C. 5.7L
D. 6.2L

4. The diagram shows a galvanic cell, with zinc at the anode and a metal at the cathode.



Consider the following standard reduction potentials:

Half-reaction	***E° (V)***
$Mg^{2+} + 2e^- \rightleftharpoons Mg\ (s)$	-2.36
$Fe^{2+} + 2e^- \rightleftharpoons Fe\ (s)$	-0.44
$Pb^{2+} + 2e^- \rightleftharpoons Pb\ (s)$	-0.13
$Ag^+ + e^- \rightleftharpoons Ag\ (s)$	+0.80

Name: Teacher:

Which of the following metal/metal ion combinations, when placed at the cathode, will produce a cell with the greatest theoretical potential?

A. Mg/Mg^{2+}
B. Fe/Fe^{2+}
C. Pb/Pb^{2+}
D. Ag/Ag^{+}

5. 80 mL of 5 $molL^{-1}$ HCl is added to 20 mL of 5 mol L^{-1} NaOH. Which of the following correctly summarizes the results?

	Temperature Change	***Final pH of Mixture***
A	decrease	=7
B	increase	=7
C	decrease	>7
D	increase	<7

6. The table below compares measurements taken from three polluted air sources with those of unpolluted air.

Pollutants present	***Unpolluted air***	***Sample X***	***Sample Y***	***Sample Z***
CO (ppm)	0.5	9	1	4
NO_x (ppm)	0.01	0.12	0.04	0.01
SO_2 (ppm)	0.02	0.03	0.15	0.02
Volatile organic compounds VOCs (ppm)	0.1	2.5	0.9	0.06
Particulates ($\mu g/m^3$)	20	90	150	360

Name: Teacher:

What is the most likely cause of pollution for samples *X, Y* and *Z*?

A. *X* from vehicle exhaust, *Y* from a metal smelter, *Z* from bushfires
B. *X* from power stations, *Y* from vehicle exhaust, *Z* from a metal smelter
C. *X* from vehicle exhaust, *Y* from bushfires, *Z* from agriculture
D. *X* from bushfires, *Y* from power stations, *Z* from vehicle exhaust.

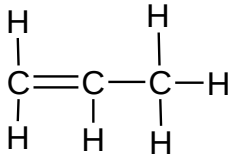
7. A student wished to identify the cation and anion present in an aqueous solution. He performed the following tests.

	Test	***Observation***
1	Nitric acid was added to the solution.	No bubbles of gas formed.
2	Sulfuric acid was added to another sample of the solution.	A white precipitate formed.
3	A flame test was performed on another sample of the solution.	A reddish-orange flame was produced.
4	Silver nitrate solution was added to another sample of the solution.	A white precipitate formed, which darkened on exposure to UV light.
5	Hydrochloric acid was added to another sample of the solution.	No precipitate formed.

These results are consistent with the presence, in the solution, of

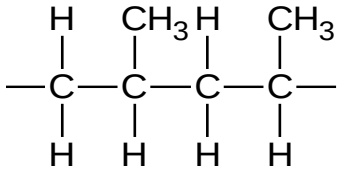
A. lead (II) ions and nitrate ions.
B. calcium ions and chloride ions.
C. barium ions and nitrate ions.
D. barium ions and chloride ions.

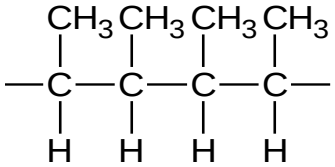
8. The diagram shows the structure of a small molecule, which undergoes polymerisation.

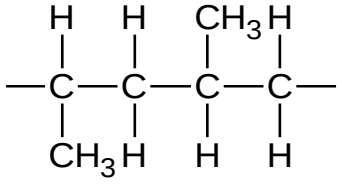


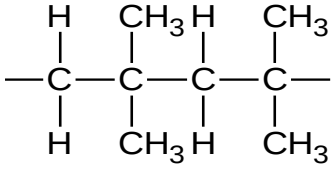
Name: Teacher:

Which structure below best represents a portion of the polymer chain formed from the polymerisation?

A. 

B. 

C. 

D. 

9. Four bottles were found, missing their labels, but they were known to contain aqueous ammonia, 0.1M NaOH, rainwater, and 0.1M HCl.

A student tested each solution with universal indicator, and compared her results with the colour reference chart shown below.

pH	1	2	3	4	5	6	7	8	9	10	11	12	13
Colour	Red		Orange		Yellow		Green	Dark Green		Blue		Purple	

Which row of the table below shows the results of her investigation?

	Ammonia (aq)	**0.1 M NaOH**	**0.1 M HCl**	**Sydney Rainwater**
(A)	Blue	Purple	Red	Dark green
(B)	Blue	Blue	Orange	Green
(C)	Purple	Purple	Red	Yellow
(D)	Orange	Red	Red	Yellow

Name: Teacher:

10. H_2SO_4 is a strong acid and CH_3COOH is a weak acid because

A. H_2SO_4 has two acidic hydrogen atoms whilst CH_3COOH only has one acidic hydrogen atom.

B. CH_3COOH does not ionise to the same extent as H_2SO_4 when dissolved in water.

C. H_2SO_4 is more soluble in water than is CH_3COOH.

D. CH_3COOH does not react with weak bases, whilst H_2SO_4 reacts with weak bases.

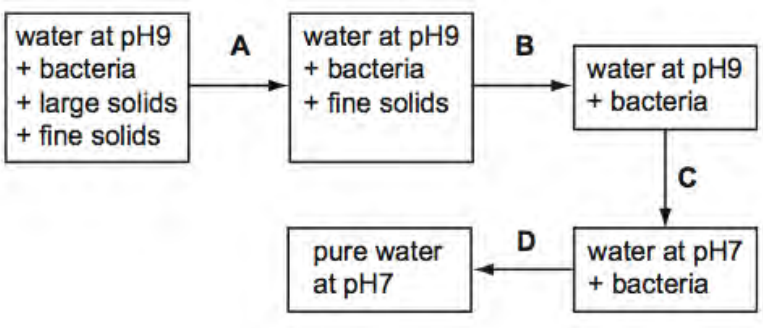
11.

www.play-with-water.ch/d4/experiments/images/img_23.jpg

The onset of the condition of the river system above can be predicted by high levels of

A. dead and decaying plants and animals
B. BOD readings
C. nutrients, especially phosphate and nitrate ions
D. turbidity

12. At which stage in the following sequence, used to purify drinking water, is chlorine added?



A. Stage A

B. Stage B

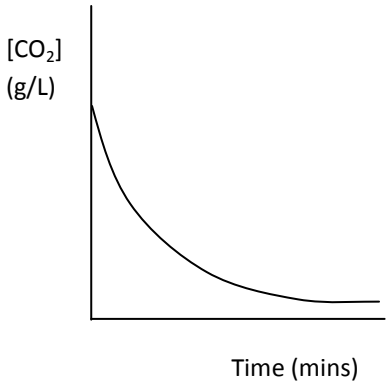
C. Stage C

D. Stage D

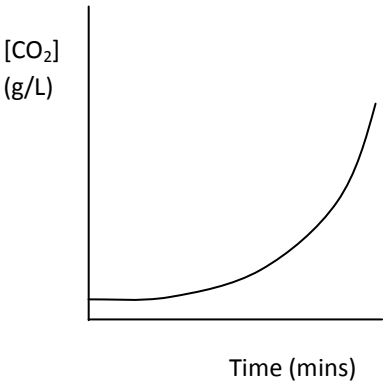
13. A sports player buys a bottle of soft drink from a shop on her way to a match. She drinks a small amount, and leaves the lid off the bottle while playing.

Which of the following graphs represents the concentration of dissolved CO_2 in the bottle over time?

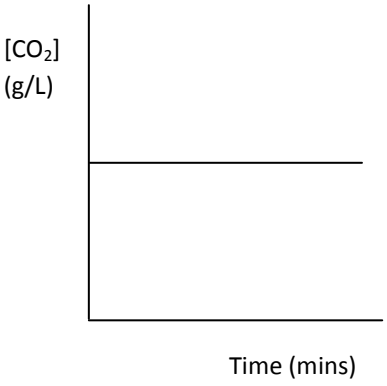
A.



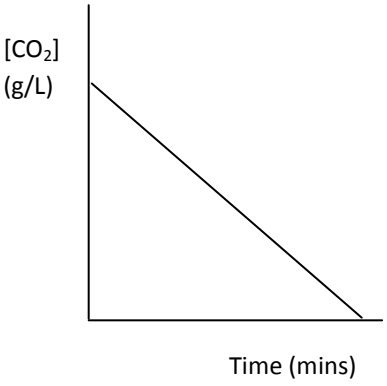
B.



C.



D.



Name: Teacher:

14. In order to determine the sulfate content of a commercial lawn-food, a student dissolves a 4.58 g sample of the lawn-food, adds excess $BaCl_2(aq)$, filters the mixture, and finally washes and dries the residue.

After drying, the residue had a mass of 7.95g.

What is the % sulfate in the lawnfood, and how could the student have made their experiment more reliable?

	% sulfate	**To increase reliability:**
(A)	58	Repeat the experiment and average the results.
(B)	73	Repeat the experiment and average the results.
(C)	58	Control important variables during the experiment.
(D)	73	Control important variables during the experiment.

15. A 4.52 g sample of lawn fertiliser was analysed for its sulfate content. After filtration and drying, 3.62 g of barium sulfate was recovered.

What is the % w/w of sulfate in the lawn fertiliser?

A. 1.45
B. 33.0
C. 40.1
D. 80.1

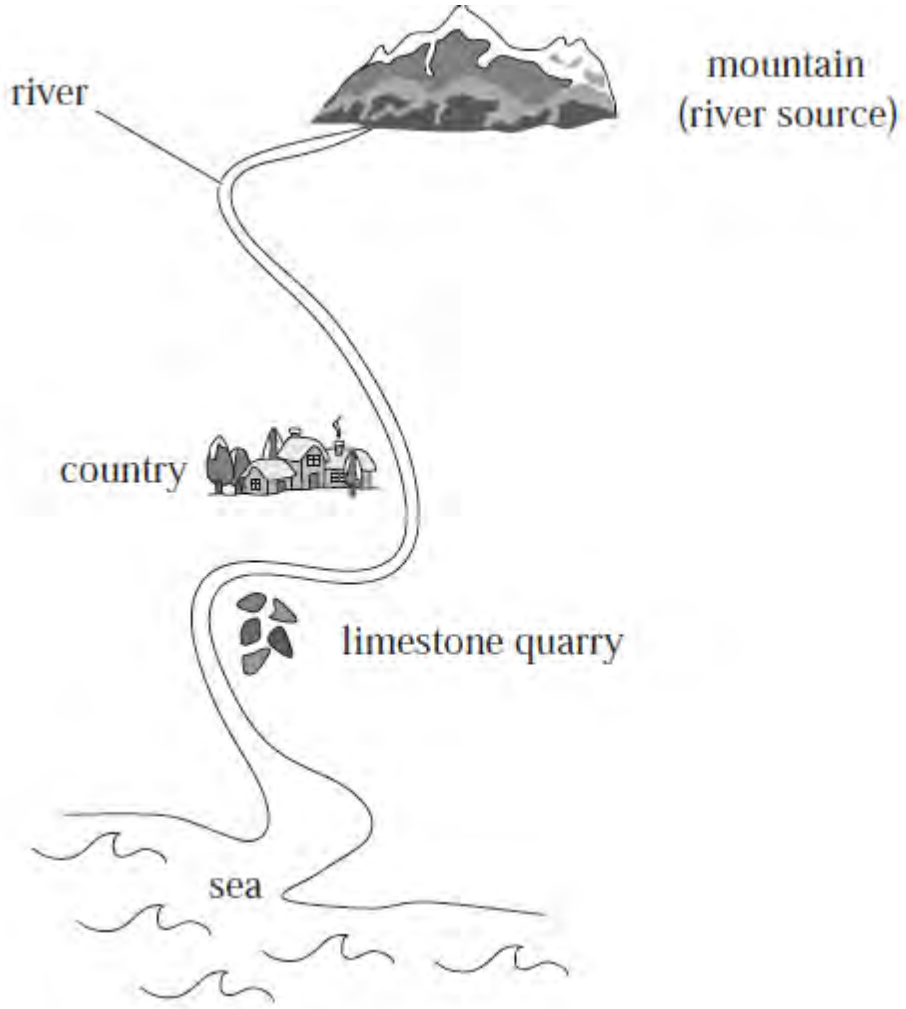
16. When phenolphthalein is added to an aqueous solution containing one of the following compounds the solution turns pink.

Which solute is present?

A. O_2
B. HF
C. NH_3
D. NH_4Cl

Name: Teacher:

17. Water quality analyses were performed at different sites on a river as shown on the map below.



The table below shows the results of the tests performed at different sites.

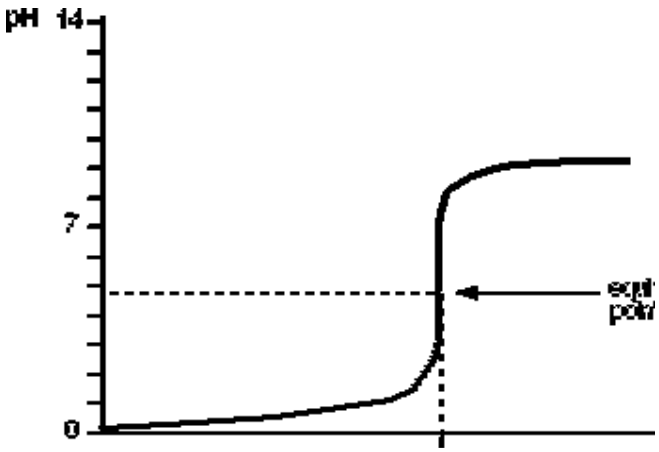
	Results of tests performed			
Site	*Dissolved oxygen*	*pH*	*Calcium ion concentration*	*Total dissolved solids*
1	11 ppm	6.8	68 ppm	38 g/L
2	10 ppm	6.8	5 ppm	0.10 g/L
3	5 ppm	7.4	60 ppm	0.60 g/L
4	5 ppm	5.2	4 ppm	0.10 g/L

Name: Teacher:

The site located at the river source (in the mountains) is

A. Site1
B. Site2
C. Site3
D. Site4

18. The graph below shows a titration curve of an aqueous alkali with an aqueous acid of similar concentration.



Volume of aqueous alkali added

What could be the acid and alkali in this titration?

	Acid	Alkali
A.	HCl	NH_3
B.	CH_3COOH	NH_3
C.	HCl	NaOH
D.	CH_3COOH	NaOH

19. In the equilibrium

$$N_2H_5^+(aq) + SCN^-(aq) \rightleftharpoons HSCN(aq) + N_2H_4(aq)$$

A. $N_2H_5^+$ acts as a acid

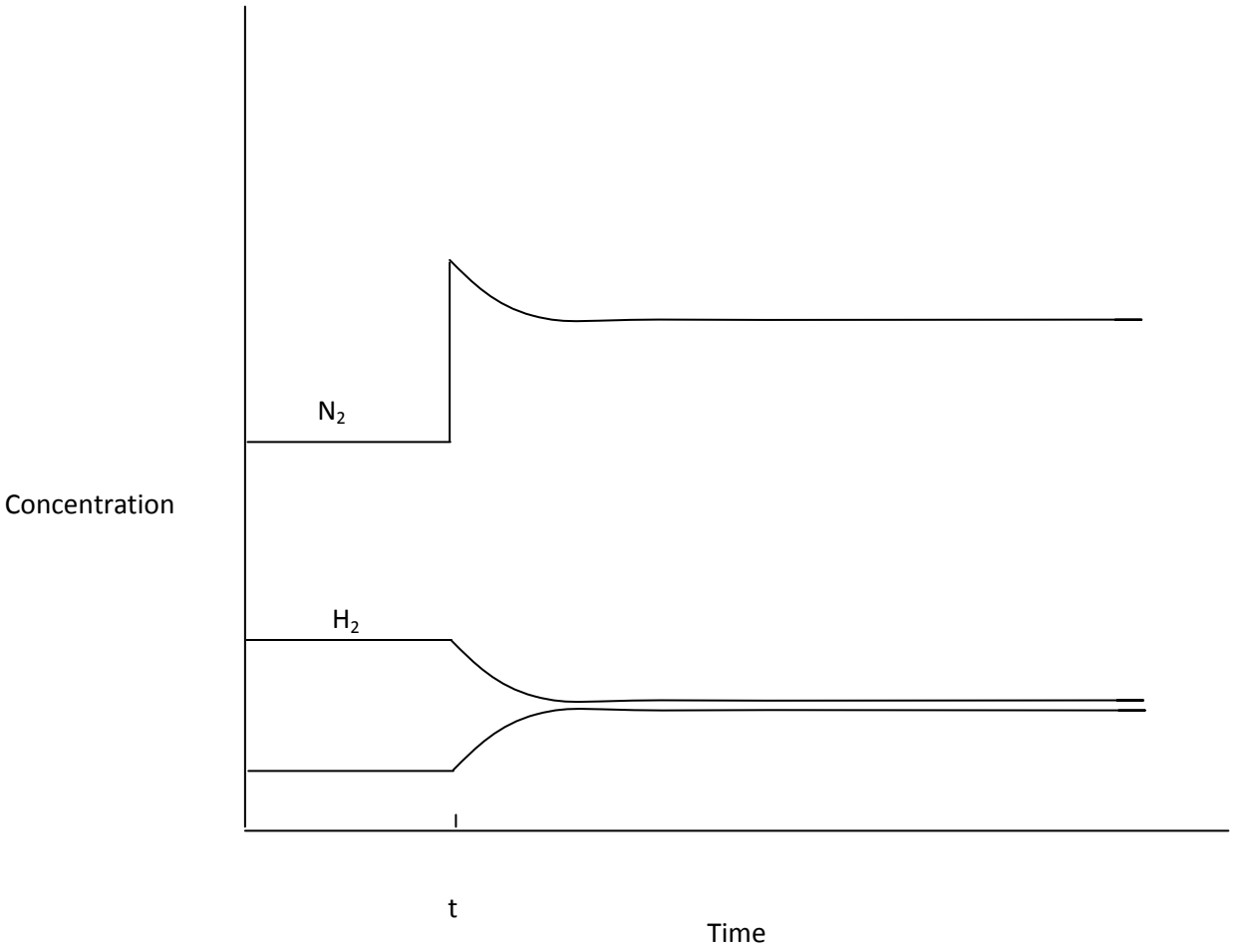
B. SCN^- acts as a acid

C. HSCN acts as a base

D. N_2H_4 acts as a acid

Name: Teacher:

20. An equilibrium mixture between nitrogen, hydrogen and ammonia was subjected to a change at **time t.** The result of this change is shown in the diagram below.



What was the change made to the equilibrium mixture at time t?

A. The pressure in the equilibrium mixture of nitrogen and hydrogen was decreased.

B. The temperature of the reaction mixture was raised.

C. The concentration of nitrogen gas in the equilibrium mixture was increased.

D. The volume of the reaction vessel was increased

Name: Teacher:

SECTION I (continued)
Part B – 55 Marks
Attempt all questions 21-34
Allow about 1 hour and 35 minutes for this part
Show all relevant working in questions involving calculations

Question 21
(6 Marks)

'Oxidation-reduction reactions are sources of electrical energy now and will become increasingly important sources of energy into the future.'

Analyse this statement, referring to at least TWO commercial cells you have studied.

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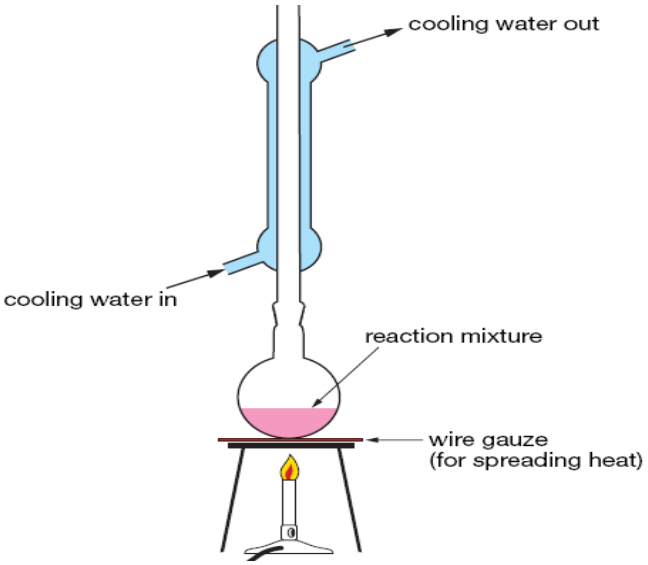
Name: Teacher:

Question 22
(6 Marks)

The diagram shows the apparatus used in a school laboratory to produce the ester, 1-propyl butanoate. One of the chemicals needed in this experiment is concentrated sulfuric acid.



(a) Name the chemicals other than concentrated sulphuric acid needed to produce the above ester. **1**

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(b) Sulfuric acid acts as a catalyst in this reaction. Its presence also increases the yield of the ester. Using Le Chatelier's Principle, explain how the sulfuric acid can increase the yield of ester. **2**

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Question 22 Cont'd on the next page

Name: Teacher:

Question 22 cont'd

(c) Justify the procedure used to prepare an ester in the laboratory. **3**

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Question 23

(3 Marks)

In the laboratory, you performed a first-hand investigation to monitor the progress of a fermentation reaction. Outline the method you used, including the measurements you made.

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Name: Teacher:

Question 24
(7 Marks)

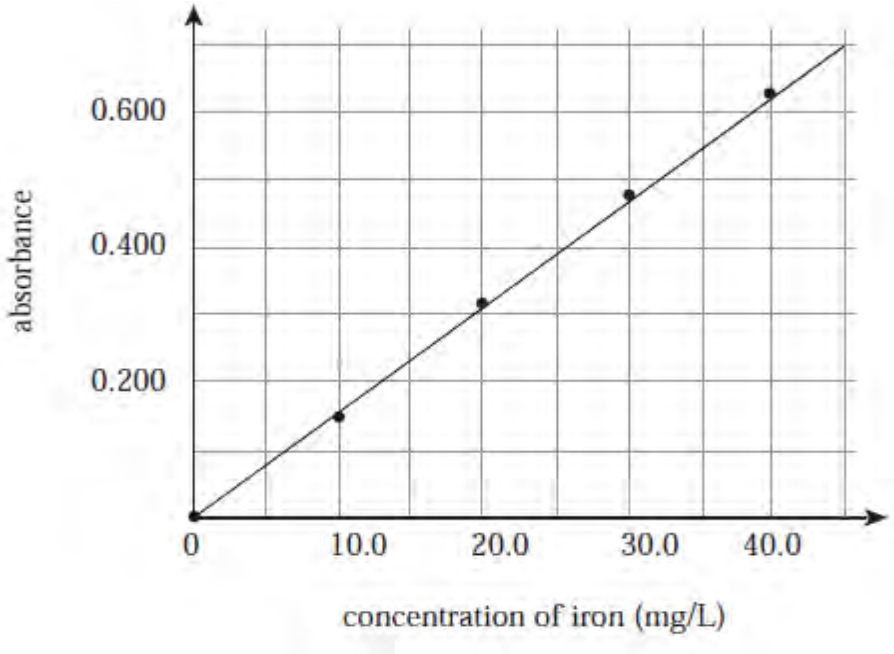
A laboratory was asked to assess the amount of iron in dietary supplement tablets. A chemist developed the following procedure.

A single tablet was weighed, dissolved in 20.0 mL dilute nitric acid and the solution was made up to a final volume of 500.00 mL. A diluted sample for analysis was prepared by pipetting 10.00 mL of this solution into a standard flask and this diluted solution was made up to a final volume of 100.00 mL. Four absorbance measurements were taken of this diluted solution. Five standard solutions of iron were also prepared.

Atomic absorption spectrometry (AAS) was used and the results are presented in the table below.

Standard iron solutions (mg/L)	*Absorbances*
0.00	0.000
10.0	0.144
20.0	0.323
30.00	0.471
40.00	0.625
Tablet samples	*Absorbances*
A	0.386
B	0.392
C	0.427
D	0.381
'Average' of absorbance of tablet samples	0.385

The following calibration curve was obtained.



Name: Teacher:

(a) Describe the chemical principles upon which AAS works to determine the concentration of minerals such as iron. **3**

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(b) AAS is a technique that produces very reliable results with a high degree of accuracy. Explain how the method used by the analytical chemist in determining the amount of iron in the dietary tablets ensures accurate and reliable results are obtained. **2**

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(c) Estimate the average amount of iron per tablet in milligrams. **2**

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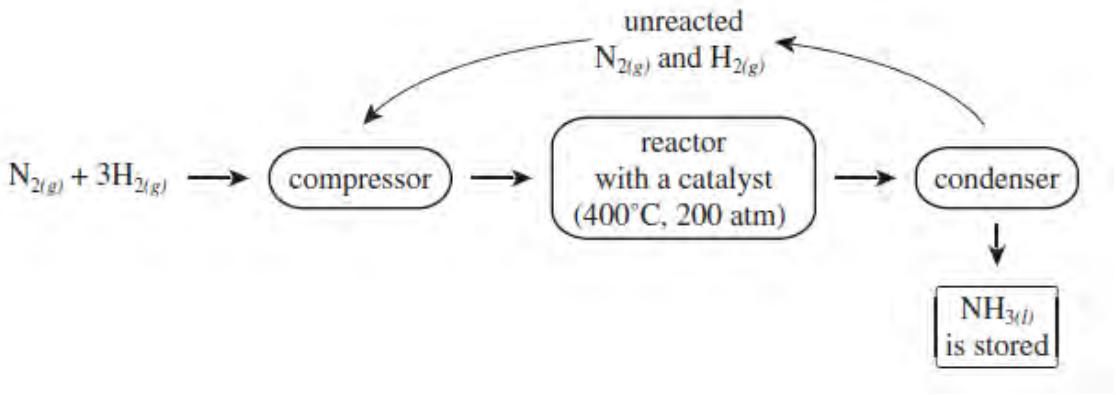
Name: Teacher:

Question 25
(6 Marks)

In a modern ammonia-producing plant many factors need to be monitored carefully. The following diagram describes the main features of such a plant:



(a) Identify the sources of the gases used to produce ammonia during the Haber Process. **1**

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(b) In this production plant, the pressure and temperature are closely monitored for the combination of the reactant gases (in the reactor) and for the removal of the product (in the condenser). Explain why the temperature and pressure must be carefully monitored in these chambers. **5**

Use appropriate equations to illustrate your answer.

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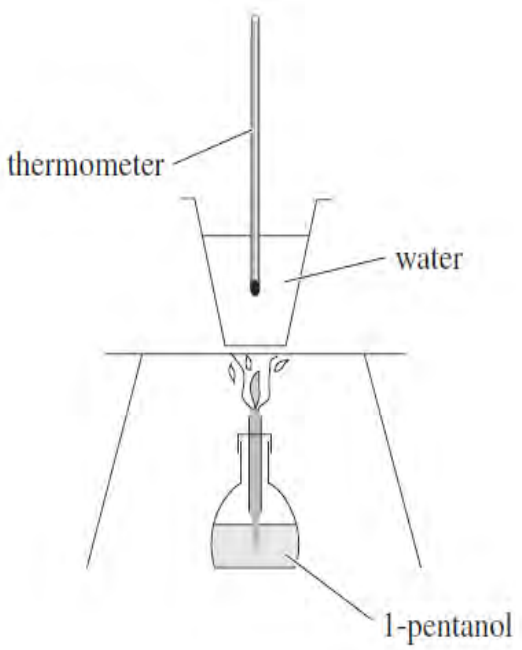
Name: Teacher:

Question 26
(3 Marks)

A student designed an experiment to determine the heat of combustion of 1-pentanol. The student set up the equipment shown in the diagram below.



The student recorded the following measurements:

Mass of water	500.0 g
Initial temperature of water	17.5°C
Final temperature of water	47.5°C
Initial mass of spirit burner and 1-pentanol	37.15 g
Final mass of spirit burner and 1-pentanol	35.14 g

Using these results, calculate an experimental value for the heat of combustion in kJ g^{-1}.
Show your working.

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Name: Teacher:

Question 27
(3 Marks)

A standard solution was prepared by dissolving analytical grade sodium hydrogen carbonate, 2.628 g, in sufficient distilled water to give a final volume of 500.0 mL. The concentration of sodium hydrogen carbonate in this standard solution was 0.06256 mol L–1.

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

Titration	*Volume of sodium hydrogen carbonate solution (mL)*
1	23.40
2	23.55
3	24.75
4	23.35

Determine the concentration of the hydrochloric acid solution. Include a balanced equation for the reaction between sodium hydrogen carbonate and hydrochloric acid. **3**

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Name: Teacher:

Question 28
(5 Marks)

(a) It was suspected that the water in a river was being contaminated by sewage. What test(s) would you use to check for sewage pollution downstream from the point of suspected discharge? Explain what answer you would expect from the test(s) if the water was indeed polluted by sewage. **2**

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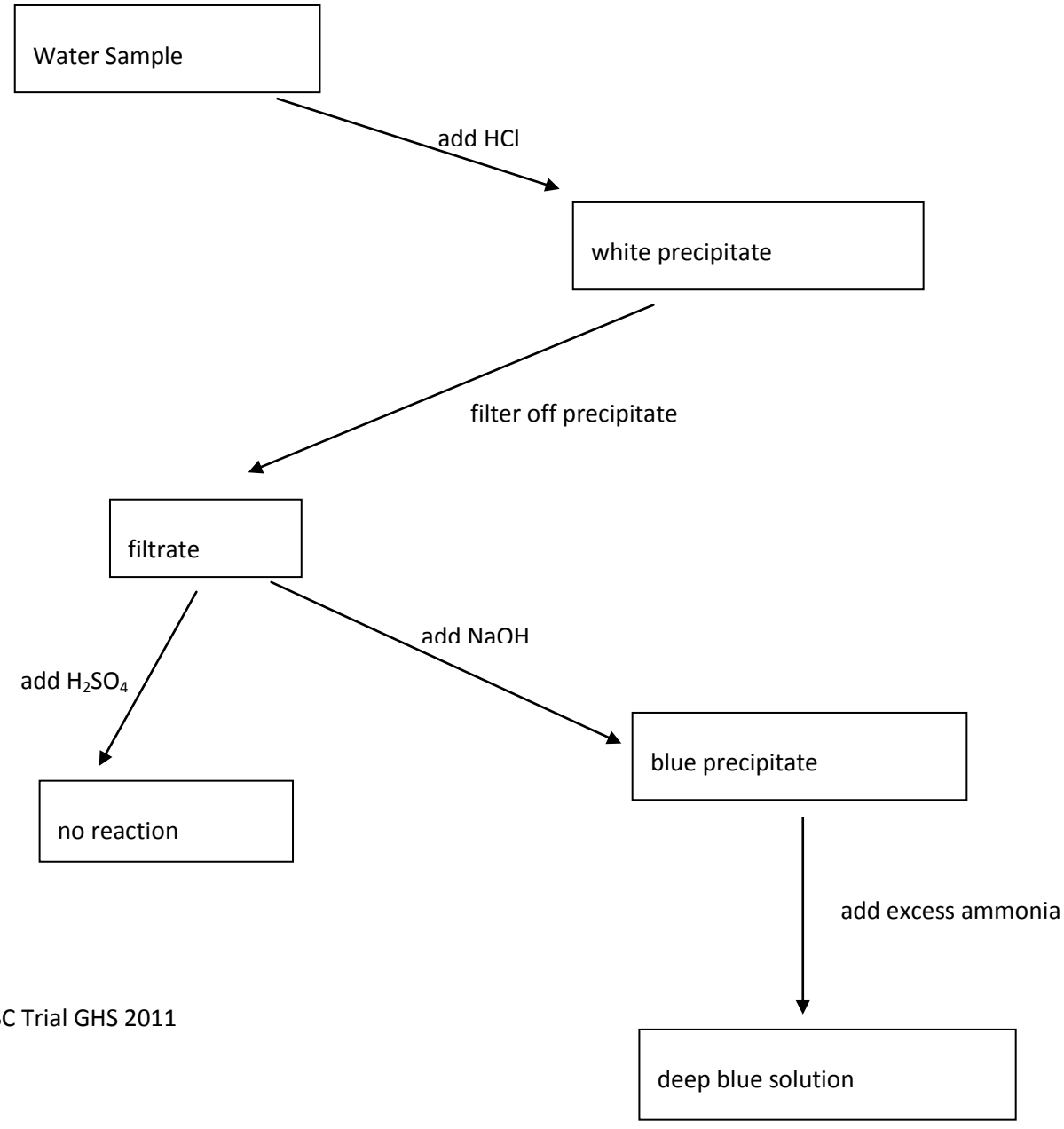
A chemist performed the tests shown in the flow chart below to determine the cation(s) present in a water sample.



Name: Teacher:

(i) What cation(s) is/are present in the solution? **1**

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(ii) Write balanced chemical equations for the **FIRST TWO** reactions in the flow chart sequence. **2**

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Name: Teacher:

Question 29
(6 Marks)

A scientist who was truly in his element making discoveries

Sydney Morning Herald, January 21, 2011

Albert Ghiroso, 1915–2010.

Albert Ghiorso designed many of the accelerators and detectors that made it possible to produce and identify the heavy, short-lived radioactive elements beyond uranium on the periodic table, the heaviest found in nature. In all, he discovered 12 of them.

(a) What is the general name for the "short short-lived radioactive elements beyond uranium on the periodic table"? **1**

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(b) Identify two means of detecting radiation. **1**

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(c) Write a balanced nuclear equation in which plutonium-244 is irradiated to give an isotope of curium. **1**

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(d) Using examples, describe the production of short-lived radioactive elements beyond uranium. **3**

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Name: Teacher:

Question 30
(3 Marks)

In a practical activity, a student conducted a first-hand investigation to distinguish between samples of hexane and 1-hexene using bromine water.

Explain how bromine water is useful in distinguishing between hexane and 1-hexene. **3**
Include relevant equations, using structural formulae, in your answer.

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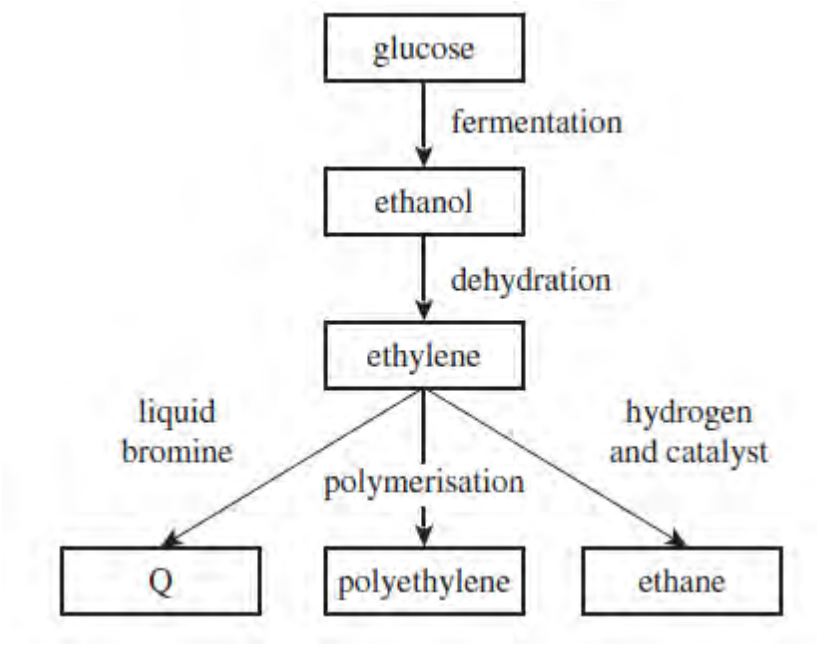
Name: Teacher:

Question 31
(4 Marks)
The following flow diagram shows a series of reactions.



(a) Draw a structural equation to illustrate the production of Q. **1**

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(b) Ethylene can be readily converted into ethane. Give a reason for the presence of a catalyst in this reaction. **1**

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(c) Polyethylene can be used as a cling film. Describe this use in terms of its properties. **2**

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Name: Teacher:

Question 32
(4 Marks)

It is well known that safety glasses should always be worn during practicals involving acids since spills and splashes can occur. The corrosive nature of acids can damage workbenches or pose a risk to people working in the lab.

A handbook for risk assessment states:
'To minimise risk, large acid spills should be neutralised with lime ($CaCO_3$) before mopping up.'

Assess this recommended method. **4**

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Name: Teacher:

SECTION II

25 Marks

Allow about 45 minutes for this part

Answer the question in a writing booklet. Extra writing booklets are available
Show all relevant working in questions involving calculations

Question 33 - Industrial Chemistry **(25 Marks)**

(a) Sulfuric acid is one of the world's most widely used chemicals. It is produced industrially by the so called Contact Process. Sulfur dioxide, air and water are the main feedstocks in its production.

(i) Why is the production process called the Contact Process? **1**

(ii) The sulfur dioxide for the Contact Process is usually obtained from the combustion of sulfur. Write a balanced equation for the combustion of sulfur. **1**

(iii) What reaction conditions will maximise the yield of sulfur trioxide in the Contact Process? **3**

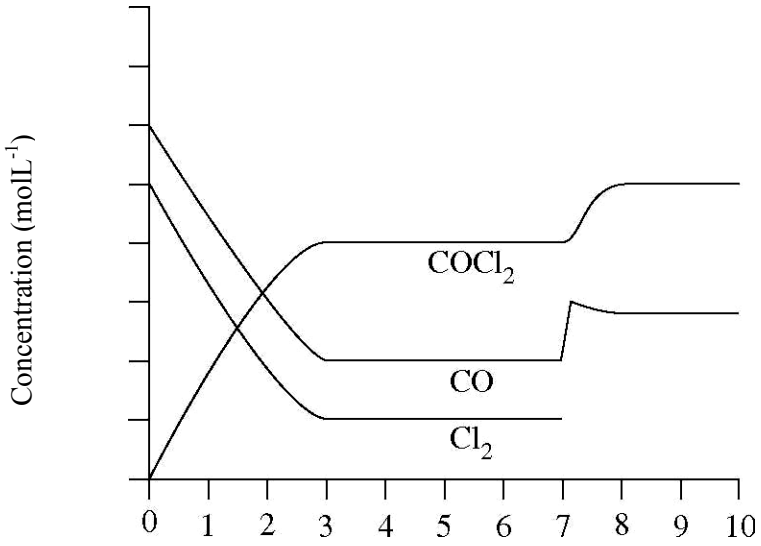
(iv) Sulfuric acid is an oxidising agent. Describe, with a balanced equation, sulfuric acid being used in the oxidation of copper(II) metal. **2**

(v) What are the safety precautions necessary for the transport and storage of concentrated (98%) sulfuric acid? Explain the reasons for the precautions you specify. **3**

(b) Phosgene is produced from chlorine and carbon monoxide according to the equation:

$$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$$

When CO and Cl_2 are mixed in the presence of activated carbon at 500°C the concentration of each gas changes according to the graph below.



Name: Teacher:

(i) Write the expression for K at equilibrium. **1**

(ii) Determine the value of the equilibrium constant at $500^{o}C$. **2**

The change in concentration of chlorine after 7 minutes is not shown on this graph.

(iii) What change was made at 7 minutes? **1**

(iv) Outline the effect of this change on the concentration of Cl_2. **1**

(v) Explain what effect this change will have on the equilibrium constant. **1**

(d) (i) Compare the products of electrolysis of molten sodium chloride and of aqueous solutions of sodium chloride. Use appropriate equations in your response. **3**

(ii) "The production of sodium hydroxide, using the mercury cell process, has had a negative impact on the natural environment."

"As a result, membrane cells have been widely adopted for the industrial production of sodium hydroxide."

Assess these statements **6**

Name: Teacher:

SECTION I
75 marks

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

Use the multiple-choice answer sheet provided for Questions 1-20.

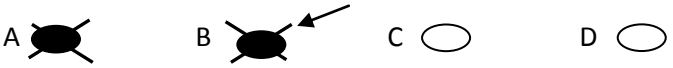
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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.

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



1. The extraction of zinc from zinc sulphide produces sulphur dioxide as a by-product according to the equation:

$ZnS(s) + O_2(g) \quad Zn(s) + SO_2(g)$

What volume of sulphur dioxide gas will be released at 25^0C & 100kPa when 3.2g of ZnS is reacted.

A. 745.7ml
B. 814ml
C. 0.814ml
D. 2.10ml

Name: Teacher:

2. Chromate and dichromate ions form an equilibrium mixture as represented in the equation:

$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$

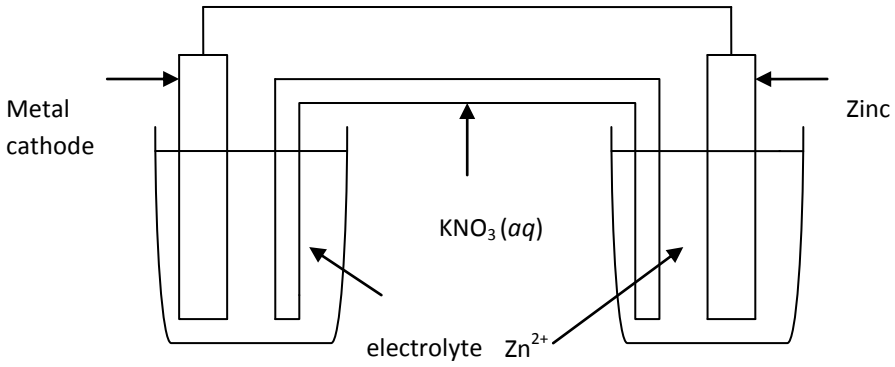
Which of the following solutions, when added to the equilibrium mixture, would decrease the concentration of the dichromate ions?

A. Sodium chloride
B. Hydrochloric acid
C. Acetic acid
D. Sodium acetate

3. The volume of gas produced when 6.0 g magnesium ribbon reacts with 400 mL of 0.50 mol L^{-1} hydrochloric acid at 25°C and 100 kPa pressure is closest to

A. 2.3L
B. 2.5L
C. 5.7L
D. 6.2L

4. The diagram shows a galvanic cell, with zinc at the anode and a metal at the cathode.



Consider the following standard reduction potentials:

Half-reaction	***E° (V)***
$Mg^{2+} + 2e^- \rightleftharpoons Mg\ (s)$	-2.36
$Fe^{2+} + 2e^- \rightleftharpoons Fe\ (s)$	-0.44
$Pb^{2+} + 2e^- \rightleftharpoons Pb\ (s)$	-0.13
$Ag^+ + e^- \rightleftharpoons Ag\ (s)$	+0.80

Name: Teacher:

Which of the following metal/metal ion combinations, when placed at the cathode, will produce a cell with the greatest theoretical potential?

A. Mg/Mg^{2+}
B. Fe/Fe^{2+}
C. Pb/Pb^{2+}
D. Ag/Ag^{+}

5. 80 mL of 5 $molL^{-1}$ HCl is added to 20 mL of 5 mol L^{-1} NaOH. Which of the following correctly summarizes the results?

	Temperature Change	***Final pH of Mixture***
A	decrease	=7
B	increase	=7
C	decrease	>7
D	increase	<7

6. The table below compares measurements taken from three polluted air sources with those of unpolluted air.

Pollutants present	***Unpolluted air***	***Sample X***	***Sample Y***	***Sample Z***
CO (ppm)	0.5	9	1	4
NO_x (ppm)	0.01	0.12	0.04	0.01
SO_2 (ppm)	0.02	0.03	0.15	0.02
Volatile organic compounds VOCs (ppm)	0.1	2.5	0.9	0.06
Particulates ($\mu g/m^3$)	20	90	150	360

Name: Teacher:

What is the most likely cause of pollution for samples *X, Y* and *Z*?

A. *X* from vehicle exhaust, *Y* from a metal smelter, *Z* from bushfires
B. *X* from power stations, *Y* from vehicle exhaust, *Z* from a metal smelter
C. *X* from vehicle exhaust, *Y* from bushfires, *Z* from agriculture
D. *X* from bushfires, *Y* from power stations, *Z* from vehicle exhaust.

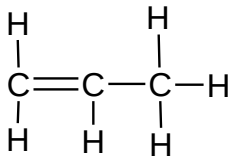
7. A student wished to identify the cation and anion present in an aqueous solution. He performed the following tests.

	Test	***Observation***
1	Nitric acid was added to the solution.	No bubbles of gas formed.
2	Sulfuric acid was added to another sample of the solution.	A white precipitate formed.
3	A flame test was performed on another sample of the solution.	A reddish-orange flame was produced.
4	Silver nitrate solution was added to another sample of the solution.	A white precipitate formed, which darkened on exposure to UV light.
5	Hydrochloric acid was added to another sample of the solution.	No precipitate formed.

These results are consistent with the presence, in the solution, of

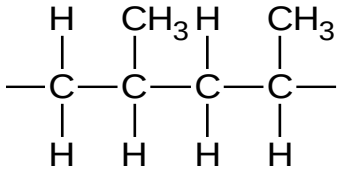
A. lead (II) ions and nitrate ions.
B. calcium ions and chloride ions.
C. barium ions and nitrate ions.
D. barium ions and chloride ions.

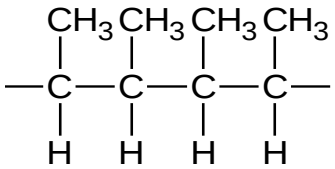
8. The diagram shows the structure of a small molecule, which undergoes polymerisation.

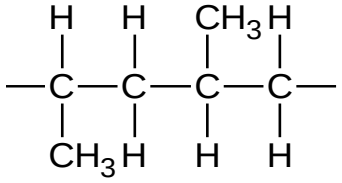


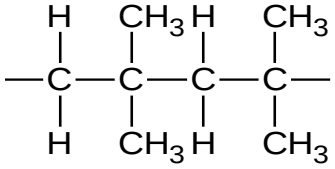
Name: Teacher:

Which structure below best represents a portion of the polymer chain formed from the polymerisation?

A. 

B. 

C. 

D. 

9. Four bottles were found, missing their labels, but they were known to contain aqueous ammonia, 0.1M NaOH, rainwater, and 0.1M HCl.

A student tested each solution with universal indicator, and compared her results with the colour reference chart shown below.

pH	1	2	3	4	5	6	7	8	9	10	11	12	13
Colour	Red		Orange		Yellow		Green	Dark Green		Blue		Purple	

Which row of the table below shows the results of her investigation?

	Ammonia (aq)	**0.1 M NaOH**	**0.1 M HCl**	**Sydney Rainwater**
(A)	Blue	Purple	Red	Dark green
(B)	Blue	Blue	Orange	Green
(C)	Purple	Purple	Red	Yellow
(D)	Orange	Red	Red	Yellow

Name: Teacher:

10. H_2SO_4 is a strong acid and CH_3COOH is a weak acid because

A. H_2SO_4 has two acidic hydrogen atoms whilst CH_3COOH only has one acidic hydrogen atom.

B. CH_3COOH does not ionise to the same extent as H_2SO_4 when dissolved in water.

C. H_2SO_4 is more soluble in water than is CH_3COOH.

D. CH_3COOH does not react with weak bases, whilst H_2SO_4 reacts with weak bases.

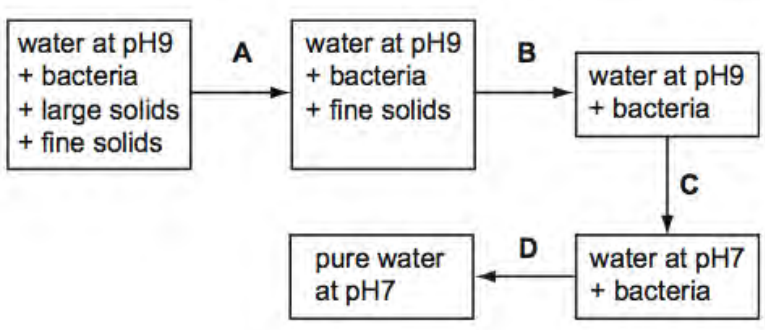
11.

www.play-with-water.ch/d4/experiments/images/img_23.jpg

The onset of the condition of the river system above can be predicted by high levels of

A. dead and decaying plants and animals
B. BOD readings
C. nutrients, especially phosphate and nitrate ions
D. turbidity

12. At which stage in the following sequence, used to purify drinking water, is chlorine added?



Name: Teacher:

A. Stage A

B. Stage B

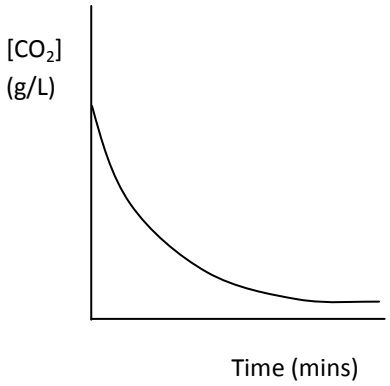
C. Stage C

D. Stage D

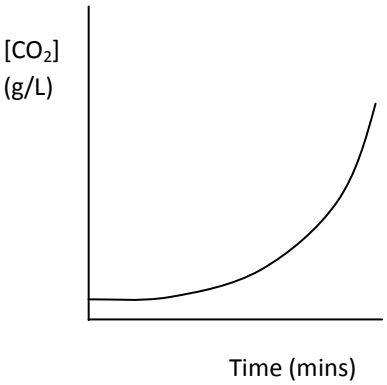
13. A sports player buys a bottle of soft drink from a shop on her way to a match. She drinks a small amount, and leaves the lid off the bottle while playing.

Which of the following graphs represents the concentration of dissolved CO_2 in the bottle over time?

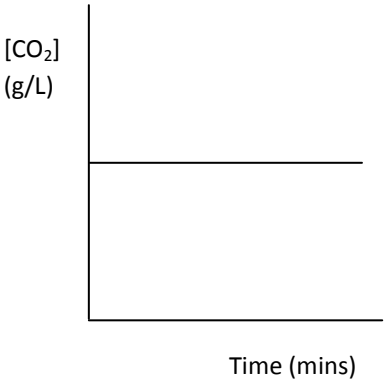
A. <- Correct Answer



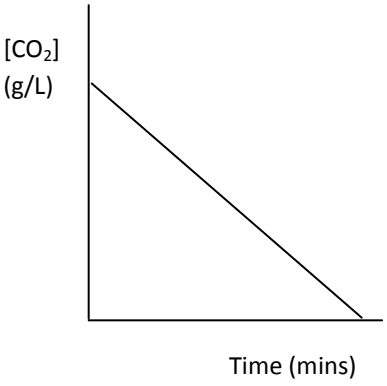
B.



C.



D.



Name: Teacher:

14. In order to determine the sulfate content of a commercial lawn-food, a student dissolves a 4.58 g sample of the lawn-food, adds excess $BaCl_2(aq)$, filters the mixture, and finally washes and dries the residue.

After drying, the residue had a mass of 7.95g.

What is the % sulfate in the lawnfood, and how could the student have made their experiment more reliable?

	% sulfate	To increase reliability:
(A)	58	Repeat the experiment and average the results.
(B)	73	Repeat the experiment and average the results.
(C)	58	Control important variables during the experiment.
(D)	73	Control important variables during the experiment.

15. A 4.52 g sample of lawn fertiliser was analysed for its sulfate content. After filtration and drying, 3.62 g of barium sulfate was recovered.

What is the % w/w of sulfate in the lawn fertiliser?

A. 1.45
B. 33.0
C. 40.1
D. 80.1

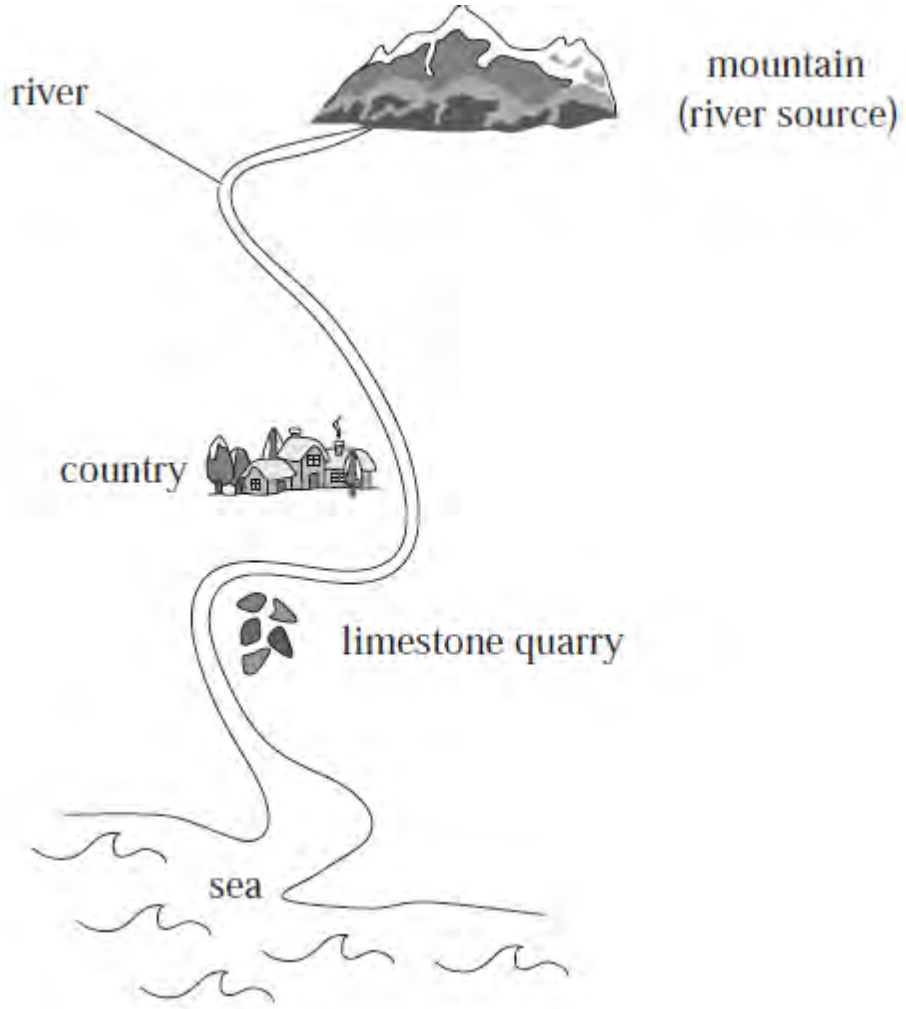
16. When phenolphthalein is added to an aqueous solution containing one of the following compounds the solution turns pink.

Which solute is present?

A. O_2
B. HF
C. NH_3
D. NH_4Cl

Name: Teacher:

17. Water quality analyses were performed at different sites on a river as shown on the map below.



The table below shows the results of the tests performed at different sites.

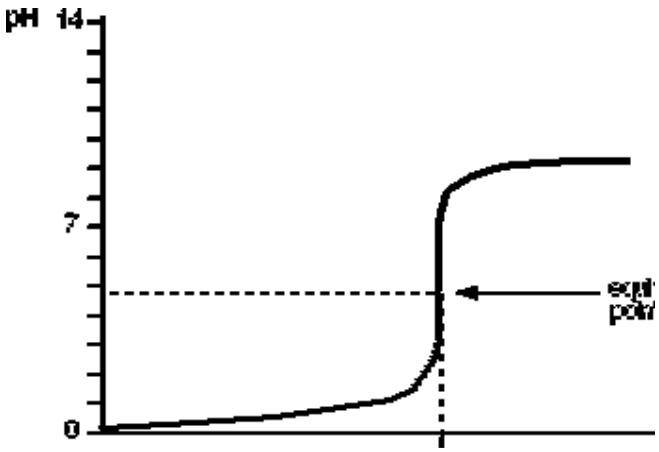
	Results of tests performed			
Site	*Dissolved oxygen*	*pH*	*Calcium ion concentration*	*Total dissolved solids*
1	11 ppm	6.8	68 ppm	38 g/L
2	10 ppm	6.8	5 ppm	0.10 g/L
3	5 ppm	7.4	60 ppm	0.60 g/L
4	5 ppm	5.2	4 ppm	0.10 g/L

Name: Teacher:

The site located at the river source (in the mountains) is

A. Site1
B. Site2
C. Site3
D. Site4

18. The graph below shows a titration curve of an aqueous alkali with an aqueous acid of similar concentration.



Volume of aqueous alkali added

What could be the acid and alkali in this titration?

	Acid	Alkali
A.	HCl	NH_3
B.	CH_3COOH	NH_3
C.	HCl	NaOH
D.	CH_3COOH	NaOH

19. In the equilibrium

$$N_2H_5^+(aq) + SCN^-(aq) \rightleftharpoons HSCN(aq) + N_2H_4(aq)$$

A. $N_2H_5^+$ acts as a acid

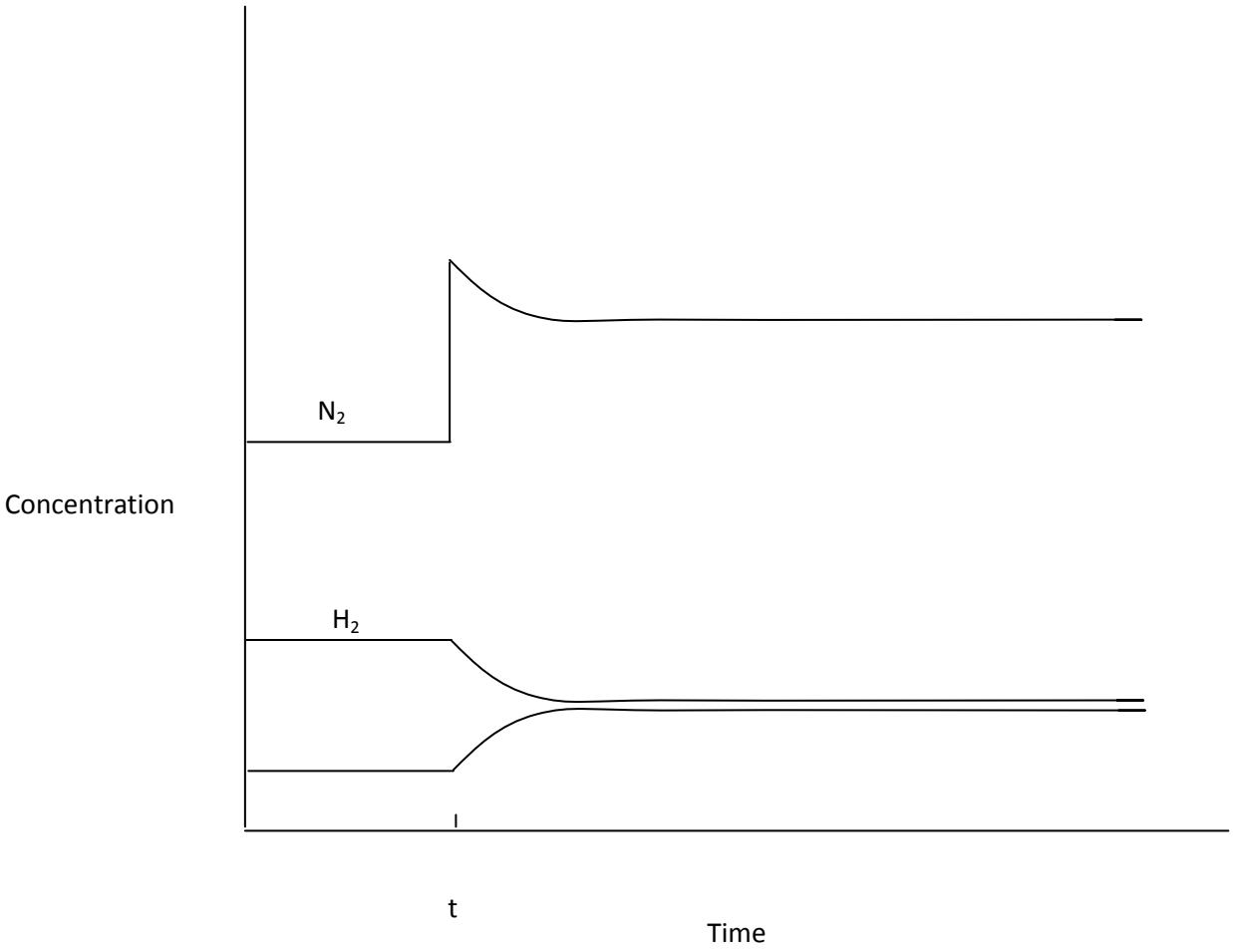
B. SCN^- acts as a acid

C. HSCN acts as a base

D. N_2H_4 acts as a acid

Name: Teacher:

20. An equilibrium mixture between nitrogen, hydrogen and ammonia was subjected to a change at **time t.** The result of this change is shown in the diagram below.



What was the change made to the equilibrium mixture at time t?

A. The pressure in the equilibrium mixture of nitrogen and hydrogen was decreased.

B. The temperature of the reaction mixture was raised.

C. The concentration of nitrogen gas in the equilibrium mixture was increased.

D. The volume of the reaction vessel was increased

Name: Teacher:

Answers

Question 21 (6 marks)

Criteria	Marks

• Analyses the statement by:
  • Relating production of electrical energy to galvanic cells and oxidation-reduction reactions
  • Including at least TWO significant reasons why the use of galvanic cells may become increasingly important as sources of energy
  • Including references to at least TWO commercial galvanic cells
	6

• Discusses the production of electrical energy in galvanic cells • Discusses at least TWO significant reasons why the use of galvanic cells may become increasingly important as sources of energy • Briefy outline at least TWO commercial galvanic cells OR • One cell described	5
• Discusses the production of electrical energy in galvanic cells • Discusses ONE significant reason why the use of galvanic cells may become increasingly important as sources of energy • outline at least TWO commercial galvanic cells Or One cell described	4
• Explains why oxidation-reduction reactions are sources of energy • Discusses ONE significant reason why the use of galvanic cells may become increasingly important as sources of energy • Outline one cell	3
• Explains why oxidation-reduction reactions are sources of energy and/or • Discusses ONE significant reason why the use of galvanic cells may become increasingly important as sources of energy Or • One cell described	2
• Explains why oxidation-reduction reactions are sources of energy OR • Discusses ONE significant reason why the use of galvanic cells may become increasingly important as sources of energy	1

Sample answer (Answers may differ according to the galvanic cells studied)
Oxidation-reduction reactions all involve the transfer of electrons from a reducing agent to an oxidising agent. As an electric current involves the movement of electrons through a conducting material, such as a copper wire, oxidation-reduction reactions can provide the source of the electrical energy.
Galvanic cells are formed when oxidation and reduction reactions at the anode and cathode of a cell bring about a transfer of electrons through an external circuit. Thus electrical energy can be generated from oxidation-reduction reactions. Commercial batteries, consisting of one or more galvanic cells, are used as sources of electrical energy.

A dry-cell battery is currently widely used as a source of energy for low power applications.

Anode: $Zn\ (s) \rightleftharpoons Zn^{2+}\ (aq) + 2e^-$

Cathode: $NH_4^+ (aq) + MnO_2 (s) + H_2O (l) + e^- \rightleftharpoons Mn(OH)_3 (s) + NH_3 (aq)$

The electrons generated in the anode half-cell pass through the external circuit to the cathode, thus generating electrical energy.
Lead-acid batteries are currently used as sources of energy in motor vehicles.
The reactions involve loss of electrons (oxidation) to the car circuits from the lead anode and gain of electrons (reduction) at the lead oxide coated cathode.

At the anode: $Pb (s) + SO_4^{2-} (aq) \rightarrow PbSO_4 (s) + 2e^-$

At the cathode: $PbO_2 (s) + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 (s) + 2H_2O$

These batteries involve 6 galvanic cells in parallel and are rechargeable. Thus the oxidation-reduction reactions in galvanic cells have been providing electrical energy for society in the past and will continue to do so for the foreseeable future.

Galvanic cells which are more efficient, smaller, more reliable or of higher power output than dry cells or lead-acid cells have already been developed as specialised sources of energy for today's society. Fuel cells, using hydrogen and oxygen, generated the electrical power needed in space vehicles over past decades and fuel cells using methanol have been used for generating power for public transport. The use of photovoltaic technology, linking the use of solar energy and the transfer of electrons by oxidation-reduction reactions, is opening up possibilities for energy efficient construction into the future.
As world supplies of fossil fuels (petrol, diesel, etc.) diminish, electrical energy may become increasingly important. Battery powered (electric) cars have been produced in recent years, as have hybrid vehicles which use both battery power and petrol. Electric cars are environmentally more acceptable, as they do not directly release carbon dioxide. The use of electrical energy may reduce society's dependence on renewable carbon-based energy sources such as ethanol and cellulose. Fuels are derived from these energy sources by fermentation reactions, which are inefficient. Furthermore, fuels derived from biomass still release carbon dioxide into the atmosphere.

Hence the use of the oxidation-reduction reactions in galvanic cells to produce electrical energy is likely to become increasingly important into the future, as long as the recharging of these batteries can use solar, wind or other clean energy sources.

Question 22

a 1-Propanol and butanoic acid (1 mark if both are correct)

b.

Criteria	Marks
• Identifies that sulfuric acid acts as a dehydrating agent AND • Uses Le Chatelier's Principle to explain how the removal of water shifts the equilibrium to increase the yield of ester	2
• Identifies that sulfuric acid acts as a dehydrating agent OR • Uses Le Chatelier's Principle to explain how the removal of water shifts the equilibrium to increase the yield of ester	1

Sample answer

Concentrated sulfuric acid is considered a dehydrating agent as it is strongly attracted to water molecules. Its presence in the mixture during esterification means that the water formed during the reaction is attracted towards the sulfuric acid and hence is removed from the equilibrium as the ester forms. Using Le Chatelier's Principle, this means that the equilibrium shifts to the right to compensate for the removal of water from the equilibrium.

c. Any three steps in method identified and justified (use of condenser, use of heating mantle or use of water bath or use of condenser for any other reason, use of heat source etc.

(3 marks)

Question 23

Criteria	Marks
• Outlined a valid method States reactants in a conical flask connected to lime water in a beaker. Both conical flask and lime water in beaker are weighed. • Placed under optimum conditions in a oven or incubator. • States mass changes of both conical flask and beaker are taken and recorded over 3-5 days. • State mass changes were determined.	3
• Outlined a valid method States reactants in a conical flask connected to lime water in a beaker. Both conical flask and lime water in beaker are weighed. AND/OR • Placed under optimum conditions in a oven or incubator. AND/OR • States mass changes of both conical flask and beaker are taken and recorded over 3-5 days. Mass changes were determined.	2
Brief mention of reactants in conical flask connected to lime water in a beaker	1

Sample answer

The progress of a fermentation reaction can be monitored by measurements of the changes in mass of the fermentation vessel as fermentation proceeds. As fermentation proceeds, the mass of the vessel containing the glucose solution and the yeast falls, as the carbon dioxide produced is removed by reaction with limewater.

A flask fitted with a cork and delivery tube into a solution of limewater (calcium hydroxide) was filled with a dilute glucose solution, yeast and a yeast nutrient solution. The delivery tube was clamped to prevent entry of air while mass measurements were made. The delivery tube dipped into a solution of limewater held in a flask.

The mass of the original fermentation vessel was measured over a period of days. (Alternatively, the mass of the collecting limewater vessel was measured over a period of days.) The decrease (or increase) in mass of the vessel (or the limewater container) is assumed to be due to the loss (or gain) of carbon dioxide. The moles of carbon dioxide produced is used as a measure of the progress of the fermentation, as each mole of glucose fermented produces 2 moles of carbon dioxide.

Name: Teacher:

Question 24

(a) Atoms can absorb light of particular frequencies. A light beam, of a frequency that is strongly absorbed by the atoms of the element being analysed, is passed through an atomised sample of the solution. Electrons in atoms of the element being analysed are excited (absorb energy) and move to a higher energy level. A detector measures the intensity of the transmitted light beam. The amount of light absorbed indicates the concentration of metal ions. The greater the absorbance, the greater the concentration.

States that absorption takes place at a particular frequency AND States that light is shone through an atomised sample AND States that absorption takes place. States that absorption is proportional to concentration	3
States that absorption takes place at a particular frequency AND/OR States that light is shone through an atomised sample. And/OR • States that absorption takes place. • States that absorption is proportional to concentration	2
Any one of above	1

(b) Four different sample solutions are prepared and analysed. This process of repetition ensures reliable results are obtained. Three of the four results (samples A, B and D) have been used in determining the average absorbance as the absorbance for sample C is significantly different to the absorbances for samples A, B and D. Using the concordant results is a method of ensuring accuracy.

Preparing a number of standard solutions and recording their absorbances allows a graph with a line of best fit to be drawn. This graphical technique accounts for some experimental errors and additionally ensures an accurate and reliable result is obtained.

Nominates one aspect of this experimental procedure that demonstrates the reliability of the process. (Four readings out of which three are consistent and results averaged) • Nominates one aspect of this experimental procedure that demonstrates the accuracy of the process (Standard solution used to find absorbance which is plotted to form a calibration curve. This eliminate any error and produce accuracy.	2
Only one of the above	1

Reliability and accuracy was to do with method rather than instrument

(c) The graph can be used to determine the concentration of iron in the diluted samples.

23-25 mg/L as seen on graph. (1 mark) must be correctly taken from graph
1000 mL sample = 25 mg
100 mL =2.5mg
10 ml =2.5mg 500mL = 12.5mg final answer (1 mark)

Name: Teacher:

Question25

(a)

Identifies correct sources (hydrocarbons or fossil fuel not accepted)	1

(b) The temperature and pressure must be monitored in both the reaction chamber and the condenser chamber for the following reasons.
The reaction chamber is where the hot mixture of nitrogen and hydrogen gases are passed over a catalyst and react to form ammonia.

$$N_{2(g)} + 3H_{2(g)} \overset{Fe/FeO}{\rightleftharpoons} 2NH_{3(g)} \quad \Delta H = -92 \text{ kJ}$$

Temperature: the reaction is exothermic and the equilibrium (forward reaction) is favoured by low temperature. The rate of reaction is too slow at low temperatures and so a compromise temperature of around 500°C is used. The exothermic nature of the reaction means that the reaction must be carefully monitored to maintain this temperature.
Pressure: the equilibrium (forward reaction) is favoured by high pressures as 4 mole of reactant gas produces only 2 mole of product gas. The pressure used is around 350 atmospheres which must be carefully monitored to maintain yield, by not dropping too low, and to
ensure safety, by not going too high.
The condenser chamber is where the ammonia is liquefied and collected.

$$NH_{3(g)} \rightleftharpoons NH_{3(l)}$$ (optional)

Pressure: the pressure of the gas mixture needs to be kept quite high to make it easier to liquefy the ammonia.
Temperature: the gases are cooled and the liquid ammonia collected while the nitrogen and hydrogen are recycled to the reactor chamber.
The pressure and temperature must be monitored to ensure that all of the ammonia is collected to ensure efficient conversion by further driving the equilibrium to replace the removed ammonia.

Examines both the reactor and the condenser • Specifically addresses pressure specifically relates the need to monitor to the equilibrium process • Specifically addresses temperature specifically relates the need to monitor to the equilibrium process • Addresses the extent of the reaction and the rate in the reactor to safety specifically with pressure • Addresses the temperature decrease • maintaining pressure in the condenser • Includes appropriate equations (one equation for the synthesis)	5
Any four of above addressed including equation for synthesis.	4
Any three of above addressed including equation for synthesis.	3
Any two of above addressed including equation for synthesis.	2
Any one of above addressed including equation for synthesis.	1

Name: Teacher:

Question 26

Calculates the correct value with units and all calculations shown	3
No units	2
Wrong value but correct method	1

Question 27

$NaHCO3 + HCl \longrightarrow NaCl + H2O + CO2$

Average volume = 23.40 + 23.55 + 23.35

= 23.43 mL

n NaHCO3 = 0.02343 × 0.06256 = 0.001466 mole

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

Conc of HCl= 0.05864 mol L –1

• Writes a correctly balanced equation. • Correctly determines average titration volume. • Correctly determines moles of NaHCO3. • Correctly determines the concentration of acid .	4
Any three of the above	3
Any two of the above	2
Only one of the above	1

Question 28

Suggested answer

(a) The main problems expected from sewage discharge would be disease-causing microorganisms and oxygen-demanding wastes. Thus water suspected to be contaminated by sewage would be tested for coliform bacteria counts and for biochemical oxygen demand (BOD). Both these indicators would have increased values compared to clean water.

• water suspected to be contaminated by sewage would be tested for coliform bacteria counts and for biochemical oxygen demand	1
• increased values compared to clean water	1

b(i)

Suggested answer

Pb^{2+} (white precipitate with HCl) and Cu^{2+} (blue precipitate with OH^- which dissolves in NH_3)

• Pb^{2+} and Cu^{2+}	1

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b(ii)

$Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4$ $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$

• $Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4$	1
• $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$	1

Question 29

(a)

Transuranic

Uses appropriate name	1

(b)

Any two from: photographic film, Geiger-Muller tube, gold leaf electroscope, spark counter, cloud chamber, bubble chamber, scintillation detectors.

Identifies two means	1
Identifies one means	1/2

(c)

Writes appropriate equation with correct symbols and numbers $^{244}Pu \longrightarrow {}^4He + Cm$	2
Writes appropriate equation with one error	1

(d)

Gives two examples with equations AND Explains production in linear accelerators and cyclotrons	3
Gives two examples with equations AND Explains production in linear accelerators OR cyclotrons	2
Gives one example with equations OR Explains production in linear accelerators OR cyclotrons	1

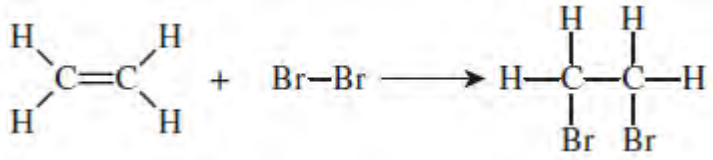
Question 30

• Gives correct equations using structural formula of only hexane and hexene • Mentions double bond broken • Mentions test for unsaturation or to detect presence of	3

double bond	
Any two	2
Any one	1

Question 31

(a)



Draws a correct structural equation	1

(b)

The purpose of the catalyst is to speed up the rate of reaction (conversion of reactants to products) by lowering the activation energy. The catalyst remains in (or returns to) its original form at the end of the reaction.

States a clear reason for the presence of the catalyst	1

(c)

Property of LDPE	Suitability of property to use
Very flexible	Allows for it to be easily wrapped around items
Excellent cling properties	It can easily cling to itself
Transparent (fewer crystalline regions)	Better visibility of items that have been wrapped
Impermeable to water and resistant to most chemicals (including oil and grease)	Useful for sealing – keeps food crisp, prevents leakage, etc.
Melting point of approximately 115°C	Can be used to cover food that requires defrosting
Good elastic recovery and puncture resistance	Resistant to handling – retains toughness and pliability over a wide temperature range

• Identifies several properties of LDPE • Clearly relates two or more properties to the use of the	2

product.	
Identifies some properties of LDPE **AND** • Clearly relates one property to the use of the product	1

Question 32

Usefulness of advice	Drawbacks of advice
Adding $CaCO_3$ neutralises (increases the pH of) the spilt liquid. It reduces the risk of corrosive reaction between skin or eyes or equipment and the acid.	The base being used to neutralise acid could be mildly hazardous in its own right. Avoiding contact of lime with eyes, airways etc. would be necessary. $NaHCO_3$ (bicarb soda) is possibly a better choice of base to use since it is slightly less hazardous than $CaCO_3$ while serving the same purpose.
Fizzing of $CaCO_3$ when added clearly indicates a reaction with the acid. When the fizzing ceases, it can be assumed that all acid is neutralised. Continue to add lime until fizzing ceases. The area can then be washed up or hosed down safely.	Heat is released during the neutralisation process. There would be a need for caution of large amounts of heat posing a burn or heat hazard during the clean-up.
The base used is not strong or soluble and thus poses minimal risk, so it provides a neutralising action with minimal risk from the base itself.	The spill could be contained from spreading first by adding sand or vermiculite to the puddle of liquid. Once this has absorbed the spill, it can then be swept up. This may be less expensive than $CaCO_3$ and larger quantities may be readily available.
The powdered sample will absorb some of the liquid of the spill, thus preventing the spread of the liquid (into drains etc.)	It's not mentioned that the area will still need to be washed down with detergent and water after the bulk of the spill is cleared away.
The advice is suitable for small or large spills of acid and for spills of strong, weak, concentrated or dilute acid.	Apart from goggles, no safety gear is specifically mentioned. Also there is no mention of the need to ventilate the area.
Lime is readily available.	

Demonstrates a thorough knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk • Thoroughly considers the advantages and disadvantages of using the recommended method • Provides a detailed assessment or judgement of the problems and benefits of the method	4
Demonstrates a sound knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk OR • Outlines some of the advantages and disadvantages of using the recommended method • Provides an overall judgement of the method	3
Demonstrates a limited knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk OR • Identifies an advantage and a disadvantage of using the recommended method OR • Provides an explanation of a problem or benefit of the method .	2
Identifies one advantage of using the method OR • Identifies one disadvantage of using the method	1

Name: Teacher:

Question 33a(i)

Suggested answer

The process is called the Contact process because SO_2 and O_2 gases must come in contact with a catalyst.

• correct answer	1

a(ii)

Suggested answer

$$S(s) + O_2(g) \longrightarrow SO_2(g)$$

• correct equation	1

a(iii) Suggested answer

Moderate temperatures (400–500°C)

Catalyst – vanadium(v) oxide and excess oxygen

Pressures of 1–2 atm

• moderate temperatures (400–500°C)	1
• catalyst – vanadium(v) oxide and excess oxygen	1
• pressures of 1–2 atm	1

a(iv)

Suggested answer

Sulfuric acid can be used to oxidise copper to copper ions.

$$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$$

OR

$$Cu + H_2SO_4 \longrightarrow CuSO_4 + H_2$$

• correct equation with states and detailed description mentioning dilute/conc acid reaction	2
• Incorrect balancing of equation OR missing detail	1

Determines the correct value with calculations shown	2
Determines the correct value but calculations not shown	1

• Some correct information	½

a(v)

Concentrated (98%) sulfuric acid can be safely stored or transported in steel containers. Care must be taken to avoid contamination of the acid with water, because water could set off a vigorous reaction between acid and a steel container.

• can be safely stored or transported in steel containers
• avoid contamination of the acid with water

Writes the correct expression	1

• water could set off a vigorous reaction between acid and a steel container

b(i)

(ii)

(iii)

CO added	1

(iv)

Cl_2 concentration will slowly decrease until new equilibrium	1

(v)

No change. Temp remains the same	1

c(i)

• Uses link words to compare • Any three correct equations • Shows different products	3
• Uses link words to compare • Any two correct equations • Shows different products	2
• No link words • Any one correct equation	1

(c)
(ii)

Criteria	Marks
• Assessment of the 2 statements AND • Overviews of the mercury and membrane cells AND • Comparison of mercury and membrane cells impact on environment • Equations to represent cell reactions	6
• Overviews of the mercury and membrane cells AND • Comparison of mercury and membrane cells impact on environment • Equations to represent cell reactions	4-5

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• Overviews of the mercury and membrane cells OR • Comparison of impact of mercury and membrane cells on environment	2-3
• Some correct information about the industrial production of sodium hydroxide by either the mercury or membrane cells or some information about the impact of mercury on the environment	1

Sample answer

Caustic soda is an important chemical used in the manufacture of soaps, detergents, paper, domestic cleaners, plastics and fabrics. It is made by the electrolysis of concentrated sodium chloride. Sodium hydroxide needs to be manufactured in a pure form, without the formation of harmful by-products or contamination by mercury, so that its use does not impact negatively on the environment.

The overall electrolysis reaction is the same for both mercury and membrane cells. Both involve the use of concentrated sodium hydroxide.

$$\mathbf{2NaCl}\textit{(aq)} + \mathbf{2H_2O}\textit{(l)} \rightarrow \mathbf{2NaOH}\textit{(aq)} + \mathbf{Cl_2}\textit{(g)} + \mathbf{H_2}\textit{(g)}$$

In the **mercury cell**, liquid mercury is the cathode.

The reaction here is:

$$\mathbf{Na^+}\textit{(aq)} + \mathbf{e^-} \rightarrow \mathbf{Na}\textit{(l)}$$ **(dissolved in the mercury, as an amalgam).**

The anode reaction is:

$$\mathbf{2Cl^-}\textit{(aq)} \rightarrow \mathbf{Cl_2}\textit{(g)} + \mathbf{2e^-}$$

The sodium and mercury amalgam flows from the electrolysis cell into a separate chamber. Here the sodium reacts with water to form hydrogen and sodium hydroxide. The used sodium chloride can contain traces of mercury and is discharged back into the ocean. More **than 100 g of mercury per tonne of sodium hydroxide** can be released into the ocean. Mercury metal is unreactive but some bacteria can break it down and mercury compounds can pass through a food chain. Mercury is known to affect the nervous system and can cause brain damage in humans.

The **membrane cell** is an electrolysis cell using a **polymer (PTFE) diaphragm (the membrane**) which incorporates anions.

The electrolysis cell reactions are:

At the cathode:

$$\mathbf{2H_2O}\textit{(l)} + \mathbf{2e^-} \rightarrow \mathbf{H_2}\textit{(g)} + \mathbf{2OH^-}\textit{(aq)}$$

At the anode:

$$\mathbf{2Cl^-}\textit{(aq)} \rightarrow \mathbf{Cl_2}\textit{(g)} + \mathbf{2e^-}$$

This membrane prevents the flow of anions but allows cations (here sodium ions) to pass through it. The chloride ions stay in the anode compartment and do not have an opportunity to react with the hydroxide ions produced in the cathode compartment (**so no dangerous and reactive chlorite ions** are formed).

The sodium ions can migrate through the membrane to form sodium hydroxide solution in the cathode compartment.

No new mercury cells are being constructed and all new cells contain the PTFE membrane.

Overall assessment

The production of sodium hydroxide using a mercury cell did have a positive impact, in that it produced pure sodium hydroxide, but it had a negative impact on the environment by releasing mercury compounds into the food chain. As a result, the majority of old mercury cells have been replaced by modern diaphragm cells, which use the stable inert polymer PTFE as a **cation exchange** membrane to separate the anode and cathode half-cells. As a result, no mercury is released into the environment and no other impurities (such as the chlorite ion) are produced or remain in the spent brine. The membrane cell can produce almost **pure sodium hydroxide** and the environmental hazards associated with earlier cells have been avoided.