2012

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper

. • Write your Student Number at the top of pages 11, 12, 14, 16, 18 and 20

Total marks – 100

Section I Pages 3 – 23

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 Pages 24 – 25

25 marks

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

Section I
75 marks

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

Use the multiple choice answer sheet on page 11.

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

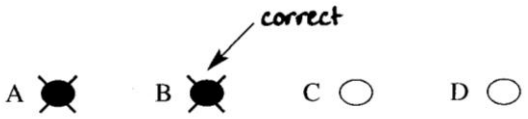
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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.



Mark your answers on the ANSWER sheet on page 11.

Multiple Choice

Use the multiple – choice answer sheet on page 11 for Questions 1 – 20.

1. A catalyst is used in the production of ethanol from ethylene and in the reverse process of the production of ethylene from ethanol.
Which is the catalyst used for each of the productions listed above in correct sequence?

(A) Concentrated H_2SO_4 and dilute H_2SO_4

(B) Concentrated H_2SO_4 for both processes

(C) Dilute H_2SO_4 and concentrated H_2SO_4

(D) Dilute H_2SO_4 for both processes

2. Which of the following can be used to detect radiation?

(A) A scintillation counter

(B) A data logger

(C) A voltmeter

(D) A spectrophotometer

3. Why is ethanol used as a major constituent of perfumes?

(A) Ethanol is cheap.

(B) Ethanol has a low density.

(C) Ethanol is inflammable.

(D) Ethanol is a good solvent.

4. Which statement best describes the boiling points within a homologous series?

(A) They decrease as the molecules become larger.

(B) They are all approximately the same.

(C) They increase as the molecular weight increases.

(D) They are independent of intermolecular forces.

5. Which statement best defines the term "specific heat capacity" of a pure substance?

(A) The amount of heat needed to melt a pure substance

(B) The amount of heat needed to boil a pure substance

(C) The amount of heat needed to increase the temperature of 1.0 g of a pure substance by 1^0C

(D) The amount of heat needed to increase the temperature of 1.0 mol of a pure substance by 1^0C

6 A 250 mL sample of rainwater is titrated using 0.0095 mol L^{-1} sodium hydroxide solution. If 8.30 mL of the sodium hydroxide solution was required to reach the endpoint, what was the pH of the rainwater?

(A) 0.54

(B) 3.50

(C) 4.50

(D) 5.40

7. Which type(s) of UV penetrate(s) the atmosphere most?

(A) UV-A (~ 320 – 400 nm)

(B) UV-B (~ 220 – 320 nm)

(C) UV-C (~ 120 – 220 nm)

(D) UV-B and UV-C to the same extent

8. How much oxygen gas is required for the complete combustion of 1.0 mol ethane?

(A) 35 L oxygen gas

(B) 3.5 mol oxygen gas

(C) 56 g of oxygen gas

(D) 4.2 X 10^{24} oxygen molecules

9. Consider the following species:

(i) Oxygen molecule
(ii) Oxygen atom
(iii) Ammonia
(iv) Hydrogen ion
(v) Water

Which pairs react together by coordinate covalent bonding?

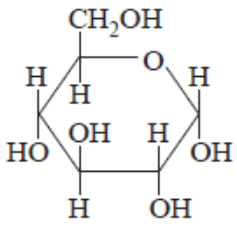
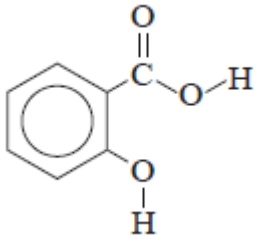
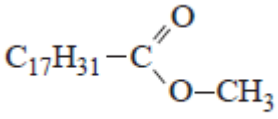
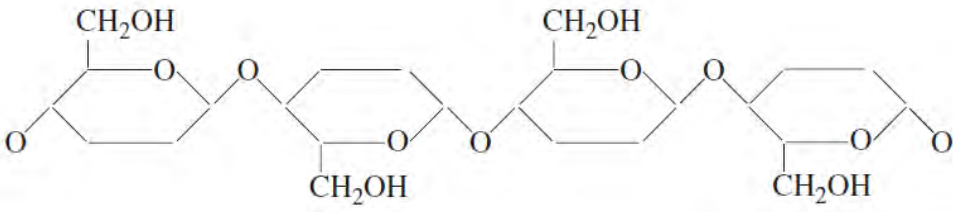
(A) (i) & (ii) and (ii) & (iii)

(B) (iv) & (v) and (i) & (v)

(C) (i) & (ii) and (i) & (iii)

(D) (iv) & (v) and (i) & (ii)

10. Which of the following chemicals is the product of a condensation polymerization reaction?

W 	X 
Y 	Z 

(A) W

(B) X

(C) Y

(D) Z

11. Which of the following reactions is a redox reaction?

(A) $Co(OH)_2(s) + 4NH_3\ (aq) \rightleftharpoons Co(NH_3)_4^{2+}\ (aq) + 2\ OH^-(aq)$

(B) $2Fe^{3+}\ (aq) + Fe\ (s) \rightleftharpoons 3Fe^{2+}(aq)$

(C) $C_{12}H_{22}O_{11}(s) \xrightarrow{dehydrating\ agent} 12\ C(s) + 11\ H_2O(l)$

(D) $Ba^{2+}\ (aq) + SO_4^{2-}\ (aq) \rightleftharpoons BaSO_4(s)$

12. Four samples of river and ocean water from different areas are tested and the results tabulated.

Which of the samples is from a polluted ocean beach?

Water sample	BOD (ppm)	Turbidity	Chloride ion concentration (mol L^{-1})	Phosphate (mg L^{-1})
(A)	4	Low	0.55	0.04
(B)	5	Very low	3.0×10^{-3}	0.1
(C)	17	High	2.2×10^{-5}	1.0
(D)	15	High	0.55	1.0

13. Given the following reactions:

(i) $CO_2\ (g) + 2\ H_2O(l) \rightleftharpoons HCO_3^-\ (aq) + H_3O^+\ (aq)$
(ii) $H_3O^+\ (aq) + OH^-(aq) \rightarrow 2\ H_2O(l)$
(iii) $NH_3\ (g) + NaH\ (s) \rightarrow NaNH_2(s) + H_2(g)$
(iv) $NH_4Cl\ (aq) + NaOH(aq) \rightarrow NaCl\ (aq) + H_2O\ (l) + NH_3(g)$

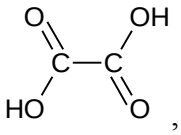
Which list contains reactants which is/are Bronsted-Lowry acid(s) only?

(A) H_3O^+, NH_3, NH_4Cl

(B) H_3O^+, CO_2, NH_4Cl

(C) NH_3, H_3O^+, NaH, NH_4Cl

(D) CO_2, H_3O^+, NaH, NH_4Cl

14. A solution of oxalic acid,  , and HCl both have a pH of 2.00.

A group of students made the following hypotheses:

(i) The oxalic acid and the HCl solutions both have the same free H_3O^+ ion concentration.
(ii) The extent of ionization of the two acids are the same.
(iii) Equal volumes of the acids will neutralize the same volume of 0.1034 mol L^{-1} NaOH.
(iv) The total number of ions in both solutions will be equal.

Which of the hypotheses is/are correct?

(A) (i), (ii), (iii) and (iv)

(B) (i), (ii) and (iii) only

(C) (i) and (iii) only

(D) (i) only

15. The natural indicator, H_2Z , exhibits several colours as the pH changes. This may be explained by the stepwise ionization of H_2Z shown by the equations and the subsequent mixing of coloured ions at particular pH values.

$H_2Z + H_2O \rightleftharpoons HZ^- + H_3O^+$
red *yellow*

$HZ^- + H_2O \rightleftharpoons Z^{2-} + H_3O^+$
yellow *blue*

If the indicator is yellow in ammonium chloride solution, what will its colour be in sodium hydroxide, hydrochloric acid and sodium acetate solutions?

Note: red+ yellow = orange and blue + yellow = green.

	sodium hydroxide	*hydrochloric acid*	*sodium acetate*
(A)	blue	red	green
(B)	blue	yellow	green
(C)	green	red	blue
(D)	yellow	blue	green

16. What will be the pH of a solution prepared by mixing 10.0 mL of a 0.200 mol L^{-1} hydrochloric acid and 5.00 mL of 0.120 mol L^{-1} barium hydroxide solutions and diluting the mixture to 100.0 mL?

(A) 3.10

(B) 2.10

(C) 1.27

(D) 12.7

17. If concentrated acid is spilled on the laboratory bench, which of the following measures can best significantly reduce the damage to humans and to the environment?

(A) Carefully pour water on the acid and then mop up with paper towel with gloved hands.

(B) Carefully add solid sodium hydrogen carbonate and scoop the excess wet sodium hydrogen carbonate with a plastic dust pan with gloved hands.

(C) Carefully pour a solution of sodium hydrogen carbonate on the acid and then mop up with paper towel with gloved hands.

(D) Carefully add solid sodium hydroxide on the acid and then scoop the excess wet sodium hydroxide with a plastic dust pan with gloved hands.

18. A student determined the total dissolved solids in a sample of river water by the evaporation technique. A 9.60 L sample of drinking water was filtered. The dried residue in the filter paper had a mass of 1.22 g. When the filtrate was evaporated to dryness, it yielded a residue of 4.11 g.

What is the concentration of the total dissolved solids in ppm?

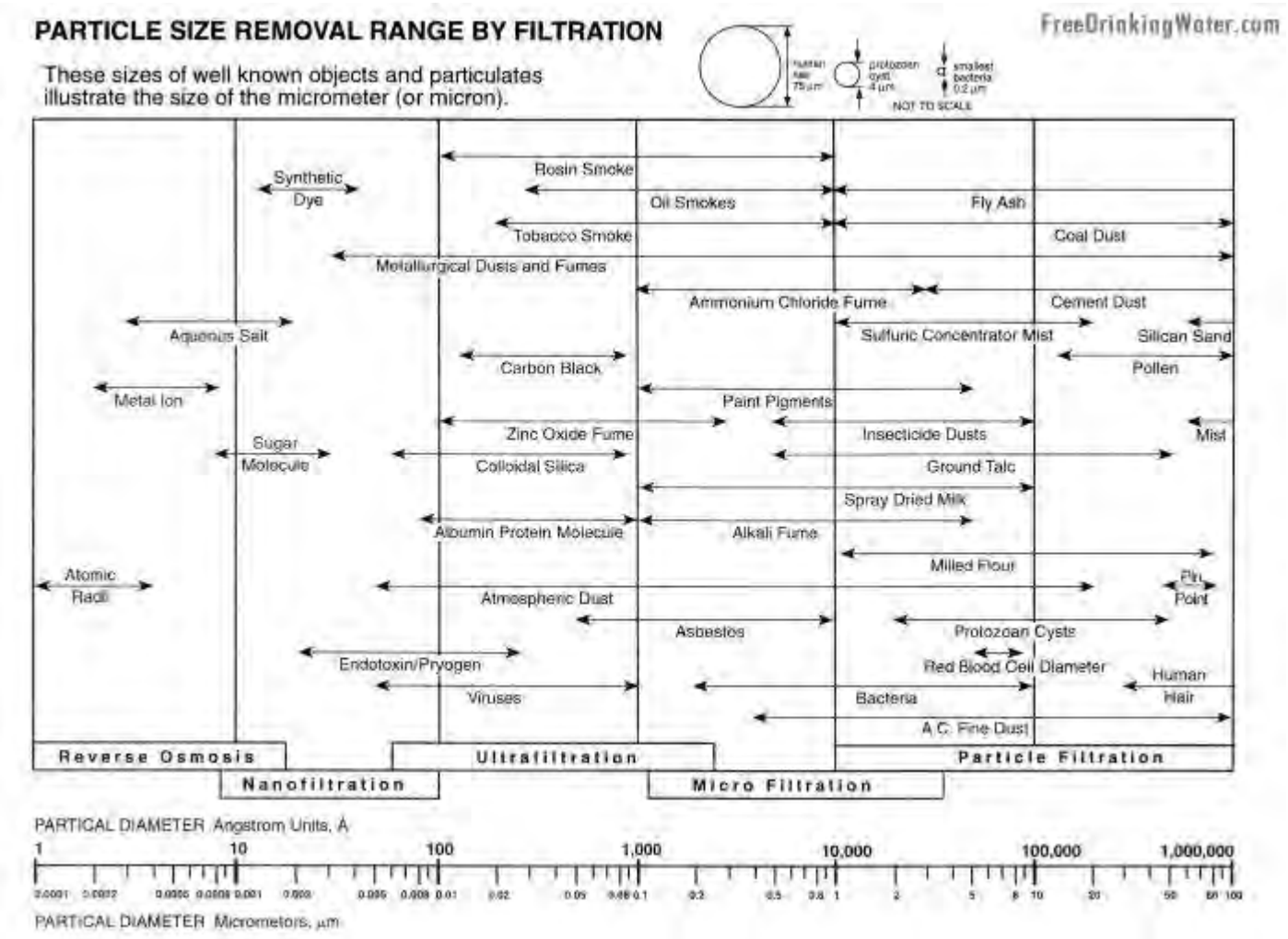
(A) 127

(B) 301

(C) 428

(D) 555

19. Examine the table on the particle removal range of various filters



From: http://www.freedrinkingwater.com/water-education/quality-water-filtration-method.htm

Town water supply is typically contaminated with fine dust, protozoan cysts, atmospheric dust and certain viruses.

Which of the techniques of filtration sequentially applied would be most useful to purify the water?

(A) Particle filtration → micro filtration → ultrafiltration

(B) Ultrafiltration → micro filtration → particle filtration

(C) Ultrafiltration→ nanofiltration → reverse osmosis

(D) Reverse osmosis → nanofiltration → ultrafiltration

20. Which of the following is least stable in the atmosphere?

(A) An oxygen molecule because it is the most reactive

(B) An ozone molecule because it is the least reactive

(C) An oxygen free radical because it is the most reactive

(D) An oxide ion because it is the least reactive

Student Number …….

Section I **Mark -----/20**

Part A

Multiple Choice Answer Sheet

1.	A ○	B○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○
11.	A ○	B ○	C ○	D ○
12.	A ○	B ○	C ○	D ○
13	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15.	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○
19.	A ○	B ○	C ○	D ○
20.	A ○	B ○	C ○	D ○

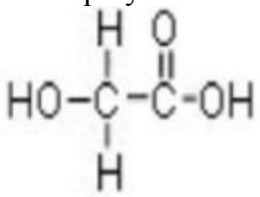
Part B. 55 marks
Attempt questions 21 – 31.
Allow about 1 hour and 40 minutes for this part.

- 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.

Marks

Question 21 (5 marks)

Polyglycolic acid (PGA) is a biodegradable polyester used in surgery for self-dissolving sutures. PGA is created from the polymerization of glycolic acid.



(a) Give an equation for the reaction between two glycolic acid molecules. **2**

(b) For effective application, the suture fibre requires a molecular mass of at least 60,000. Calculate the average number of units per molecule for this mass. **1**

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(c) Give an explanation for the biodegradable properties of PGA. **2**

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Question 22 (3 marks) **Mark(s)**

(a) Identify one radioisotope commonly used in industry. **1**

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(b) Describe the use of the above named radioisotope. **2**

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Question 23 (3 marks)

Write a balanced chemical equation showing the reaction between butanoic acid and ethanol using structural formula. Name the products formed. **3**

Student Number …….

Marks

Question 24 (4 marks)

(a) Identify a heavy metal ion which may cause pollution of waterways. **1**

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(b) Describe a chemical test which could be used to monitor the presence and concentration of this heavy metal in waterways. Include a relevant chemical equation in your answer. **3**

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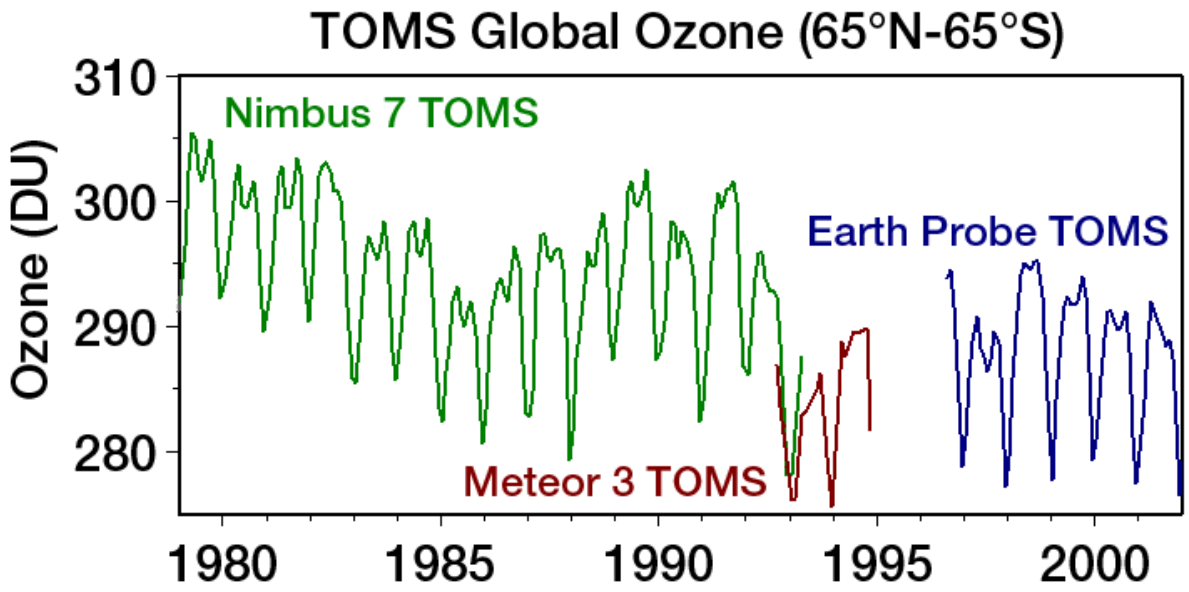
Marks

Question 25 (4 marks)

There have been concerns about changes in atmospheric ozone in the stratosphere since the 1970s. Measurements of the changes in atmospheric ozone have been conducted since the early 1980s. The graph below shows a record of these changes as recorded by the Nimbus & TOMS satellites.

Note: No data was recorded in 1996.



Analyse the information provided in the graph above that shows atmospheric ozone concentrations. **4**

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Student Number……..

Marks

Question 26 (6 marks)

Evaluate the significance of the Haber process at the time of its development during World War I. **6**

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Marks

Question 27 (5 marks)

The lead acid battery was invented by Gaston Plante in 1859 and George Leclange invented the dry cell battery in 1866. The first commercial carbon-zinc battery similar to the Leclange's was first commercially produced in 1896.

Using either the dry cell or the lead- acid cell, assess and justify the development of a modern commercial battery in terms of chemistry and its impact on society. **5**

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Student Number …….

Marks

Question 28 (5 marks)

The Winkler method is used to determine the amount of dissolved oxygen in water. The method depends on the oxidation of Mn^{2+} to Mn^{3+} by the dissolved oxygen in the water. Iodide ions, added to the mixture, in turn, reduce the Mn^{3+} back to Mn^{2+} producing iodine (I_2). The iodine produced is reacted with sodium thiosulfate solution of known concentration. The amount of sodium thiosulfate solution consumed is indicative of the dissolved oxygen level. The overall reaction between dissolved oxygen and sodium thiosulfate is given by the equation:

$O_2\ (g)\ +\ 4\ Na_2S_2O_3\ (aq)\ +\ 2\ H_2SO_4\ (aq) \rightarrow 2Na_2S_4O_6\ (aq)\ +2\ Na_2SO_4\ (aq)\ +2\ H_2O\ (l)$

(a) If 50.0 mL of a water sample requires 8.00 mL of 0.0100 mol L^{-1} $Na_2S_2O_3$ solution. What is the concentration of dissolved oxygen in % (w/v) in the water sample? **3**

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(b) If all the dissolved oxygen in a 1.00 L sample of the water is boiled off and collected, what volume will the oxygen gas occupy at 25°C and 100 kPa? **2**

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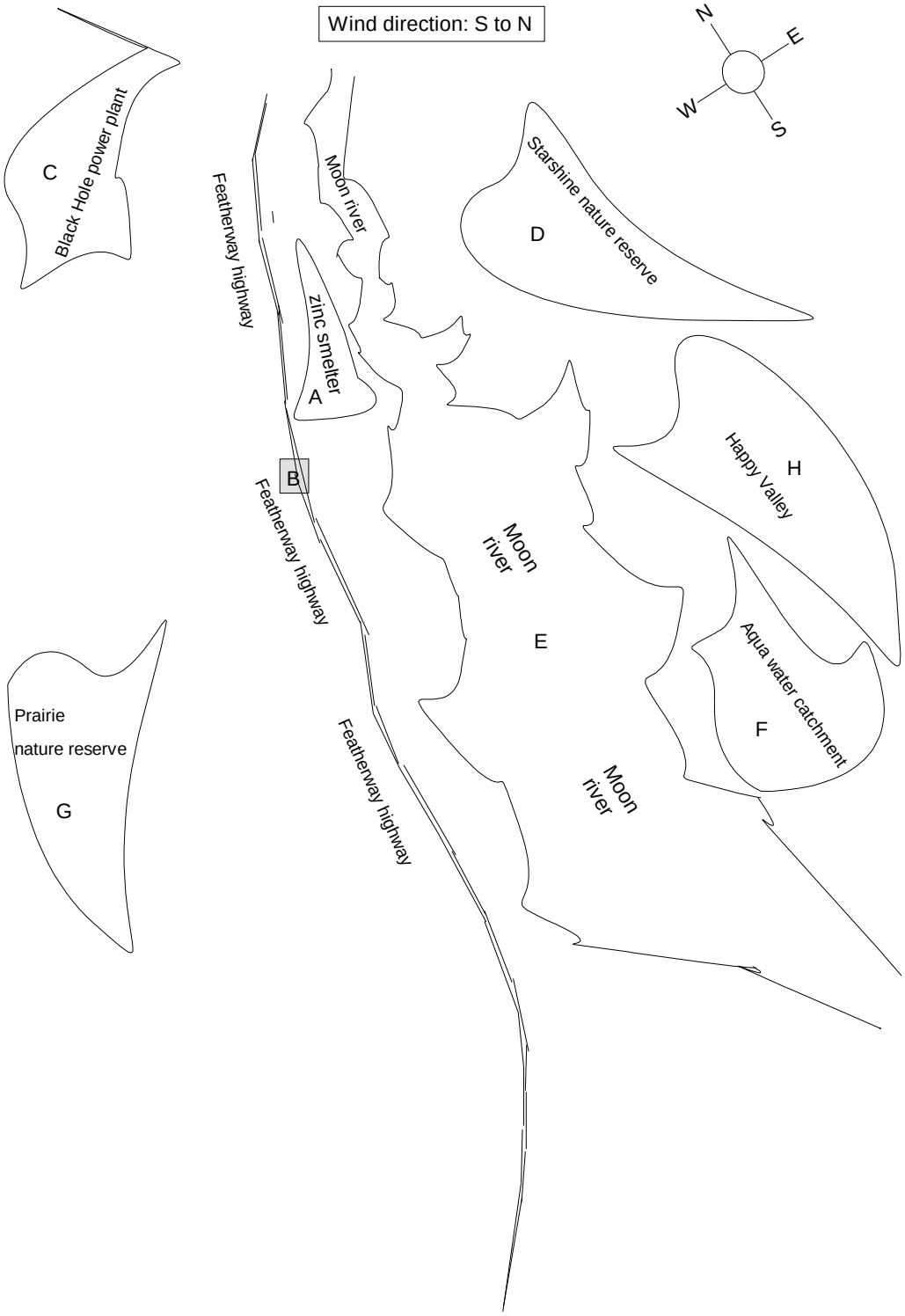
Question 29 (5 marks)

Noxious gases were measured in the JR Shire (see diagram). These measurements are given on the next page.



Question 29 continues on the next page

Marks

Question 29 continues…

Examine the diagram and the table below giving the measurements of atmospheric SO_2 and NO_2 for various areas given in the table.

Area	*Name of area as given in the diagram*	*SO_2 (ppb)*	*NO_2(ppb)*
A	Zinc smelter	200	100
B	Feather way highway	180	100
C	Black Hole power plant	300	200
D	Starshine nature reserve	100	50
E	Moon river	100	50
F	Aqua water catchment	10	2
G	Prairie nature reserve	10	25
H	Happy valley	10	0

Explain using equations, why there are high levels of SO_2 and NO_2 in areas A, B and C. **5**

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Marks

Question 30 (7 marks)

A buffer is a solution that resists changes in pH when small amounts of acid or alkali are added to it.

(a) Use equilibrium principles and the Bronsted – Lowry theory to compare the change in pH of a 1:1 molar solution of $CaCl_2$ - HCl and a 1:1 molar solution of $NaH_2PO_4 – Na_2HPO_4$ when a small amount of acid is added to the mixture. Include an equation in your answer. **5**

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(b) Why is the Arrhenius theory inadequate to explain the difference in behaviour? **2**

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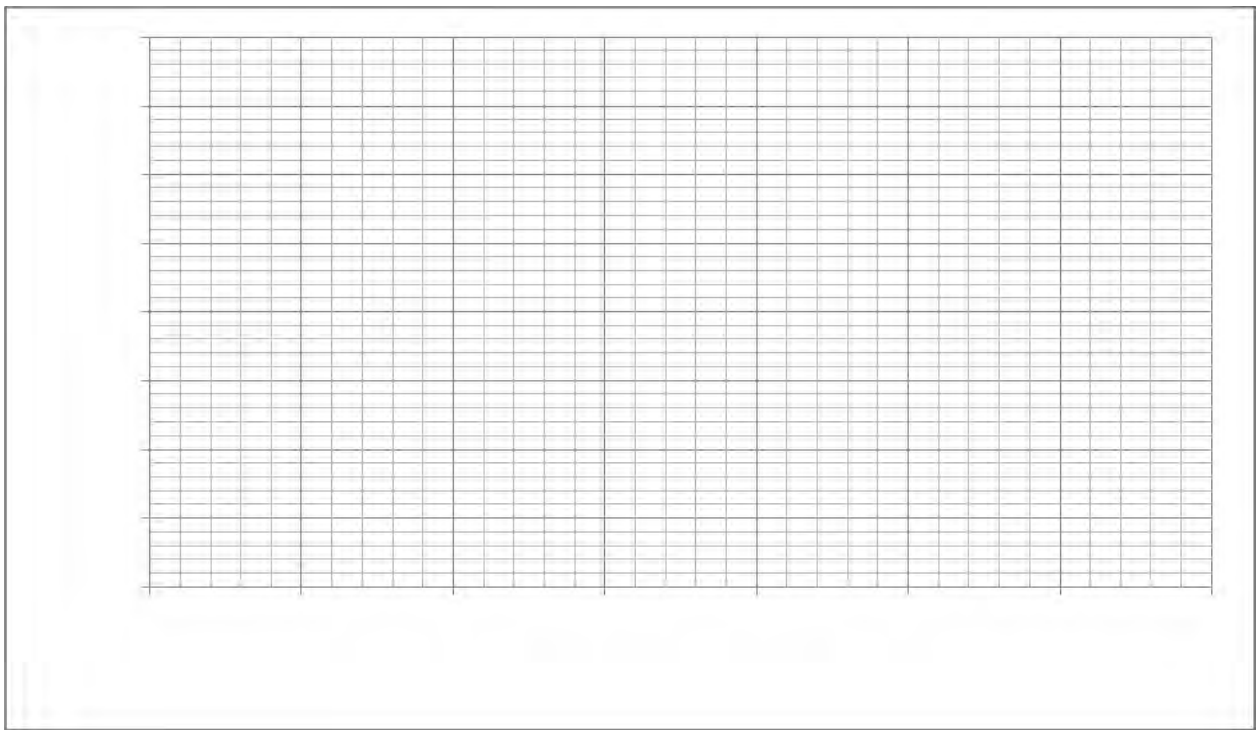
Marks

Question 31 (8 marks)

A student living in the country wanted to determine the hardness of her town water supply. She used both AAS and EDTA titration to determine the level of Ca^{2+} ions in her water supply. She collected two samples of the water, taken at 6 am and 6 pm everyday for ten consecutive days: 20 samples in all.
The AAS instrument she used was provided with a calcium lamp. For the measurements, she prepared four replicate standard solutions of Ca^{2+} ranging from 10.0 to 30.0 ppm. She passed each standard solution (12 solutions) and the 20 water samples several times through the AAS instrument. She then averaged the results and recorded them in the table.

Standard Solutions (ppm)	*Average absorbance*
0.00	0.000
10.0	0.230
20.0	0.470
30.0	0.723
Water samples	0.600

(a) Plot the data from the table. **2**



(b) Use the graph to determine the concentration of the Ca^{2+} in ppm in the water sample. **1**

Ca^{2+} ion concentration: ……

Question 31 continues on the next page

Marks

(c) For comparison, the student also determined the Ca^{2+} concentration by EDTA titration.

She took 100.00 mL from each of the 20 water samples to give a total volume of 2.000 L, evaporated the 2.000 L sample to about 50 mL and then diluted to 100.00 mL in a volumetric flask. From this flask, she took a 20.00 mL aliquot and titrated it with a 0.02510 mol L^{-1} sodium EDTA solution. EDTA reacts with both calcium ion and magnesium ion in a 1:1 ratio.

She repeated the titration three more times and tabulated the results.

Trial	Volume of EDTA solution (mL)
1	14.50
2	13.25
3	13.23
4	13.24

(i) Calculate the hardness in ppm of the water sample in terms of Ca^{2+} ion. **3**

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(ii) Explain the discrepancy in the results of the two techniques used for the analyses. **2**

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Proceed to Question 32 on the next page

Section II Elective Question: Industrial Chemistry

25 marks
Attempt question 32
Allow about 45 minutes for this section

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

Question 32

(a) The most common method for the industrial production of hydrogen is the steam reforming process, given by the following reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +207 \text{ kJ mol}^{-1}$$

(i) Using Le Chatelier's principle, explain the general conditions of temperature and pressure that would favour the production of hydrogen. **4**

(ii) At 1500 ^{o}C the concentrations of the gases in a particular equilibrium mixture were found to be

$[CH_4] = 0.400 \text{ mol L}^{-1}$ $[CO] = 0.300 \text{ mol L}^{-1}$ $[H_2O] = 0.068 \text{ mol L}^{-1}$

and K = 5.67 at 1500^0C for the reaction.

Give an equilibrium expression for the steam reforming process and calculate the concentration of hydrogen in the reaction mixture at equilibrium. **2**

(b) Identify two reaction conditions used to produce sulfur trioxide from sulfur dioxide and explain how these conditions maximize the rate and yield of sulfur trioxide. **4**

(c) Glyceryl tristearate can be reacted with sodium hydroxide solution in the production of soap.

(i) Identify the products of this saponification reaction. **2**

(ii) Account for the cleaning action of this soap by describing its structure and effect as an emulsifier. **4**

(d) Describe the mercury process used for producing sodium hydroxide. Include in your answer the chemistry and an environmental impact associated with the process. **6**

Question 32 continues on page 25

Question 32 continues…

(e) Sodium carbonate is manufactured by the Solvay process.

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

(ii) Describe the chemistry involved in the purification of brine in the Solvay process. **2**

End of paper

2012

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Chemistry ANSWERS

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

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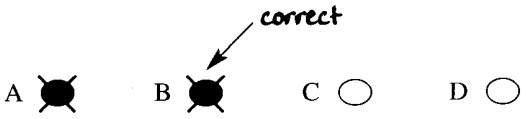

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1. A catalyst is used in the production of ethanol from ethylene and in the reverse process of the production of ethylene from ethanol.
Which is the catalyst used for each of the productions listed above in correct sequence?

(A) Concentrated H_2SO_4 and dilute H_2SO_4

(B) Concentrated H_2SO_4 for both processes

(C) Dilute H_2SO_4 and concentrated H_2SO_4

(D) Dilute H_2SO_4 for both processes

2. Which of the following can be used to detect radiation?

(A) A scintillation counter

(B) A data logger

(C) A voltmeter

(D) A spectrophotometer

3. Why is ethanol used as a major constituent of perfumes?

(A) Ethanol is cheap.

(B) Ethanol has a low density

(C) Ethanol is inflammable.

(D) Ethanol is a good solvent.

4. Which statement best describes the boiling points within a homologous series?

(A) They decrease as the molecules become larger.

(B) They are all approximately the same.

(C) They increase as the molecular weight increases.

(D) They are independent of intermolecular forces.

5. Which statement best defines the term "specific heat capacity" of a pure substance?

(A) The amount of heat needed to melt a pure substance.

(B) The amount of heat needed to boil a pure substance.

(C) The amount of heat needed to increase the temperature of 1.0 g of a pure substance by 1^0C.

(D) The amount of heat needed to increase the temperature of 1.0 mol of a pure substance by 1^0C.

6 A 250 mL sample of rainwater is titrated using 0.0095 mol L^{-1} sodium hydroxide solution. If 8.3 mL of the sodium hydroxide solution was required to reach the endpoint, what was the pH of the rainwater?

(A) 0.54

(B) 3.50

(C) 4.50

(D) 5.40

7. Which type(s) of UV penetrate(s) the atmosphere most?

(A) UV-A (~ 320 – 400 nm)

(B) UV-B (~ 220 – 320 nm)

(C) UV-C (~ 120 – 220 nm)

(D) UV-B and UV-C to the same extent.

8. How much oxygen gas is required for the complete combustion of 1.0 mol ethane?

(A) 35 L oxygen gas

(B) 3.5 mol oxygen gas

(C) 56 g of oxygen gas

(D) 4.2×10^{24} oxygen molecules

9. Given the following substances:

(i) oxygen molecule
(ii) oxygen atom
(iii) ammonia
(iv) hydrogen ion
(v) water

Which pairs react together by coordinate covalent bonding?

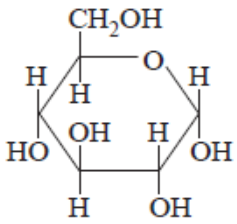
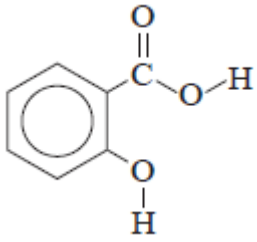
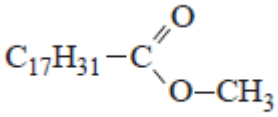
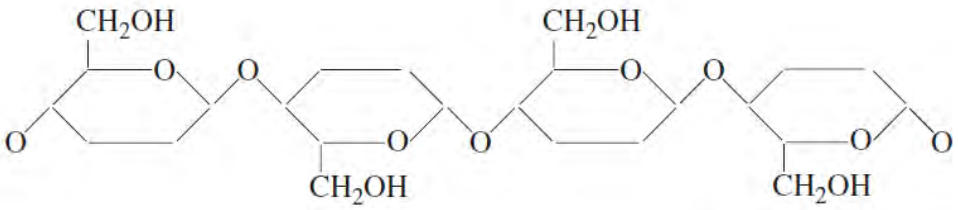
(A) (i) & (ii) and (ii) & (iii)

(B) (iv) & (v) and (i) & (v)

(C) (i) & (ii) and (i) & (iii)

(D) (iv) & (v) and (i) & (ii)

10. Which of the following chemicals is the product of a condensation polymerization reaction?

W 	X 
Y 	Z 

(A) W

(B) X

(C) Y

(D) Z

11. Which of the following reactions is a redox reaction?

(A) $Co(OH)_2(s) + 4NH_3\ (aq) \rightarrow\ Co(NH_3)_4^{2+}\ (aq) +\ 2\ OH^-(aq)$

(B) $\mathbf{2Fe^{3+}\ (aq) +\ Fe\ (s)} \rightleftharpoons \mathbf{3Fe^{2+}(aq)}$

(C) $C_{12}H_{22}O_{11}(s) \xrightarrow[dehydrating\ agent]{} 12\ C(s)\ +\ 11\ H_2O(l)$

(D) $Ba^{2+}\ (aq)\ +\ SO_4^{2-}\ (aq) \rightarrow\ BaSO_4(s)$

12. Four samples of river and ocean water, from different areas, are tested and the results tabulated as follows:
Which of the samples is from a polluted ocean beach?

Water sample	BOD (ppm)	Turbidity	Chloride ion concentration (mol L^{-1})	Phosphate (mg L^{-1})
(A)	4	Low	0.55	0.04
(B)	5	Very low	3.0×10^{-3}	0.1
(C)	17	High	2.2×10^{-5}	1.0
(D)	**15**	**High**	**0.55**	**1.0**

13. Given the following reactions:

(i) $CO_2\ (g)\ +\ 2\ H_2O(l) \rightleftharpoons\ HCO_3^-\ (aq) + H_3O^+\ (aq)$
(ii) $H_3O^+\ (aq)\ +\ OH^-(aq) \rightarrow 2\ H_2O(l)$
(iii) $NH_3\ (g) + NaH\ (s) \rightarrow NaNH_2(s)\ +\ H_2(g)$
(iv) $NH_4Cl\ (aq) + NaOH(aq) \rightarrow NaCl\ (aq) + H_2O\ (l)\ + NH_3(g)$

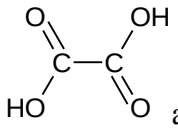
Which list contains reactants which is/are Bronsted-Lowry acid(s) only?

(A) $\mathbf{H_3O^+, NH_3, NH_4Cl}$

(B) H_3O^+, CO_2, NH_4Cl

(C) $NH_3, H_3O^+, NaH, NH_4Cl$

(A) $CO_2, H_3O^+, NaH, NH_4Cl$

14. A solution of oxalic acid,  and HCl both have a pH of 2.00.

A group of students made the following hypotheses:

(i) The oxalic acid and the HCl solutions both have the same free H_3O^+ ion concentration.
(ii) The extent of ionization of the two acids are the same.
(iii) Equal volumes of the acids will neutralize the same volume of 0.1034 mol L^{-1} NaOH.
(iv) The total number of ions in both solutions will be equal.

Which of the hypotheses is/are correct?

(A) (i), (ii),(iii) and (iv)

(B) (i), (ii) and (iii) only

(C) (i) and (iii) only

(D) (i) only

15. The natural indicator, H_2Z , exhibits several colours as the pH changes. This may be explained by the stepwise ionization of H_2Z shown by the equations and the subsequent mixing of coloured ions at particular pH values.

$$H_2Z + H_2O \rightleftharpoons HZ^- + H_3O^+$$
red *yellow*

$$HZ^- + H_2O \rightleftharpoons Z^{2-} + H_3O^+$$
yellow *blue*

If the indicator is yellow in ammonium chloride solution, what will its colour be in sodium hydroxide, hydrochloric acid and sodium acetate solutions?
Note: red+ yellow = orange and blue + yellow = green.

	sodium hydroxide	*hydrochloric acid*	*sodium acetate*
(A)	**blue**	**red**	**green**
(B)	blue	yellow	green
(C)	green	red	blue
(D)	yellow	blue	green

16. What will be the pH of a solution prepared by mixing 10.0 mL of a 0.200 mol L^{-1} hydrochloric acid and 5.00 mL of 0.120 mol L^{-1} barium hydroxide solutions and diluting the mixture to 100.0 mL?

(A) 3.10

(B) 2.10

(C) 1.27

(D) 12.7

17. If concentrated acid is spilled on the laboratory bench, which of the following measures can best significantly reduce the damage to humans and to the environment?

(A) Carefully pour water on the acid and then mop up with paper towel with gloved hands.

(B) Carefully add solid sodium hydrogen carbonate and scoop the excess wet sodium hydrogen carbonate with a plastic dust pan with gloved hands.

(C) Carefully pour a solution of sodium hydrogen carbonate on the acid and then mop up with paper towel with gloved hands.

.

(D) Carefully add solid sodium hydroxide on the acid and then scoop the excess wet sodium hydroxide with a plastic dust pan with gloved hands.

18 A student determined the total dissolved solids in a sample of river water by the evaporation technique. A 9.60 L sample of drinking water was filtered. The dried residue in the filter paper had a mass of 1.22 g . When the filtrate was evaporated to dryness. it yielded a residue of 4.11 g.

What is the total dissolved solids in ppm?

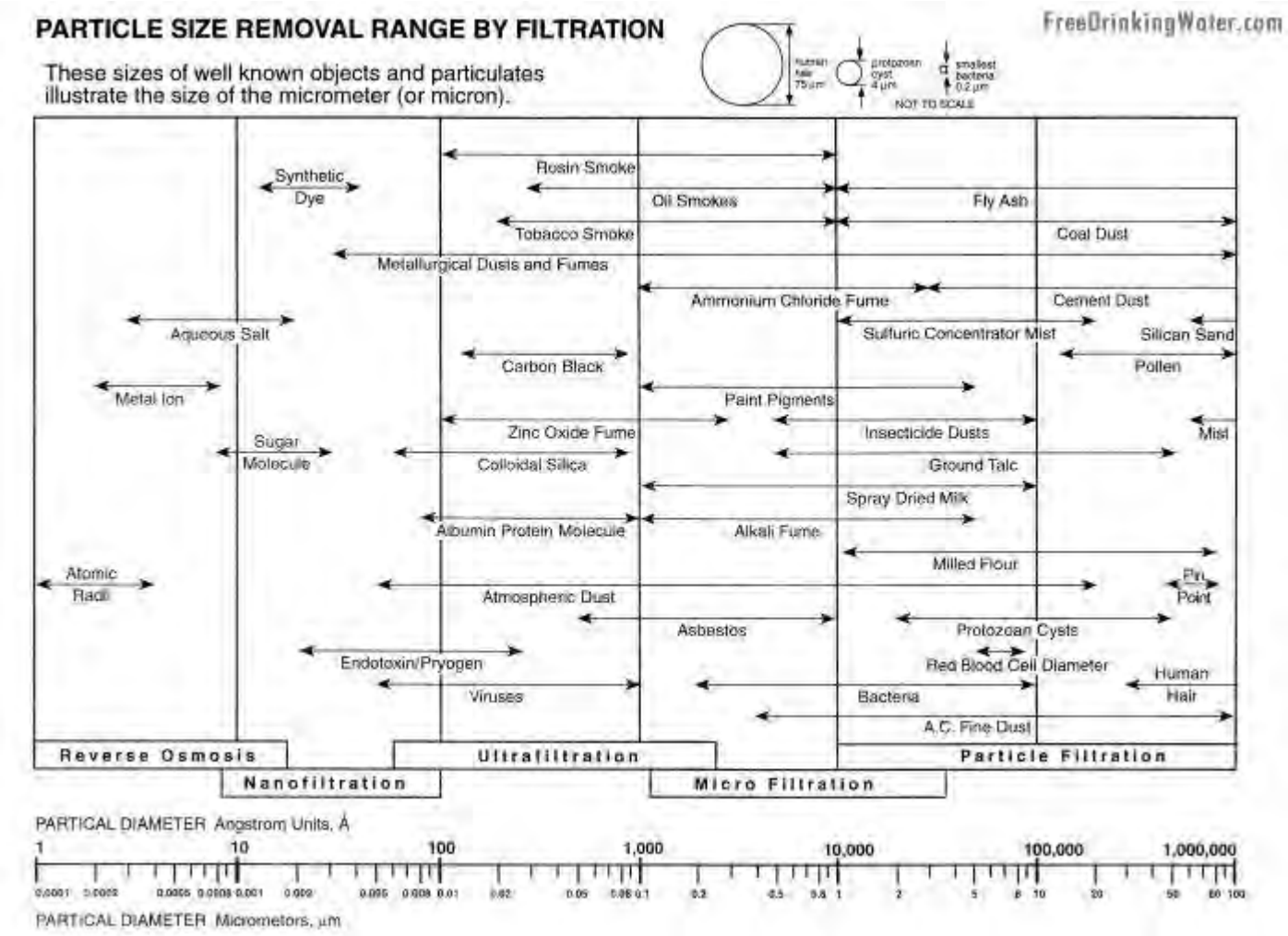
(A) 127

(B) 301

(C) 428

(D) 555

19. Examine the table on the particle removal range of various filters



From: http://www.freedrinkingwater.com/water-education/quality-water-filtration-method.htm

Town water supply is typically contaminated with fine dust, protozoan cysts, atmospheric dust and certain viruses.

Which of the techniques of filtration sequentially applied would be most useful to purify the water?

(A) **Particle filtration → micro filtration → ultrafiltration**

(B) Ultrafiltration → micro filtration → particle filtration

(C) Ultrafiltration→ nanofiltration → reverse osmosis

(D) Reverse osmosis → nanofiltration → ultrafiltration

20. Which of the following is least stable in the atmosphere?

(A) An oxygen molecule because it is the most reactive.

(B) An ozone molecule because it is the least reactive.

(C) An oxygen free radical because it is the most reactive.

(D) An oxide ion because it is the least reactive.

Student Number …….

Section I **Mark -----/20**

Part A

Multiple Choice Answer Sheet

1.	A ○	B○	C ●	D ○
2.	A ●	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ●
4.	A ○	B ○	C ●	D ○
5.	A ○	B ○	C ●	D ○
6.	A ○	B ●	C ○	D ○
7.	A ●	B ○	C ○	D ○
8.	A ○	B ●	C ○	D ○
9.	A ○	B ○	C ○	D ●
10.	A ○	B ○	C ○	D ●
11.	A ○	B ●	C ○	D ○
12.	A ○	B ○	C ○	D ●
13	A ●	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ●
15.	A ●	B ○	C ○	D ○
16.	A ○	B ●	C ○	D ○
17.	A ○	B ●	C ○	D ○
18.	A ○	B ○	C ●	D ○
19.	A ●	B ○	C ○	D ○
20.	A ○	B ○	C ●	D ○

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

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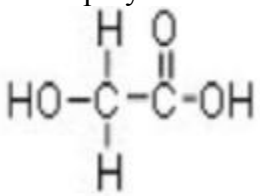
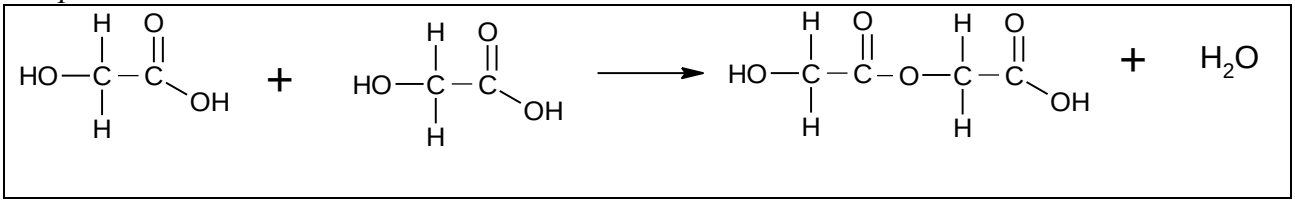
Question 21 (5 marks)

Polyglycolic acid (PGA) is a biodegradable polyester used in surgery for self-dissolving sutures.
PGA is created from the polymerization of glycolic acid.



(a) Give an equation for the reaction between two glycolic acid molecules. **2**

Sample answer



Marking Criteria	*Mark*
Correct equation with reactants and both products	2
One correct product	1

(b) For effective application, the suture fibre requires a molecular mass of at least 60,000.
Calculate the average number of units per molecule for this mass. **1**

Sample Answer
One glycolate unit mass = (2 x 12) +(2 x 16) + (2 x 1) = 58
One molecule = 60,000/58 = 1035 monomer units *(1 mark)*
Outcomes : H9, H10

(c) Give an explanation for the biodegradable properties of PGA. **2**

Sample answer
A biodegradable substance can be broken down into simpler molecules by natural processes in the environment.
As the body has aqueous and acidic solutions, the environment of the sutures is capable of breaking down the polymer into simpler monomer units.

Marking Criteria	*Mark*
Defines biodegradable and explains the conditions of the body are capable of reversing the polymerization.	2
Defines biodegradable OR Outlines that the conditions of the body are capable of reversing the polymerization.	1

Question 22 (3 marks)

(a) Identify one radioisotope commonly used in industry. **1**

Sample Answer : Caesium – 137

Marking Criteria

Criteria	*Mark*
Correct identification of one radioisotope used in industry	1

(b) Describe the use of the above named radioisotope. **2**

Sample Answer :

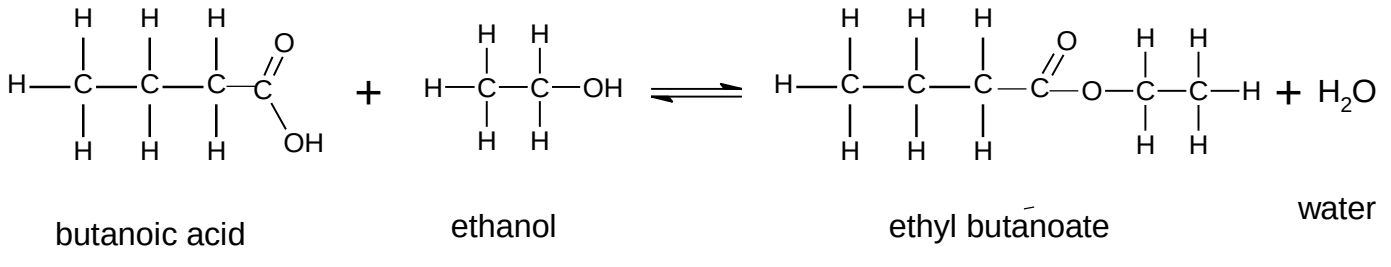
Used to monitor and control the thickness of materials eg. Steel, aluminium, paper sheets. OR irradiation of food etc.

Marking Criteria

Criteria	Mark
Describes the use of the named radioisotope	2
States the use of named radioisotope	1

Question 23 (3 marks)

Write a balanced chemical equation showing the reaction between butanoic acid and ethanol using structural formula. Name the products formed. **3**



Question 24 (4 marks)

(a) Identify a heavy metal ion which may cause pollution of waterways. **1**

Sample Answer : Pb^{2+} or Lead

Marking Criteria

Criteria	*Mark*
Correct identification of one heavy metal ion polluting waterways	1

(b) Describe a chemical test which could be used to monitor the presence and concentration of this heavy metal in waterways. Include a relevant chemical equation in your answer. **3**

Sample Answer :

In a school laboratory, heavy metals may be detected by adding sodium sulfide solution to a higher concentration sample of water collected from ma stream ; the heavy metal ion reacts with the sulfide ion to form sulfide precipitates.

Eg Pb^{2+} + S^{2-} $\rightarrow PbS(s)$
The concentration of the metal ion could be determined by gravimetric analysis ie precipitation from a known volume of sample then filter, dry and weigh precipitate.
Or using AAS using specific hollow cathode lamp and standard concentrations to construct a calibration curve then analyse sample against calibration curve.

Outcome(s):H4

Marking Criteria

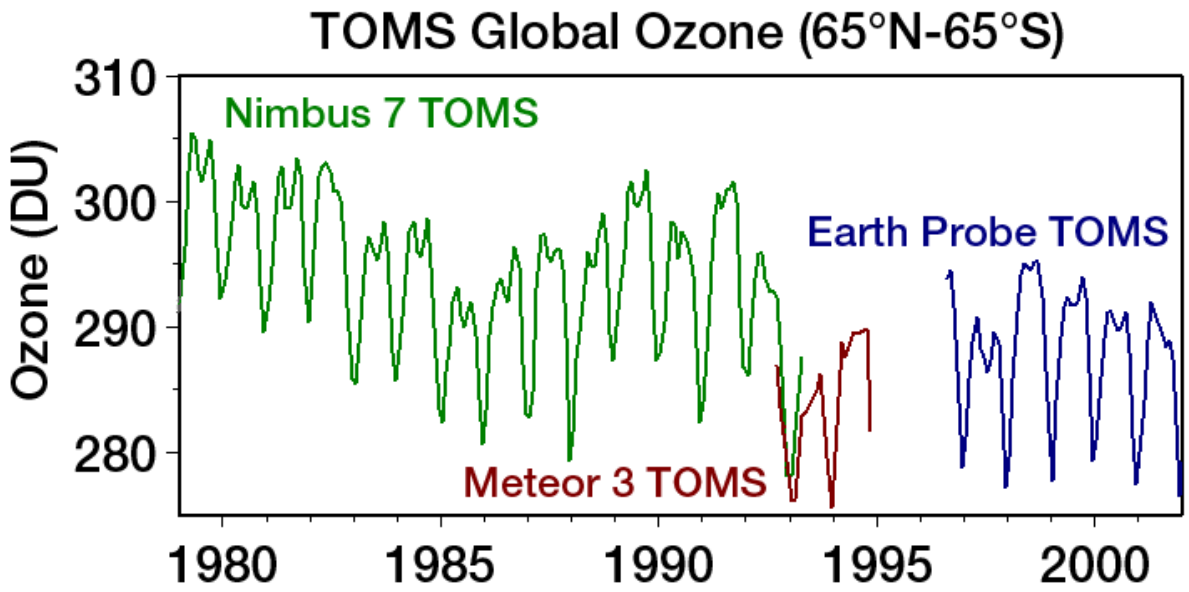
Criteria	*Mark*
Correct description of a chemical test including an equation; must have one qualitative and one quantitative test clearly described to get full marks	3
One of the above missing	2
Correct description or equation or of either a qualitative or quantitative test	1

Question 25 (4 marks)

There have been concerns about changes in atmospheric ozone in the stratosphere since the 1970s. Measurements of the changes in atmospheric ozone have been conducted since the early 1980s. The graph below shows a record of these changes as recorded by the Nimbus & TOMS satellites.

Note: No data was recorded in 1996.

Mark(s)



Analyse the information provided in the graph above that indicates changes in atmospheric ozone concentrations. **4**

Sample Answer:

The graph shows information gained from the 1970s to 200s which was gained from spectrophotometers eg Nimbus and TOMS satallites. The graph indicates that there has been a decrease in ozone levels since the early 1980s with a dramatic decrease in the early 1990s. Since then the levels have increased slightly then fallen again and remained at this lower level through the 2000s. These results correlate with the signing of the Montreal Protocol in the early 1990s which resulted in a decrease in the levels of CFCs going into the atmosphere thus a correlation in the drop of the level of ozone depletion at this time as shown in the graph. There is a slow increase and stabilization after 1998 which is a few years after the signing of the Montreal protocol ie a reduction in the use of CFCs thus allowing ozone levels to recover to some extent.
The graph also shows seasonal fluctuations in ozone levels which correspond to drops in ozone levels in spring time.
Outcomes H4, H13

Marking Criteria

Criteria	Marks
Thorough analyses of graph and explanation of changes in ozone levels due to CFC and effect of Montreal protocol	4
One of the above missing	3

Description of graph only without analysis of chemistry	2
Identification of one factor related to data in graph	1

Question 26 (6 marks)

Evaluate the significance of the Haber process at the time of its development during WW1. **6**

Outcome(s):H1, H3, H13

Sample Answer :
The development of the Haber process happened at a crucial time in history. During WW1, the British Royal navy blockaded shipments of saltpetre to Germany from South America. This was the only source of nitrates for the Germans to use in the production of fertilisers and explosives. The Haber process allowed the production of ammonia which was then used to produce synthetic fertilisers to grow crops to feed a population during the war years.It also allowed the production of nitric acid which was used to make explosives eg TNT and nitroglycerine. This prolonged the war.
Evaluation :
The development of the Haber process, while it prolonged WW1 in the short term, has in the long term allowed for large scale production of fertilisers and crops which has benefited the whole of humanity as world population increased.

Marking Criteria

Criteria	*Mark*
Evaluation of the development of the Haber process including a thorough description and analyses of the political and social situation at the time (WW1)	6
Discussion of the development of the Haber process at that time in history	5
Description of the development of the Haber process	4
Outline of the development of the Haber process	3
Statement relating to the historical and social implication of the development of the Haber process	2
Identification of one historical or social implication of the development of the Haber process	1

Mark(s)

Question 27 (5 marks)

The lead acid battery was invented by Gaston Plante in 1859 and George Leclange invented the dry cell battery in 1866. The first commercial carbon-zinc battery similar to the Leclange's was first commercially produced in 1896.

Using either the dry cell or the lead- acid cell, assess and justify the development of a modern commercial battery in terms of chemistry and its impact on society. **5**

Outcome: H13, H1,H3,H4,H7

Sample Answer:

The Leclange battery is inexpensive, available in a variety of sizes and suitable for a wide range of application. It, however, tends to leak because of the acidic electrolyte eroding the zinc canister and the production of hydrogen gas. There was a need for a more innovative product.

anode: $Zn \rightarrow Zn^{2+} + 2e^-$
cathode $2\,MnO_2 + 2H^+ + 2e^- \rightarrow Mn_2O_3 + H_2O$
overall: $Zn + 2\,MnO_2 + 2H^+ \rightarrow Mn_2O_3 + H_2O$

An innovative battery and an improvement on the the Leclange is the development of the button cell. In this battery much of the shortcomings of the Leclange battery are overcome in addition to the size. Because the electrolyte is KOH instead of ammonium chloride, the battery does not leak as the zinc is not converted to Zn ions but to impervious ZnO. Because both reactants and products are solids, (see the overall reaction) the generated power of the battery does not gradually decrease.

anode: $Zn(s) + 2\,OH^- \rightarrow ZnO(s) + H_2O(l) + 2e^-$
cathode: $Ag_2O(s) + H_2O(l) + 2e^- \rightarrow 2\,Ag(s) + 2\,OH^-$

Overall: : $Ag_2O(s) + Zn(s) \rightarrow ZnO(s) + 2\,Ag(s)$

The dry cell have had a large impact on society by making flashlights, radios and some toys among others portable. An even larger impact is the button cell which has revolutionized treatment of medical conditions such as deafness (hearing aid), heart condition, (pacemaker) small calculators possible.

Criteria	*Mark(s)*
Discussion of the chemistry of the dry cell and the button cell, *Discussion of the disadvantages of the dry cell or the lead acid battery*	*2* *1*
Discussion of the impact of the batteries(Leclange and modern) on society	*2*

Mark(s)

Question 28 (5 marks)

The Winkler method is used to determine the amount of dissolved oxygen in water. The method depends on the oxidation of Mn^{2+} to Mn^{3+} by the dissolved oxygen in the water. Iodide ions, added to the mixture, in turn, reduce the Mn^{3+} back to Mn^{2+} producing iodine (I_2). The iodine produced is reacted with sodium thiosulfate solution of known concentration. The amount of sodium thiosulfate solution consumed is indicative of the dissolved oxygen level. The overall reaction between dissolved oxygen and sodium thiosulfate is given by the equation:

$O_2\,(g) \;+\; 4\,Na_2S_2O_3\,(aq) \;+\; 2\,H_2SO_4\,(aq) \rightarrow 2Na_2S_4O_6\,(aq) \;+ 2\,Na_2SO_4\,(aq) \;+ 2\,H_2O\,(l)$

(a) If 50.0 mL of a water sample requires 8.00 mL of 0.0100 mol L^{-1} $Na_2S_2O_3$ solution. What is the concentration of dissolved oxygen in % (w/v) in the water sample? **3**

Outcome: H13, H10

Sample answer:

(a) moles oxygen = ¼ moles $Na_2S_2O_3$ = ¼ (V x C) = ¼ (0.008 x 0.0100) = 2.0 x 10^{-5} moles. (1 mark)

mass of oxygen = 2.0 x 10^{-5} moles.x 2(16) g/mole = 6.4 x 10^{-4} g (1 mark)

$$\text{concentration in g/100 mL} = \frac{6.4\times10^{-4}}{50.00}\times 100 = 1.28\times10^{-3}\ \%$$ *(1 mark)*

(b) If all the dissolved oxygen in a 1.00 L sample of the water is boiled off and collected, what volume will the oxygen gas occupy at 25°C and 100 kPa? **2**

(b) C in g/100 mL= 1.28 x 10^{-3} g/100 ml

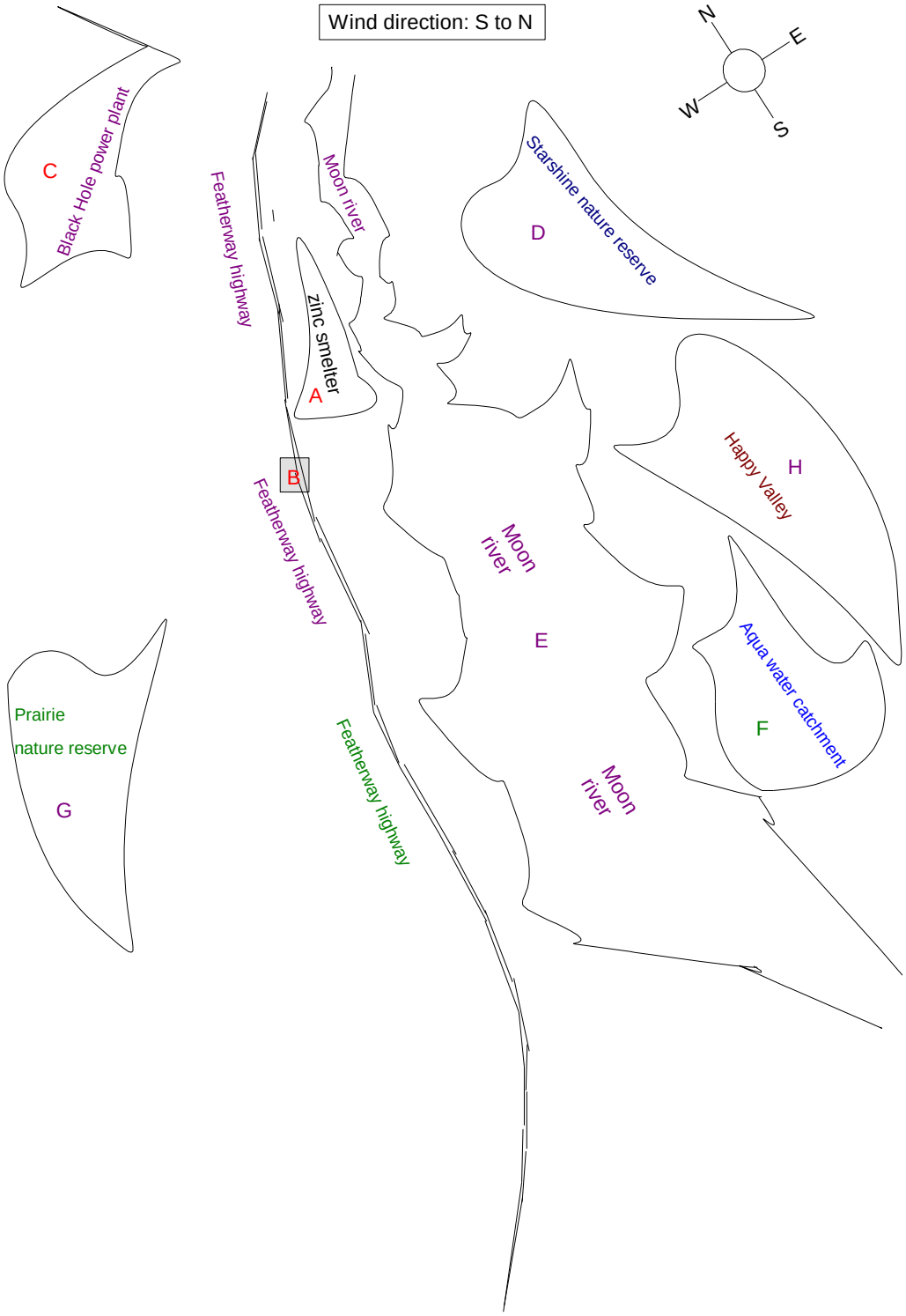
= 1.28 x 10^{-2} g/L

$$\text{moles } O_2 \text{ in 1.0 L} = \frac{1.28\times10^{-2}\ g}{(2\times16.00)\ g/mole} = 4.00\times10^{-4}\ mole$$ *(1 mark)*

volume = moles x V_M = 4.00 x 10^{-4} mole x 24.79 L/mole = 9.9 x 10^{-3} L (1 mark)

Question 29 (5 marks)

Noxious gases were measured in the JR Shire (see diagram). These measurements are given on the next page.:



Question 24 continues next page

Question 29 continues…

Examine the diagram and the table below giving the measurements of atmospheric SO_2 and NO_2 for various areas given in the table.

Area	*Name of area as given in the diagram*	*SO_2 (ppb)*	*NO_2(ppb)*
A	Zinc smelter	200	100
B	Feather way highway	180	100
C	Black Hole power plant	300	200
D	Starshine nature reserve	100	50
E	Moon river	100	50
F	Aqua water catchment	10	2
G	Prairie nature reserve	10	25
H	Happy valley	10	0

Explain using equations, why there are high levels of SO_2 and NO_2 in areas A, B and C. **5**

Outcomes: H4,H13,H16

Sample answers:

Area A *is the zinc smelter and this is shown by the high level of SO_2 and NO_2 . The high level of SO_2 is due to the SO_2 being produced by the smelter (Eqn 1) and the NO_2 is due to the high temperatures (Eqn 2) being used in the smelting process*

(Eqn 1) $2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$

(Eqn 2) $N_2(g) + O_2(g) \rightarrow 2NO$

Area B *is near a highway and hence, the NO and NO_2 are produced by the traffic going on in the area. The high temperature combustion results in the production of NO which is subsequently oxidized to NO_2*

$N_2(g) + O_2(g) \rightarrow 2NO$ *the formation of NO*

(Eqn 3) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ *oxidation of NO to NO_2*

Area C *is the powerplant, where SO_2, NO and NO_2 are likely to be emitted from impure coal being used and the normal process of combustion.*

(Eqn 4) $S_{coal} + O_2(g) \rightarrow SO_2(g)$

Other areas are farther from the source of pollution and not in the direction of the prevailing wind

Criteria	*Mark(s)*
Correct explanation for the level of SO_2 and NO_2 for areas A, B and C and three equations	*5*
Correct explanation for the level of SO_2 and NO_2 for areas A, B and C and two equations	*4*
Correct explanation for the level of SO_2 and NO_2 for areas A, B and C and one equation	*3*
Correct explanation for the level of SO_2 or NO_2 for areas A, B and C and one equation	*2*
Correct explanation for the level of SO_2 or NO_2 for areas A, B and C no equation	*1*

Question 30 (7 marks)

A buffer is a solution that resists changes in pH when small amounts of acid or alkali are added to it.

(a) Use equilibrium principles and the Bronsted – Lowry theory to compare the change in pH of a 1:1 molar solution of $CaCl_2$ - HCl and a 1:1 molar solution of $NaH_2PO_4 – Na_2HPO_4$ when a small amount of acid is added to the mixture. Include an equation in your answer. **5**

Outcomes: H10, H14, H2

Sample answer:

The ability of a mixture to resist changes in the pH when an acid or a base is added to the mixture depends on the presence in the mixture of species that will combine with the acid or the base, i.e, both an acid and a base must be present in the mixture to combine with any added base or acid to maintain the pH. With a strong acid such as HCl, which is completely ionized in aqueous solution, the conjugate base, Cl^- is too weak a base to combine with any added acid (proton). Hence, if an acid is added to the $CaCl_2$-HCl mixture, which cannot act as a buffer, the pH will decrease by a large amount.

In the $NaH_2PO_4 – Na_2HPO_4$ mixture, the equilibrium $H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$ exists. In the weak acid $H_2PO_4^-$ the proton holds on to its conjugate base, the HPO_4^{2-} ion, until a base stronger than HPO_4^{2-} such as the OH^- ion comes along. It (the proton) then combines with it.

If an acid is added, the base HPO_4^{2-} combines with the added acid and shifts the equilibrium to the left using up the acid and the decrease in the pH is minimal due to the added acid.

Criteria	Mark(s)
▸ A general statement summarizing the buffering ability of the two pairs of reagents ▸ Comparison of the reactions of the ions $H_2PO_4^-$, HPO_2^{2-} and the Cl^- ions with water , and relating these to their relative basic strength compared with water. ▸ Inclusion of an appropriate equation to illustrate the shift in equilibrium required to maintain the pH when an acid is added.	5
▸ No statement given as to the buffering ability of the two pairs of reagents ▸ Comparison of the reactions of the ions $H_2PO_4^-$, HPO_2^{2-} and the Cl^- ions with water, and relating these to their relative basic strength compared with water. ▸ Inclusion of an appropriate equation to illustrate the shift in equilibrium required to maintain the pH when an acid is added.	4
▸ No statement given as to the buffering ability of the two pairs of reagents ▸ Discusses the reactions of the ions $H_2PO_4^-$ and HPO_2^{2-} ions only with water, and relating these to their relative basic strength of these ions compared with water. ▸ Inclusion of an appropriate equation or a statement to illustrate the shift in equilibrium required to maintain the pH when an acid is added.	3
▸ No statement given as to the buffering ability of the two pairs of reagents ▸ Discusses the reactions of the ions $H_2PO_4^-$ or, HPO_2^{2-} ions with water, and relating these to their relative basic strength of these ions compared with water.	2

▸ No equation included but use equilibrium principles to explain the buffering ability.	
No statement given as to the buffering ability of the two pairs of reagents ▸ Discusses the reactions of the ions $H_2PO_4^-$, HPO_2^{2-} ions only with water, and relating these to their relative basic strength of these ions compared with water. ▸ No equation or explanation	1

(b) Why is the Arrhenius theory inadequate to explain the difference in behaviour? **2**

Sample answer:
Although the Arrhenius theory, includes the concept of strong and weak molecular acids dissociating, it is inadequate because it has not considered the concept of base and acid strength as shown by the relative tendency of the species present to accept or donate protons compared with each other and compared with the solvent. The concept of acid and basic strength according to the Bronsted – Lowry scale is needed to explain the difference in behaviour.

Criteria	Mark(s)
▸ States that the Arrhenius concept has not related the idea of strong and weak acids to the position of equilibrium when an acid is placed in water. ▸ States that the Arrhenius concept has not considered the role of the solvent in acid-base reaction and hence the	2
▸ States that the Arrhenius concept has not related the idea of strong and weak acids to the position of equilibrium when an acid is placed in water. ▸ States that the Arrhenius concept has not considered the role of the solvent in acid-base reaction. If one of the above points is stated.	1

Question 31 (8 marks)

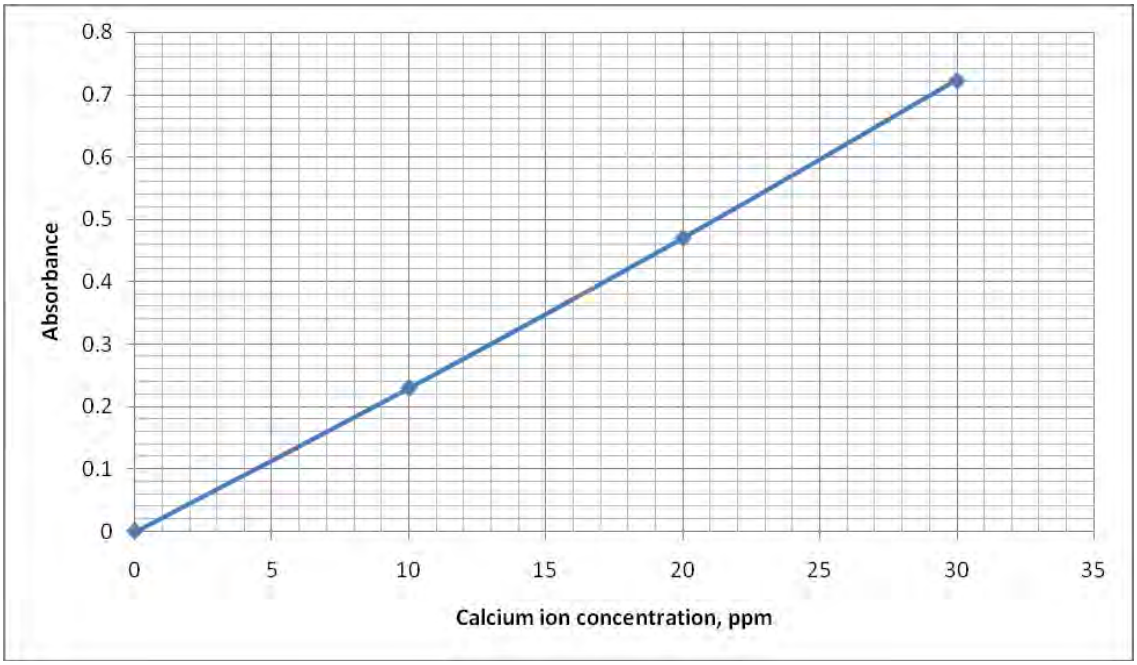
A student living in the country wanted to determine the hardness of her town water supply. She used both AAS and EDTA titration to determine the level of Ca^{2+} ions in her water supply. She collected two samples of the water, taken at 6 am and 6 pm everyday for ten consecutive days: 20 samples in all.
The AAS instrument she used was provided with a calcium lamp. For the measurements, she prepared four replicate standard solutions of Ca^{2+} ranging from 10.0 to 30.0 ppm. She passed each standard solution (12 solutions) and the 20 water samples several times through the AAS instrument. She then averaged the results and recorded them in the table.

Standard Solutions (ppm)	*Average absorbance*
0.00	0.000
10.0	0.230
20.0	0.470
30.0	0.723
Water samples	0.600

(a) Plot the data from the table. **2**

Outcomes: H13

Sample answer:



Marking Guidelines

Criteria	*Mark(s)*
Correct orientation of axes and plotting	*1*
Correct interpolation of Ca ion concentration	*1*
Graph	*1*

(b) Use the graph to determine the concentration of the Ca^{2+} in ppm in the water sample. **1**

Sample answer:
The calcium concentration is about 25.0 ppm as read from the graph.

(c) For comparison, the student also determined the Ca^{2+} concentration by EDTA titration.

She took 100.00 mL from each of the 20 water samples to give a total volume of 2.000 L, evaporated the 2.000 L sample to about 50 mL and then diluted to 100.00 mL in a volumetric flask. From this flask, she took a 20.00 mL aliquot and titrated it with a 0.02510 mol L^{-1} sodium EDTA solution. EDTA reacts with both calcium ion and magnesium ion in a 1:1 ratio.

She repeated the titration three more times and tabulated the results.

Trial	Volume of EDTA solution (mL)
1	14.50
2	13.25
3	13.23
4	13.24

(i) Calculate the hardness in ppm of the water sample in terms of Ca^{2+} ion. **3**

Outcomes: H13
Sample answer:

Sample concentration protocol: sample volume = 20 x 100.00 mL = 2000.00 mL
2000.00 mL sample concentrated to 100.00 mL
Concentration factor: ***20 times***

moles EDTA = moles Ca^{2+} $= C_{Ca} \times V_{Ca} = C_{EDTA} \times Volume_{EDTA} =$

$$[Ca^{2+}] = \frac{C_{EDTA} \times V_{EDTA}}{V_{Ca}} = \frac{0.02510 \times 0.01324}{0.0200} = 0.016566\, mole\, L^{-1}\ (concentrated\ water\ sample)$$

(1 mark)

$\therefore$ $[Ca^{2+}]$ in the original water sample $= \frac{0.016566}{20} = 8.283 \times 10^{-4}\ mol\, L^{-1}$ (1 mark)

Ca^{2+} *concentration in ppm* $= 8.283 \times 10^{-4}\ mol\, L^{-1} \times 40.08\ g/mol \times 1000\ mg/g = 33.2\ ppm$ *(1 mark)*

(ii) Explain the discrepancy in the results of the two techniques used for the analyses. **2**

Sample answer:

The EDTA reacted with both the calcium and magnesium ions in the sample, whereas the AAS detected the calcium ions only since a calcium lamp is being used and not a multi-element lamp.

Criteria	*Mark(s)*
Correct explanation of the discrepancy citing both non-specificity of EDTA and the specificity of the AAS technique	2
Cited the specificity of the AAS or the non-specificity of the EDTA titration technique.	1

Section II

25 marks
Attempt question 32
Allow about 45 minutes for this section

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

(a) The most common method for the industrial production of hydrogen is the steam reforming process, given by the following reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +207 kJ\ mol^{-1}$$

(i) Using Le Chatelier's principle, explain the general conditions of temperature and pressure that would favour the production of hydrogen. **4**

Sample answer
According to Le Chatelier's Principle, an equilibrium will shift to oppose any change made to it.
To favour the production of hydrogen, equilibrium would need to shift to the right.
Increasing the temperature would favour the reaction that uses heat (Le Chatelier) The reaction that uses heat is the endothermic reaction which is the forward reaction and equilibrium shifts to the right making more hydrogen.
Decreasing the pressure will favour the reaction that exerts more pressure (Le Chatelier) The reaction that exerts more pressure is the forward reaction as there are more moles of gas produced. (2:4) Equilibrium will shift right making more hydrogen.

Marking Criteria	*Mark*
Explains both conditions in terms of Le Chatelier's Principle.	4
Explains one condition in terms of Le Chatelier's Principle and identifies the other condition.	3
Identifies increasing temperature and reducing pressure OR Explains one condition in terms of Le Chatelier's Principle.	2
Identifies one condition of temperature or pressure.	1

Outcomes : H7.H8

(ii) At 1500 ^oC the concentrations of the gases in a particular equilibrium mixture were found to be

$[CH_4] = 0.400\ molL^{-1}$ $[CO] = 0.300\ molL^{-1}$ $[H_2O] = 0.068\ molL^{-1}$

and K = 5.67 at 1500^0C for the reaction.

Give an equilibrium expression for the steam reforming process and calculate the concentration of hydrogen in the reaction mixture at equilibrium. **2**

Sample answer:

$K = \frac{[CO][H_2]^3}{[CH_4]\,[H_2O]}$ *(1 mark)*

$5.67 = 0.300 \times [H_2]^3 / 0.400 \times 0.068$

$[H_2] =$ *(1 mark)*

Outcomes : H10

(b) Identify the industrial reaction conditions used to produce sulfur trioxide from sulfur dioxide and explain how these conditions maximize the rate and yield of sulfur trioxide. **4**

Sample answer.

Reaction conditions 450^0C, 1.5-2 atm, V_2O_5 catalyst

Contact process $2\,SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g) + heat$

Temperature :

The contact process is an exothermic process. Normally a low temperature would be used to shift the equilibrium to the right, however, a low temperature would result in a slow reaction. A compromise temperature of 450^0C is used to increase the rate of the reaction so that equilibrium is achieved faster, but keeps equilibrium to the left with lower yield of products(Le Chatelier).

Pressure :

High pressure would favour the forward reaction (Le Chatelier) and increase rate and a slightly higher than normal pressure is used (1.5-2 atm). Excessive high pressures are not used as sufficient yield is achieved quickly without the expense of high pressure systems.

Catalyst :

A V_2O_5 catalyst is used to increase the rate of reaction by lowering the activation energy. Equilibrium is achieved faster. The catalyst has no effect on the yield of SO_3.

Marking Criteria	*Mark*
A thorough explanation of the reaction conditions used in the Contact Process and their effects on rate and yield	4
Explains three conditions but fails to link all three to rate and yield	3
Outlines three conditions OR Explains two conditions	2
One correct condition identified OR Correct equation for the contact process OR Identifies contact process as an equilibrium	1

(c) Glyceryl tristearate, can be reacted with sodium hydroxide solution in the production of soap.

(i) Identify the products of this saponification reaction. **2**

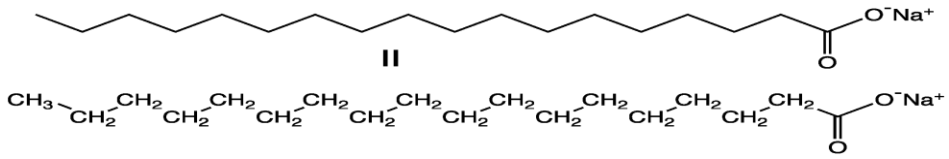
Sample answer:

Sodium stearate and glycerol (2 marks)

Outcomes : H9

(ii) Account for the cleaning action of this soap by describing its structure and effect as an emulsifier. **4**

Sample answer
The sodium part is a spectator ion and doesn't participate in the cleaning action. The anion that is left has a polar carboxylate head (COO^-) and a non-polar hydrocarbon tail.



The non-polar hydrocarbon tail forms dispersion forces with non-polar oil molecules and the tails embed themselves in the oil droplet. The polar water soluble carboxylate head of the anion can form H-bonds with polar water molecules and stay on the surface of the oil droplet. Agitation causes the oil to lift off the surface and form a micelle. Because of the polar heads on the outside of the micelle, the droplets don't combine but stay dispersed forming an emulsion. The oil has been removed from the surface, leaving it clean.

Marking Criteria	*Mark*
Accounts for the cleaning action of soap, describing its structure and outlining the functions of both ends of the anion and the formation of an emulsion.	4
Describes the cleaning action of soaps, outlining the functions of both ends of the anion.	3
Outlines the cleaning action of soaps, identifying the function of either end of the soap anion	2
Identifies one aspect of the cleaning action of soaps.	1

Outcomes : H9

(d) Describe the mercury process used for producing sodium hydroxide. Include in your answer the chemistry and the environmental impact associated with this process. **6**

Sample Answer

At the cathode : $Na(aq) + e^- \rightarrow Na(l)$ in mercury amalgam

At the anode : $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

$2Na + 2H_2O \rightarrow 2NaOH + H_2(g)$

The mercury process is an electrolytic method for the production of sodium hydroxide from brine solution. The cathode is flowing liquid mercury. Sodium ions are reduced to sodium metal and form an amalgam with the mercury, which is then pumped away. The amalgam is then sprayed in to water and the sodium reacts with the water to produce sodium hydroxide. The mercury is pumped back to the electrolysis. Chloride ions are oxidized to chlorine gas at the anode (inert platinum/titanium plates). Mercury is leaked in to the environment from this process. It is very toxic, causing neurological defects and death. Consequently, this method is being phased out of use.

Marking Criteria	*Mark*
Describes the chemistry of the mercury process and an environmental impact of the process. 2 relevant equations (or half equations) required	6
Describes some of the chemistry of the mercury process and an environmental impact of the process. At least one equation.	5
Describes some of the chemistry of the mercury process and an environmental impact of the process.	4
Outlines the chemistry of the mercury process and an environmental impact of the process.	3
Outlines the chemistry of the mercury process OR Outlines one environmental impact of the process.	2
Identifies one aspect of the mercury process	1

Outcomes : H3,H4

(e) Sodium carbonate is manufactured by the Solvay process.

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

Sodium carbonate is used in the manufacture of glass.

(ii) Describe the chemistry involved in the purification of brine in the Solvay process. **2**

Sample answer
To obtain sodium chloride from sea water, impurities must first be removed.
Calcium salts are precipitated using carbonates.
Magnesium salts are precipitated by adding hydroxides
A flocculant is added and the precipitates are skimmed off. The water is evaporated and sodium chloride crystallizes out

Marking Criteria	*Mark*
Describes the chemistry involved in brine purification	2
Outlines the chemistry involved Or Describes one precipitation reaction	1

Outcomes : H9, H10

End of paper