Student Number	
Mark / 100	

2011

TRIAL HSC 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.
- Write your Student Number at the top of this page and those of pages 10 and 11.

Total Marks – 100

Section I Pages 2 – 24

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 – 32
•Allow about 1 hour and 40 minutes for this part

Section II Pages 25 – 26

25 marks

•Attempt Question 33
•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 .....

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

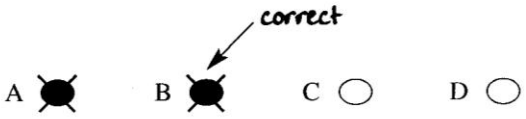
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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 grid on page 10.

Part A
Multiple Choice

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

1. Which of the following chemicals would decolourise bromine water the quickest in the presence of UV light?

(A) Concentrated H_2SO_4

(B) Cyclohexane

(C) 1-hexene

(D) 1-hexanol

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

(A) One alkane and one alkene

(B) One alkanoic acid and one alkanol

(C) Two alkanes

(D) Two alkenes

3. The molar heat of combustion of ethanol is 1367 kJ mol^{-1}. A 2.510 g sample of ethanol was combusted in heating a certain mass of water from 25°C to 45°C. 80% of the heat released was absorbed by the water. What was the quantity of water heated?

(A) 712.7 g

(B) 713.8 g

(C) 890.9 g

(D) 892.2 g

4. A sample was tested for its approximate pH using several indicators. The results are given in the table.

Indicator	*Colour of indicator in sample*
bromothymol blue	blue
litmus	blue
methyl orange	yellow
phenolphthalein	colourless

What is the most accurate estimate for the pH of the sample?

(A) Between 6.0 and 6.3

(B) 7.0

(C) Between 7.5 and 8.0

(D) Between 9.0 and 14.0

5. Why is radon-226 a radioactive isotope?

(A) Its mass number is greater than 83.

(B) It has more neutrons than protons.

(C) The ratio of neutrons to protons is not 1:1.

(D) The ratio of neutrons to protons is too low**.**

6. The half-equations for the vanadium redox cell are given below.

$VO_2^+ (aq) + 2H^+ + e^- \rightarrow VO^{2+} (aq) + H_2O (l)$

$V^{2+} (aq) \rightarrow V^{3+} (aq) + e^-$

What is the change in the oxidation state of vanadium for the reduction half-equation in this cell?

(A) 2+ to 0

(B) 3+ to 2+

(C) 2+ to 3+

(D) 5+ to 4+

7. In order to determine the relative activity of four metals, each metal was placed in the salt solutions of the other metals and observed for signs of a reaction. The results are displayed in the table.
Note that R = reaction occurred; NR = no sign of a reaction; – = not tested

	Metal 1	*Metal 2*	*Metal 3*	*Metal 4*
Salt solution of Metal 1	–	NR	R	NR
Salt solution of Metal 2	R	–	R	NR
Salt solution of Metal 3	NR	NR	–	NR
Salt solution of Metal 4	R	R	R	–

What is the relative activity of the four metals as determined by these results?

	most active metal → least active metal
(A)	3 → 1 → 4 → 2
(B)	2 → 1 → 4 → 3
(C)	3 → 1 → 2 → 4
(D)	4 → 2 → 1 → 3

8. Which of the following is a Bronsted- Lowry acid – base reaction?

(i) $CO_2(g) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$

(ii) $H_2SO_4(l) + H_2O(l) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$

(iii) $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

(iv) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

(A) all the reactions

(B) (i) and (iii) only

(C) (ii) and (iv) only

(D) (iii) and (iv) only

9 Given the following ionization/dissociation of hypothetical acids and bases in water:

(i) $HL(g) + H_2O(l) \rightarrow H_3O^+(aq) + L^-(aq)$

(ii) $MOH(s) \xrightarrow{water} M^+(aq) + OH^-(aq)$

(iii) $HZ(g) + H_2O(l) \rightleftharpoons Z^-(aq) + H_3O^+(aq)$

(iv) $H_2D^-(aq) + H_2O(l) \rightleftharpoons HD^{2-}(aq) + H_3O^+(aq)$

Which combinations would produce a buffer?

(A) NaL – HL and MOH – NaCl

(B) NaZ – HL and MOH – NaCl

(C) NaH_2D – Na_2HD and NaZ – HZ

(D) NaH_2D – Na_2HD and MCl – NaOH

10. What is the correct burette reading in mL?

(A) 21.10

(B) 21.30

(C) 21.60

(D) 22.40

11. The concentration of chloride ion in river water was determined by titration with $AgNO_3$ solution using a suitable indicator. 25.00 mL samples of river water were titrated with 1.034×10^{-2} mol L^{-1} $AgNO_3$. The average titre was 22.60 mL.

What is the concentration of the chloride ion in the river water?

(A) 9.348×10^{-3} mol L^{-1}

(B) 331 ppm

(C) 3.31×10^{-2} %

(D) 0.01148 mol L^{-1}

12. How many structural isomers can the compound with the molecular formula, $C_2H_3Cl_2F$ have?

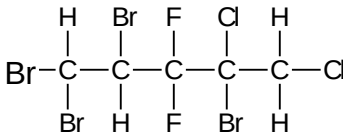
(A) 1

(B) 2

(C) 3

(D) 4

13. What is the systematic name of the following compound?



(A) 1,1,2,4– tribromo–4,5-dichloro–3,3–fluropentane

(B) 1,2– dichloro–2,4,55-tetrabromo– 3,3–difluoropentane

(C) 3,3– difluoro-4,5– dichloro–1,1,2,4–tetrabromopentane

(D) 1,1,2,4– tetrabromo-4,5–dichloro–3,3–difluoropentane

14. Ozone exhibits greater reactivity than the oxygen molecule. Which statement best explains this?

(A) Ozone has a bent structure which makes it more polar than oxygen

(B) Ozone has three oxygen atoms so it is a stronger oxidizing agent than oxygen which has two atoms.

(C) Ozone has a higher molecular mass hence dispersion forces are greater.

(D) Ozone has a single covalent bond which is more easily broken than the double covalent bond in oxygen.

15. What are the volumes in litres of 1 mole of helium gas and 1 mole of nitrogen gas respectively at 25 ^{o}C and 100 kPa ?

(A) 12.40 L and 24.79 L

(B) 24.79 L and 24.79 L

(C) 4.0 L and 28.0 L

(D) 22.71 L and 22.71 L

16. Which of the following changes will always shift equilibrium to the left ?

$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H = -52 \text{ kJ mol}^{-1}$

(A) adding a catalyst

(B) increasing pressure

(C) increasing temperature

(D) adding more reactant

17. In which of the following alternatives are the compounds listed in order of increasing boiling point ?

(A) butane, pentanoic acid, propanol

(B) propanol, pentanoic acid, butane

(C) butane, propanol, pentanoic acid

(D) pentanoic acid, pentanol, butane

18 20 mL of 0.08 mol L^{-1} HCl is mixed with 30 mL of a 0.05 mol L^{-1} NaOH.

What is the pH of the resultant solution ?

(A) 2.7

(B) 4.0

(C) 7.0

(D) 8.3

19 Which of the following would be a possible industrial source of sulfur dioxide?

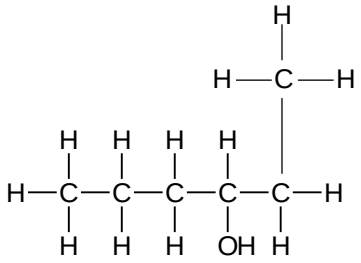
(A) volcanic eruptions

(B) smelting of metal ores

(C) photochemical smog

(D) electrolysis of sodium chloride

20 . What is the IUPAC name of the following compound ?



(A) 1–methyl–2–pentanol

(B) 3–hexanol

(C) 4– hexanol

(D) 5–methyl–4–pentanol

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 ○

Section 1 (continued)

Student Number ……..

Part B 55 marks

Attempt questions 21 – 33

Allow about 1 hour and 40 minutes for this part

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response
- Show all relevant working in questions involving calculations.

Question 21 (5 marks) **Marks**

Ethanol may be formed in a variety of ways using both renewable and non-renewable resources. Ethanol is considered a very important chemical as it has many uses in our society.

(a) Describe how ethanol may be prepared from renewable and non-renewable resources. Include relevant equations and state any reaction conditions required. **3**

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(b) Explain why ethanol is used as a common solvent for a wide range of chemicals. **2**

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Question 22 (4 marks)

Polymers have revolutionised the way society uses and forms materials.

Compare the processes of addition and condensation polymerization using examples.

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Question 23 (6 marks) **Marks**

Galvanic cells were used to form the first type of batteries.

(a) In terms of structure and chemistry, compare the galvanic cell that you investigated in the laboratory with either a dry cell or lead-acid cell. **5**

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(b) Demonstrate how you would theoretically calculate the standard cell potential (E°) for the galvanic cell that you investigated in the laboratory. **1**

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Marks

Question 24 (4 marks)

Radioisotopes are important products of nuclear chemistry.

(a) Describe the use of an identified radioisotope in industry. **2**

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(b) Outline how the radioisotope identified in (a) is produced. **2**

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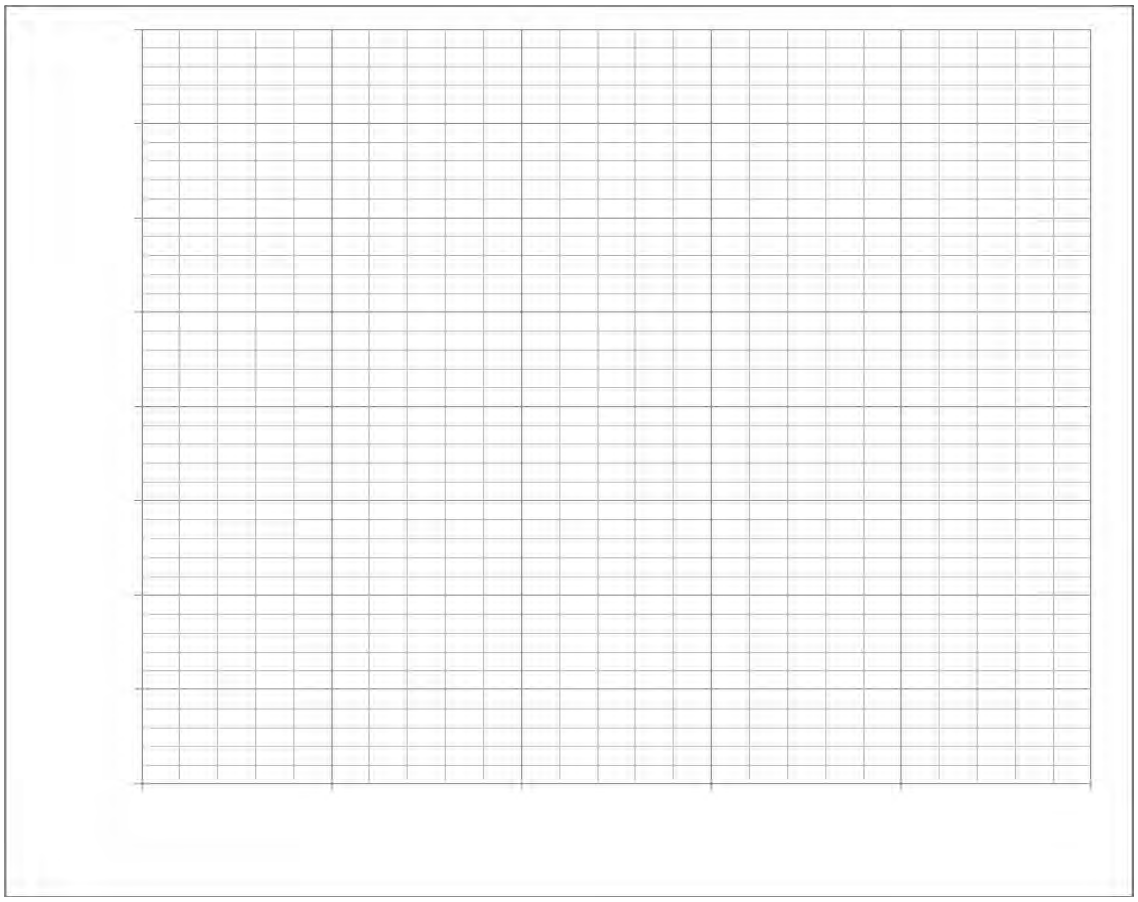
Marks

Question 25 (5 marks)

A first-hand investigation was carried out to measure the volume of gas produced when 200 mL of hydrochloric acid solution was added to various pieces of zinc. The volume of gas produced was recorded at 25 ^{o}C and 100 kPa as shown in the table below :

Mass of Zinc (g)	*Volume of Gas (mL)*
0.12	45
0.33	125
0.56	115
0.83	315
0.96	365
1.22	380
1.64	380
1.93	380

(a) Plot a line graph of the results in the grid below. **3**



Question 25 continues on next page

Marks

(b) Calculate the theoretical volume of gas produced at 25 ^{o}C and 100 kPa by the reaction of 0.75 g zinc with 200 mL of the acid. **2**

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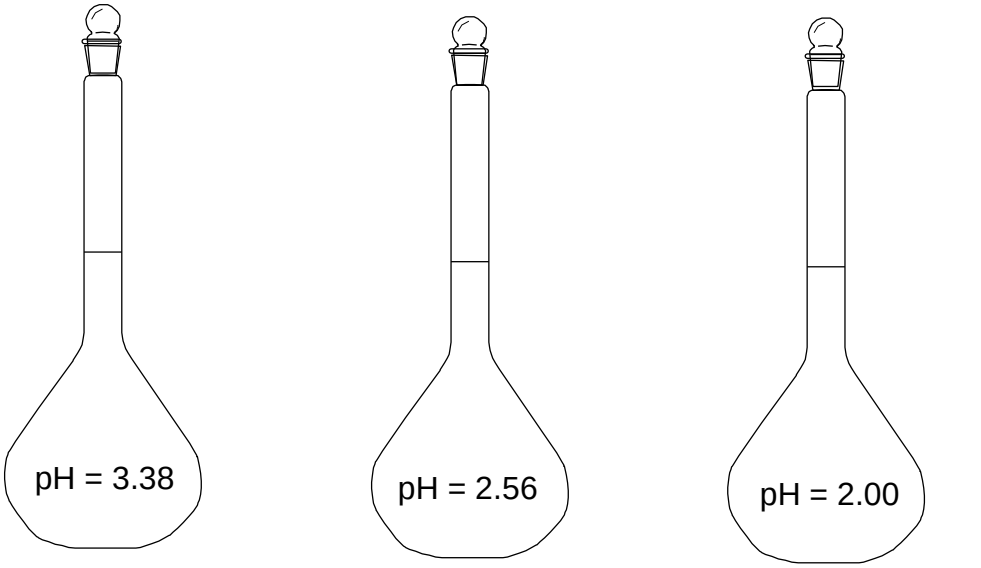
Question 26 (3 marks)



Explain the difference in pH between the three acids in the diagram. **3**

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Marks

Question 27 (3 marks)

(a) Identify the common catalyst used in esterification reactions. **1**

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(b) Outline the role of refluxing in the esterification process. **2**

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Question 28 (3 marks)

Read the information provided in the fact file about environmental chemists and then answer the question. You may use any other information in addition to the fact file information.

FACT FILE:

WORK DESCRIPTION ► An environmental chemist may focus on collecting and analyzing samples, developing remediation programs, changing production processes to yield a more environmentally friendly product, providing expert advice on safety and emergency response, or dealing with government regulations and compliance issues.
WORKING CONDITIONS ► Work is often done in an indoor lab environment. However, when studying chemicals in the environment, a riverbed or stream may become the lab. Some companies have sophisticated indoor ecosystems in which they test their products. Others collect data outdoors and kilometres away from their own production sites.
PERSONAL CHARACTERISTICS ► Because environmental chemistry is so interdisciplinary, it requires excellent interpersonal and communication skills along with the ability to express ideas efficiently to a non scientific audience. The importance of the latter becomes apparent when chemists deal with regulations or with a company's sales and marketing staff.

Explain why collaboration between chemists is essential if the environmental aspects of the industry are to be considered.

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Marks

Question 29 (7 marks)

A student carried out an investigation to analyse lawn fertiliser. The student weighed out 1.00 g of fertiliser containing 24.0 % sulfur (S) and dissolved it in water. 100 mL of 0.20 mol L^{-1} barium chloride solution was then added and a precipitate formed.

(a) Calculate the theoretical percentage by mass of sulfate (SO_4^{2-}) in the fertiliser. **3**

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(b) Complete the table to explain the possible cause(s) of deviation of the result from the expected value. **4**

Lower value	*Higher value*

Marks

Question 30 (6 marks)

Aluminium has often been linked to Alzheimer's disease whose symptom is rapid memory loss. Common drinks, such as tea may contain higher than normal levels of aluminium ions: Considering that tea is such a popular drink, a group of students decided to analyse, the level of aluminium in black tea samples by AAS when given the chance to use the instrument in a nearby university.

They weighed out 10.00 g of tea and made an infusion with 500.0 mL of demineralised water. They allowed 2 minutes for the infusion time. At the same time they prepared standard aluminium solutions ranging from 1.00 ppm to 6.00 ppm. They passed replicate samples of the tea infusion and the standards through the AAS instrument and obtained the following results:

Data table

Sample	*Concentration (ppm)*	*Absorbance*
Standard 1	1.25	0.1002
Standard 2	2.53	0.2111
Standard 3	3.68	0.3205
Standard 4	4.67	0.4504
Standard 5	5.43	0.5216
Tea infusion1	unknown	0.3565
Tea infusion 2	unknown	0.3566
Tea infusion 3	unknown	0.3565
Tea infusion 4	unknown	0.3566

(a) Assess the reliability of the analysis of the tea infusions of unknown concentrations. **1**

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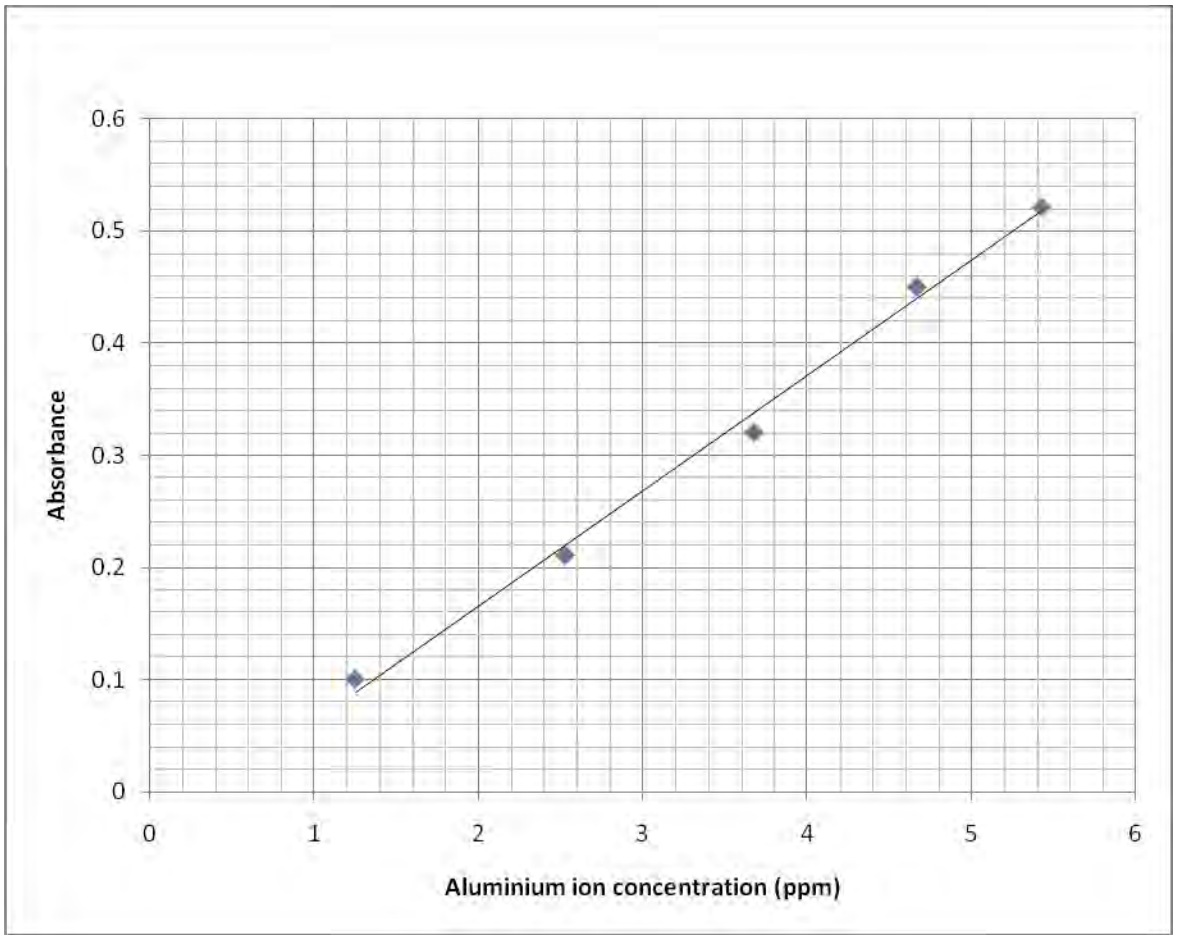
Question 30 continues on next page...

Marks

(b) The diagram below shows a graph of the results obtained by the students.



Use the graph and the data table to determine the average concentration of aluminium in ppm in the tea infusion. **1**

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Question 30 continues on next page...

Marks

(c) 2.0 g of black tea is required to make a 220 mL cup of tea and the daily tolerable limit for aluminium in tea is 7.0 mg/kg body weight.
How many cups of tea a day can a 55 kg person drink without exceeding the tolerable limit of aluminium? **4**

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Question 31 (6 marks)

Discuss how manufactured products have had a damaging impact on the composition of the atmosphere and evaluate the measures being taken to decrease the damage.

Question 32 (3 marks)

A water sample from a waterway was found to have high levels of turbidity and dissolved solids together with increased biochemical oxygen demand.
Assses the ability of this waterway to sustain aquatic life. **3**

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Test continues next page..

Section II

25 marks
Attempt question 33
Allow about 45 minutes for this section

Answer the question in a writing booklet.
Show all relevant working in questions involving calculations.

Marks

(a) The Solvay Process is used to produce sodium carbonate.

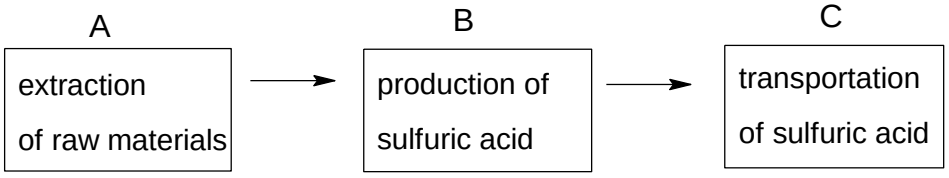
One step in the process involves the decomposition, by heat, of sodium hydrogen carbonate.

(i) Give an equation for this reaction. **1**

(ii) If 10 100 tonnes of sodium hydrogen carbonate is heated, what volume of gas will be produced at 25 ^{o}C? **3**

(iii) What happens to the gas produced in this step of the Solvay Process? **1**

(b) The flowchart shows the production and distribution of sulfuric acid.



(i) Identify one safety or environmental issue associated with A, B and C.

(ii) Describe the precautions taken to avoid the consequence of each issue identified. **6**

(c) An impurity in natural gas is hydrogen sulfide or rotten egg gas.

This gas can be removed from natural gas by the following process.

$2H_2S\,(g) + SO_2\,(g) \rightleftharpoons 3S\,(s) + 2H_2O\,(g) \quad \Delta H = -145\ kJ\ mol^{-1}$

(i) Give the equilibrium expression for this reaction. **1**

(ii) Calculate the equilibrium constant when 2.00 mol of H_2S and 2.00 mol of SO_2 react in a 1.00 L vessel at 100 ^{o}C to give 1.00 mol of water vapour under equilibrium conditions. **2**

(iii) What conditions of temperature and pressure would favour the removal of hydrogen sulfide gas? Explain these conditions in terms of Le Chatelier's principle. **4**

Question 33 continues next page..

Marks

(d) You performed a first-hand investigation to identify the products of electrolysis of aqueous sodium chloride.

Identify the product at either the cathode or the anode and describe the test you performed to identify that product. **3**

(e) Distinguish between cationic and non-ionic detergents in terms of their chemical composition and usage. **4**

End of Test

Student Number	
Mark / 100	

2011

TRIAL HSC EXAMINATION

Chemistry

ANSWERS

General Instructions

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

.

Total Marks – 100

Section I Pages....

75 marks

This section has two parts, Part A and Part B

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

Part B – 55 marks
•Attempt Questions .....
•Allow about 1 hour and 45 minutes for this part

Section II Pages .....

25 marks

•Attempt Question 33
•Allow about 45 minutes for this section

Multiple Choice

1. Which of the following chemicals would decolourise $Br_2(aq)$ the quickest in the presence of UV light?

(A) concentrated H_2SO_4

(B) cyclohexane

(C) 1-hexene

(D) 1-hexanol

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

(A) one alkane and one alkene

(B) one alkanoic acid and one alkanol

(C) two alkanes

(D) two alkenes

3. The molar heat of combustion of ethanol is 1367 kJ mol^{-1}. A 2.510 g sample of ethanol is combusted in heating a certain mass of water from 25°C to 45°C. 80% of the heat released is absorbed by the water. What was the quantity of water heated?

(A) 712.7 g

(B) 713.8 g

(C) 890.9 g

(D) 892.2 g

4. A sample was tested for its approximate pH using several indicators. The results are given in the table.

Indicator	*Colour of indicator in sample*
bromothymol blue	blue
litmus	blue
methyl orange	yellow
phenolphthalein	colourless

What is the most accurate estimate for the pH of the sample?

(A) between 6.0 and 6.3

(B) 7.0

(C) between 7.5 and 8.0

(D) between 9.0 and 14.0

5. Why is radon-226 a radioactive isotope?

(A) Its mass number is greater than 83.

(B) It has more neutrons than protons.

(C) The ratio of neutrons to protons is not 1:1.

(D) The ratio of neutrons to protons is too high.

6. The half-equations for the vanadium redox cell are given below.

$VO_2^+ (aq) + 2H^+ + e^- \rightarrow VO^{2+} (aq) + H_2O (l)$

$V^{2+} (aq) \rightarrow V^{3+} (aq) + e^-$

What is the change in the oxidation state of vanadium for the reduction half-equation in this cell?

(A) 2+ to 0

(B) 3+ to 2+

(C) 2+ to 3+

(D) 5+ to 4+

7. In order to determine the relative activity of four metals, each metal was placed in the salt solutions of the other metals and observed for signs of a reaction. The results are displayed in the table. Note that R = reaction occurred; NR = no sign of a reaction.

	Metal 1	*Metal 2*	*Metal 3*	*Metal 4*
Salt solution of Metal 1	-	NR	R	NR
Salt solution of Metal 2	R	-	R	NR
Salt solution of Metal 3	NR	NR	-	NR
Salt solution of Metal 4	R	R	R	-

What is the relative activity of the four metals as determined by these results?

	most active metal → least active metal
(A)	1 → 3 → 4 → 2
(B)	2 → 1 → 4 → 3
(C)	**3 → 1 → 2 → 4**
(D)	4 → 2 → 1 → 3

8. Which of the following is a Bronsted- Lowry acid – base reaction?

(i) $CO_2(g) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$
(ii) $H_2SO_4(l) + H_2O(l) \rightarrow HSO_4^-(l) + H_3O^+(aq)$
(iii) $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$
(iv) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

(A) (i) – (iv) all

(B) (i) and (iii) only

(C) (ii) and (iv) only

(D) (iii) and (iv) only

Outcome(s): H13

9 Given the following ionization/dissociation of hypothetical acids and bases in water:

(i) $HL(g) + H_2O(l) \rightarrow H_3O^+(aq) + L^-(aq)$

(ii) $MOH(s) \xrightarrow{water} M^+(aq) + OH^-(aq)$

(iii) $HZ(g) + H_2O(l) \rightleftharpoons Z^-(aq) + H_3O^+(aq)$

(iv) $JH_3(g) + H_2O(l) \rightleftharpoons JH_4^+(aq) + OH^-(aq)$

(v) $H_2D^-(aq) + H_2O(l) \rightleftharpoons HD^{2-}(aq) + H_3O^+(aq)$

Which combinations would produce a buffer?

(A) NaL – HL and MOH - NaCl

(B) JH_3- JH_4Cl and MOH – NaCl

(C) NaH_2D - Na_2HD and NaZ - HZ

(D) NaH_2D – Na_2HD and MCl – NaOH

Outcome(s): H13, H11

10. What is the correct burette reading in mL?

(A) 21,10

(B) 21.30

(C) 21.60

(D) 22.40

Outcome(s): H13

11. The concentration of chloride ion in river water was determined by titration with $AgNO_3$ using a suitable indicator. 25.00 mL samples of river water were titrated with 1.034×10^{-2} mol L^{-1} $AgNO_3$. The average titre was 22.60 mL .

What is the concentration of chloride in the river water?

(A) 9.348×10^{-3} mol L^{-1}

(B) 331 ppm

(C) 3.31×10^{-2} %

(D) 0.01148 mol L^{-1}

Outcome(s): H10, H13

12. How many structural isomers will the compound with the molecular formula, $C_2H_3Cl_2F$ have?

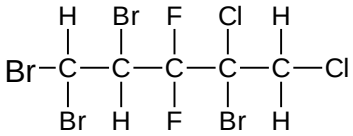
(A) 1

(B) 2

(C) 3

(D) 4

13. What is the systematic name of the following compound?



(A) 1,1,2,4- tribromo-4,5-dichloro-3,3-fluropentane

(B) 1,2-dichloro-2,4,55-tetrabromo-3,3-difluoropentane

(C) 3,3-difluoro-4,5-dichloro-1,1,2,4-tetrabromopentane

(D) 1,1,2,4-tetrabromo-4,5-dichloro-3,3-difluoropentane

Outcome(s): H13

14. Ozone exhibits greater reactivity than the oxygen molecule. Which statement best explains this?

(A) Ozone has a bent structure which makes it more polar than oxygen

(B) Ozone has three oxygen atoms so it is a stronger oxidizing agent than oxygen which has two atoms.

(C) Ozone has a higher molecular mass hence dispersion forces are greater.

(D) Ozone has a single covalent bond which is more easily broken than the double covalent bond in oxygen.

Outcome(s): H13

15. What are the volumes in litres of 1 mole of helium gas and 1 mole of nitrogen gas respectively at 25 ^{o}C and 100 kPa ?

(A) 12.40 L and 24.79 L

(B) 24.79 L and 24.79 L

(C) 4.0 L and 28.0 L

(D) 22.71 L and 22.71 L

Outcome(s): H10

16. Which of the following changes will always shift equilibrium to the left ?

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ $\Delta H = -52 kJ\ mol^{-1}$

(A) adding a catalyst

(B) increasing pressure

(C) increasing temperature

(D) adding more reactant

Outcome(s): H8

17. In which of the following alternatives are the compounds listed in order of increasing boiling point ?

(A) butane, pentanoic acid, propanol

(B) propanol, pentanoic acid, butane

(C) butane, propanol, pentanoic acid

(D) pentanoic acid, pentanol, butane

Outcome(s): H9

18. 20 mL of 0.08mol L^{-1} HCl is mixed with 30 mL of a 0.05 molL^{-1} NaOH.
What is the pH of the resultant solution ?

(A) 2.7

(B) 4.0

(C) 7.0

(D) 8.3

Outcome(s): H10

19 . Which of the following would be a possible industrial source of sulfur dioxide ?

(A) volcanic eruptions

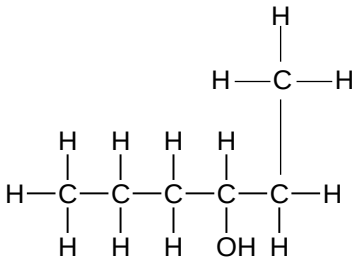
(B) smelting of metal ores

(C) photochemical smog

(D) electrolysis of sodium chloride

Outcome(s): H4

20 What is the IUPAC name of the following compound ?



(A) 1−methyl−2−pentanol

(B) 3-hexanol

(C) 4- hexanol

(D) 5−methyl−4−pentanol

Outcome(s): H9

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 ○

Section 1 (continued)

Student No. …….

Part B 55 marks
Attempt questions 21 - 33
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)

Ethanol may be formed in a variety of ways using both renewable and non-renewable resources. Ethanol is considered a very important chemical as it has many uses in our society.

(a) Describe how ethanol may be prepared from renewable and non-renewable resources. Include relevant equations and state any reaction conditions required. **3**

Sample Answer

Renewable sources: fermentation of sugar cane using yeast enzymes:

$$C_6H_{12}O_6\ (aq) \rightarrow 2CH_3CH_2OH\ (aq) + 2CO_2\ (g)$$

Non-renewable sources: addition of water to ethene using dilute H_2SO_4 (aq) as a catalyst:

$$CH_2CH_2 + H_2O\ (l) \rightarrow CH_3CH_2OH$$

Outcome criteria	*Marks*
Two balanced equations given (one for renewable and one for non-renewable resources) + all conditions stated	*3*
One of the above missing	*2*
One balanced equation given	*1*

Note:

(1) For recognising renewable and non-renewable sources of ethanol.
(1) Renewable resource equation and conditions
(1) Non-renewable resource equation and conditions

(b) Explain why ethanol is used as a common solvent for a wide range of chemicals. **2**

Sample answer:

Ethanol is a good solvent for polar chemicals like antiseptics, water, chloroform, phenolphthalein indicator and ethers. Ethanol can dissolve these substance due to its –OH end which is polar. Ethanol may also form hydrogen bonds with chemicals such as glucose and amino acids and ammonia thus enabling it to dissolve these chemicals.

Ethanol is also a suitable solvent for non-polar chemicals like iodine and short chain hydrocarbons such as 1-hexene. The non-polar hydrocarbon chain of ethanol readily forms dispersion forces with non-polar substances. However, ethanol is suitable for small hydrocarbons.

Outcome criteria	*Marks*
Describes how ethanol may form hydrogen bonds with suitable chemicals; describes the polar nature of ethanol and how this enables ethanol to dissolve polar substances; describes the role of the non-polar part of ethanol in dissolving non-polar substances	*2*
One of the above missing	*1*

Note:

Students must outline the role of hydrogen bonding or dipole-dipole forces or dispersion forces in dissolving the appropriate solute to obtain 2 marks.

Max (1) if student only describes the dissolving properties of ethanol in terms of polarity and non-polarity of ethanol without outlining the role of intermolecular forces in

Question 22 (4 marks)

Polymers have revolutionised the way society uses and forms materials.

Compare the processes of addition and condensation polymerization using examples.

Sample Answer:

Addition polymerisation requires a double bond to be present and usually use of initiators to form radicals. E.g., polyethylene is formed from the monomer ethene. Condensation polymerisation does not require a double to be present but the presence of reactive groups such as NH_2, –COOH, -OH. E.g., cellulose is formed from β-glucose monomers. Condensation polymerisation does not involve the formation of radicals. Condensation polymerisation will produce a small molecule like water or H_2 with the addition of each monomer; this is not the case in addition polymerisation. Both processes involve the addition of monomers to form a polymer. Condensation polymerisation may involve two types of monomers (e.g., nylon) whereas addition polymerisation only requires one type of monomer.

Outcome criteria	*Marks*
At least 3 differences between addition and condensation polymerisation provided with an appropriate example given for each process.	*4*
One of the above missing	*3*
Describes one difference between the two processes and states examples of the two types of polymers (or their monomers)	*2*
Describes one difference between the two processes or states examples of the two types of polymers (or their monomers)	*1*

Note:

e = example of addition polymer (monomer or polymer)
e = example of condensation polymer (monomer or polymer)

s = similarity (both involve monomer)

d = difference (double bond vs functional groups; radical vs functional group; intact molecule vs loss of small molecule like water; initiator vs no initiator; one type of monomer vs two or more types of monomers)

Must include the radical or activated species as a difference to obtain full marks.

e e or e d or e s = (1)

e e d = (2)

e e s d = (3)

e e s d d = (4)

Question 23 (6 marks)

Galvanic cells were used to form the first type of batteries.

(a) In terms of structure and chemistry, compare the galvanic cell that you investigated in the laboratory with either a dry cell or lead-acid cell. **5**

Sample Answer:

Structure (s):	*Galvanic cell*	*Dry cell*	*Lead-acid cell*
Electrodes	*Solid metals for anode (Zn) and cathode (Cu)*	*Metallic outer casing (Zn) for anode; carbon rod for cathode*	*Solid metals for anode (Pb) and cathode (Pb with a PbO_2 coating)*
Salt bridge	*Unreactive salt solution such as KNO_3 (aq)*	*No salt bridge needed*	*No salt bridge needed*
Electrolytes	*Salt solution of each metallic electrode (e.g., $Zn(NO_3)_2$ (aq))*	*NH_4Cl (aq) paste, C, MnO_2*	*5 M H_2SO_4 (aq)*
Chemistry (c):	*Galvanic cell*	*Dry cell*	*Lead-acid cell*
Anode half-reaction	*$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$*	*$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$*	*$Pb(s) + SO_4^{2-} \rightarrow PbSO_4(s) + 2e^-$*
Cathode half-reaction	*$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$*	*$NH_4^+(aq) + MnO_2(s) + H_2O(l) + e^- \rightarrow Mn(OH)_3(s) + NH_3(aq)$* *Or* *$2MnO_2 + 2NH_4^+ + 2e^- \rightarrow Mn_2O_3 + H_2O + 2NH_3$*	*$PbO_2(s) + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4(s) + 2H_2O$*
other		*MnO_2 reacts with $H_2(g)$ to decrease the amount of polarisation that occurs*	*Both electrodes attain a coat of $PbSO_4$ (s) and the $[H_2SO_4]$ decreases over time*

Outcome criteria	*Marks*
Two cells are compared with respect to 2 structural similarities/differences and 2 chemical similarities/differences (including balanced ½ equations for anode and cathode reactions). One additional structural or chemical comparison provided.	*5*
One of the above missing	*4*
Two of the above missing	*3*
Two cells are compared with respect to one structural feature and one chemical feature	*2*
Two cells are compared with respect to one structural feature or one chemical feature	*1*

Note: *s = structure c = chemistry*

s c c = 3 *s s c c = 4* *s s c c or s or c = 5*

Max (2) if only one type of cell outlined (e.g. galvanic cell structure and chemistry provided).

(b) Demonstrate how you would theoretically calculate the standard cell potential ($E^{\emptyset}$) for the galvanic cell that you investigated in the laboratory. **1**

. . . . . .

Sample answer:

$E^{\emptyset}$ = EMFs for the anode and reduction half-reactions are added.

Outcome criteria	*Marks*
Calculation of $E^{\emptyset}$ presented using the EMFs for the anode and reduction half-reactions.	*1*

Question 24 (4 marks)

Radioisotopes are important products of nuclear chemistry.

(a) Describe the use of an identified radioisotope in industry. **2**

Sample answer:

Strontium-90, cesium-137, cobalt-60 are used for monitoring the thickness of sheet materials such as paper, aluminium foil and steel products.

Outcome criteria	*Marks*
Describes the industrial use of a named radioisotope	2
Identifies a radioisotope	1

(b) Outline how the radioisotope identified in (a) is produced. **2**

Sample answer:

Cobalt-60 is made in a nuclear reactor via the bombardment of cobalt-59 with a neutron.

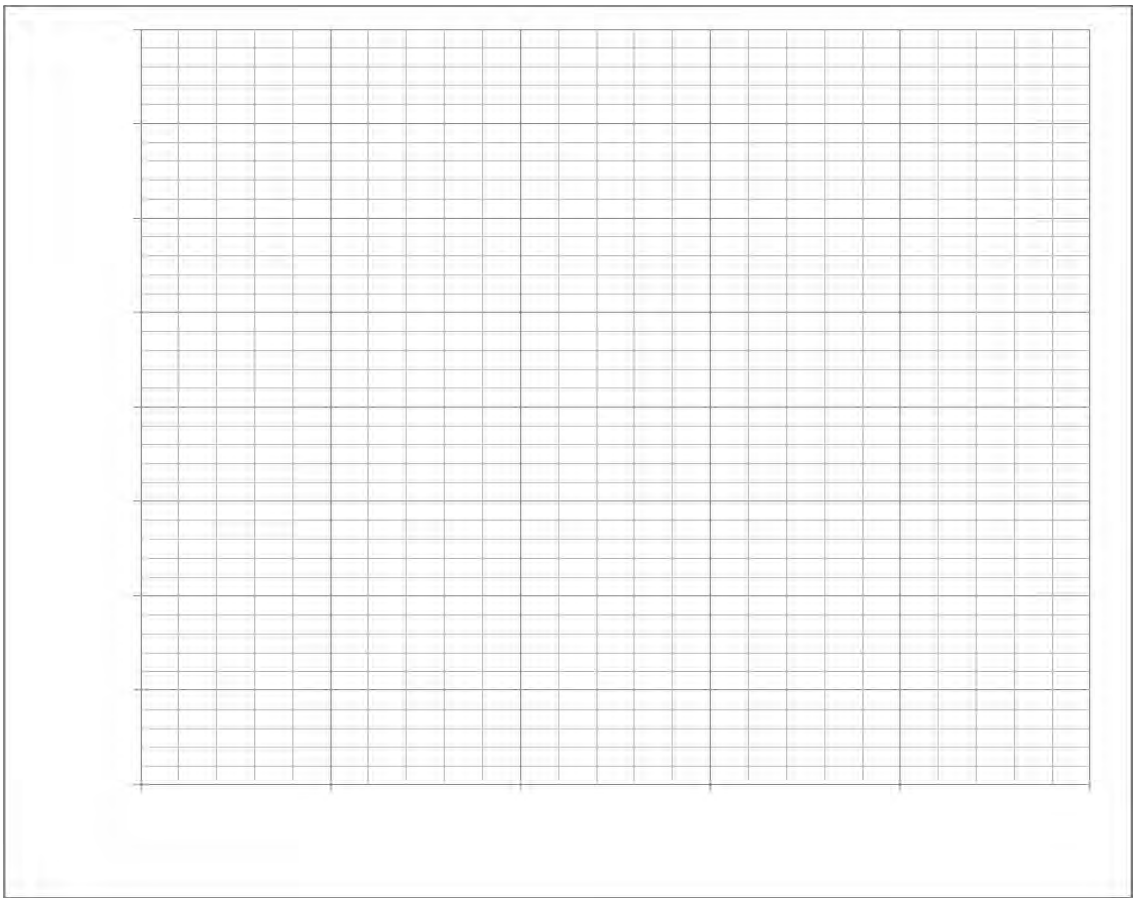
Outcome criteria	*Marks*
Describes the chemical process that occurs in a nuclear reactor to yield an identified radioisotope	2
Identifies the use of a nuclear reactor in synthesising radioisotopes	1

Question 25 (5 marks)

A first-hand investigation was carried out to measure the volume of gas produced when 200 mL of hydrochloric acid solution was added to various pieces of zinc. The volume of gas produced was recorded at 25 ^{o}C and 100 kPa as shown in the Table below :

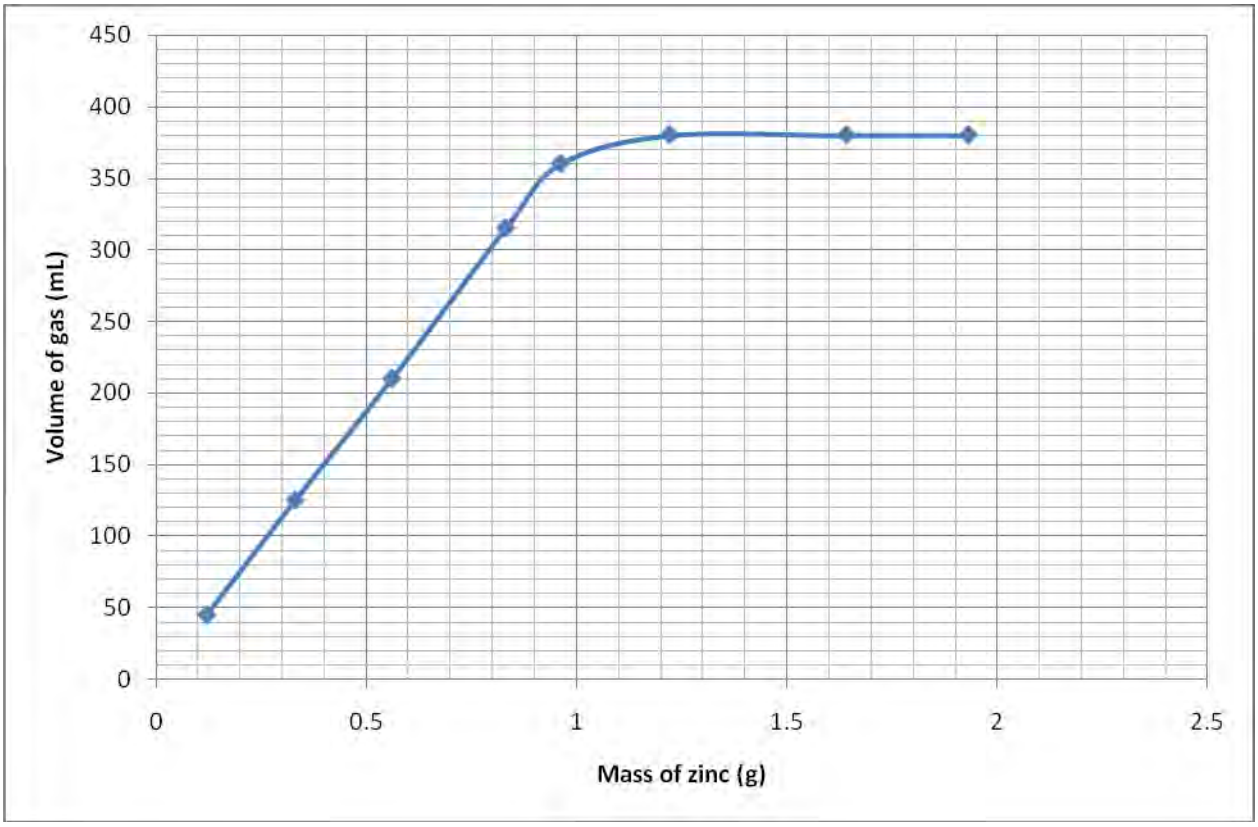
Mass of Zinc (g)	*Volume of Gas (mL)*
0.12	45
0.33	125
0.56	215
0.83	315
0.96	365
1.22	380
1.64	380
1.93	380

(a) Plot a line graph of the results in the grid below **3**



Outcomes: H13, H10

Sample Answer :



Correctly drawn line (curve) of best fit) with plotted points, labeled axes with units and appropriate scale on each axis.

Marking criteria

Criteria	*Marks*
Correctly plotted points with curve of best fit and correctly labeled axes with units and appropriate scale	*3*
Any one of the above missing	*2*
Any 2 of the above missing	*1*

(b) Calculate the theoretical volume of gas produced at 25^0C and 100 kPa by the reaction of 0.75 g zinc with 200 mL of the acid. **2**

Sample Answer :

1 mole zinc produces 1 mole of gas (hydrogen gas)

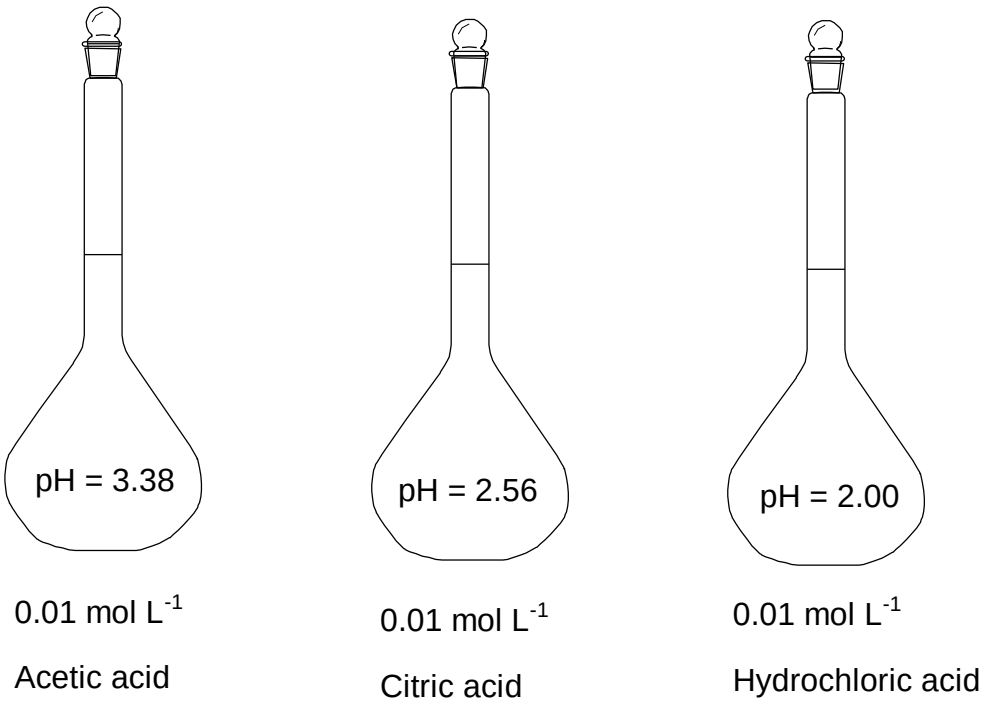
$$0.75g\ Zinc = \quad moles\ of\ zinc = \frac{0.75}{65.41}$$

$$Volume\ of\ gas = \frac{0.75}{65.41}\ x\ 24.79 = 0.28\ L$$

Marking criteria

	Marks
Correct calculation of moles of zinc and volume of gas produced	*2*
Correct calculation of moles of zinc	*1*

Question 26 (3 marks)



Explain the difference in pH between the 3 acids in the diagram. (3 marks)

Sample Answer

HCl is a strong acid which completely ionizes in solution and so the hydrogen ion concentration is equal to the concentration of the acid. Acetic and citric acid are weak acids which do not completely ionize in solution. The hydrogen ion concentration of a 0.1M acetic acid is less than that of a 0.1M citric acid ***NOT because citric acid is triprotic and acetic acid is monoprotic.*** *Strength depends on the polarity of the OH bond which is affected by a variety of factors; notably the electronegativity of the group attached to the carboxyl group, the greater the electronegativity, the stronger the acid. This is the reason why trichloroacetic acid (monoprotic) is stronger than citric acid (triprotic)*

Marking Criteria

Criteria	*Marks*
Thorough explanation for the reasons of the pH of each solution in relation to ionization of the weak and strong acids and the monoprotic and triprotic nature of acetic and citric acid respectively	*3*
Any one of the above missing	*2*
Any two of the above missing	*1*

Outcomes: H8

Question 27 (3 marks)

(a) Identify the common catalyst used in esterification reactions. **1**

……

Sample answer : concentrated H_2SO_4

Marking Criteria

Criteria	*Mark*
Correct identification of the catalyst used in esterification	1

(b) Outline the role of refluxing in the esterification process. **2**

Marking Criteria

Criteria	*Mark*
Two correct roles for the use of refluxing in esterification	*2*
One correct role for the use of refluxing in esterification	*1*

Sample Answer :

Refluxing allows the reactants to be heated so the rate of the reaction can be increased without the loss of volatile vapours of products and reactants. The reflux condenser condenses the volatile vapours of reactants and products back into the reaction vessel.

Outcomes: H9
Question 28 (3 marks)

Read the information provided in the fact file about environmental chemists and then answer the question. You may use any other information in addition to the fact file information.

FACT FILE:
WORK DESCRIPTION ► An environmental chemist may focus on collecting and analyzing samples, developing remediation programs, changing production processes to yield a more environmentally friendly product, providing expert advice on safety and emergency response, or dealing with government regulations and compliance issues.
WORKING CONDITIONS ► Work is often done in an indoor lab environment. However, when studying chemicals in the environment, a riverbed or stream may become the lab. Some companies have sophisticated indoor ecosystems in which they test their products. Others collect data outdoors and kilometres away from their own production sites.
PERSONAL CHARACTERISTICS ► Because environmental chemistry is so interdisciplinary, it requires excellent interpersonal and communication skills along with the ability to express ideas efficiently to a non scientific audience. The importance of the latter becomes apparent when chemists deal with regulations or with a company's sales and marketing staff.

Explain why collaboration between chemists is essential if the environmental aspects of the industry are to be considered. **3**

Outcome(s): H13, H3,H5,H15,H16

Sample answer:

As given in the write-up, the job of an environmental chemist has many aspects such as, collection of sample and data processing of results. Research and development are also required in order to ensure that the production processes are more environmentally friendly. All these however, cannot be done by a single chemist alone. Collaboration among the analytical chemists, industrial chemist and environmental chemists is therefore, required in order to formulate and implement environmental strategies efficiently which will satisfy government environmental regulations and maintain the industry's productivity and economic viability .

Criteria	*Mark(s)*
Elaboration on the roles and responsibilities of an environmental chemist, giving examples of the sort of work they do and the need for collaboration with other chemists.	*3*
Elaboration on the roles and responsibilities of an environmental chemist but giving no concrete example	*2*
Elaboration on the role, no responsibilities or examples	*1*

Question 29. (7 marks)

A student carried out an investigation to analyse lawn fertiliser.The student weighed out 1.00 g of fertiliser containing 24.0 % sulfur (S) and dissolved it in water. 100 mL of 0.20 mol L^{-1} barium chloride solution was then added and a precipitate formed.

(a) Calculate the theoretical percentage by mass of sulfate (SO_4^{2-}) in the fertiliser. **3**

Sample answer

$$mass\ of\ sulfur = mass\ sample\ x\ 0.240 = 0.240\,g \quad (1\ mark)$$

$$mass\ sulfate = \frac{mass\ sulfur}{atomic\ mass\ S}\ x\ molar\ mass\ sulfate = \frac{0.240}{32.07}\ x\ [32.07+4(16.00)] = 0.719\,g \quad (1\ mark)$$

$$\%\ sulfate = \frac{mass\ sulfate}{mass\ fertiliser}\ x\ 100\% = \frac{0.719}{1.00}\ x\ 100\% = 71.9\% \quad (1\ mark)$$

(b) Complete the table to explain the possible cause(s) of deviation of the result from the expected value. **4**

Lower value	***Higher value***
incomplete precipitation but not because of insufficient $BaCl_2$	*incomplete washing of precipitate to remove excess $BaCl_2$, hence making the precipitate heavier*
operational loss of precipitate (from filtering, solubility in supernatant, use of qualitative instead of quantitative filter paper)	*incomplete drying of precipitate so the precipitate is still moist and hence heavier*

Criterion	*Mark(s)*
Two valid reasons for high and two valid reasons for the low value.	*2 marks each*

Some unacceptable answers:

- *human error*
- *instrumental error to indicate high or low value because instrumental errors can be high or low*
- *obvious mistakes in the procedure such as spilling the solution , miscalculation, etc*

Question 30 (6 marks)

Aluminium has often been linked to Alzheimer's disease whose symptom is rapid memory loss. Common drinks, such as tea may contain higher than normal levels of aluminium ions: Considering that tea is such a popular drink, a group of students decided to analyse, the level of aluminium in black tea samples by AAS when given the chance to use the instrument in a nearby university.

They weighed out 10.00 g of tea and made an infusion with 500.00 mL of demineralised water. They allowed 2 minutes for the infusion time. At the same time they prepared standard aluminium solutions ranging from 1.00 ppm to 6.00 ppm. They passed replicate samples of the tea infusion and the standards through the AAS and obtained the following results:

Sample	*Concentration (ppm)*	*Absorbance*
Standard 1	1.25	0.1002
Standard 2	2.53	0.2111
Standard 3	3.68	0.3205
Standard 4	4.67	0.4504
Standard 5	5.43	0.5216
Tea infusion1	unknown	0.3565
Tea infusion 2	unknown	0.3566
Tea infusion 3	unknown	0.3565
Tea infusion 4	unknown	0.3566

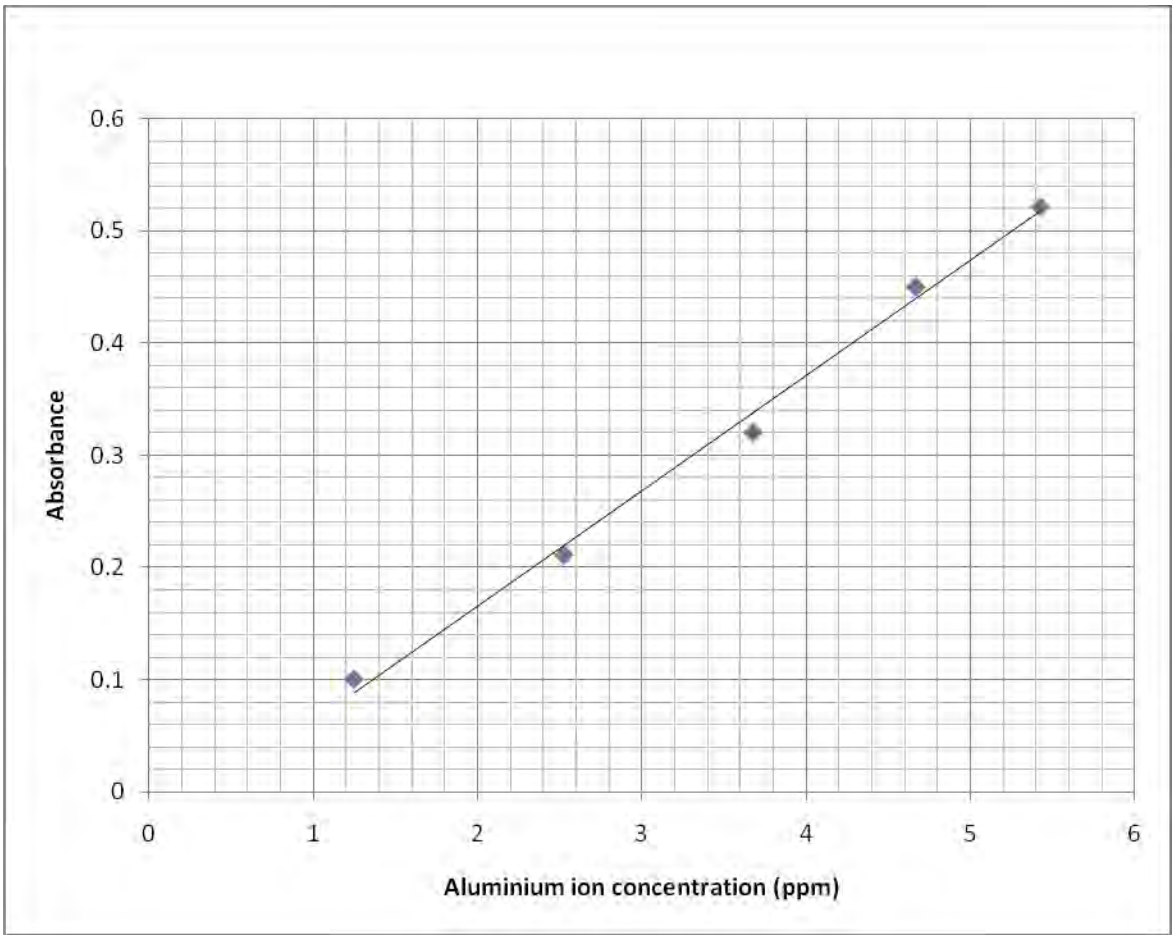
(a) Assess the reliability of the analysis of the tea infusions of unknown concentrations. **1**

Outcome(s): H11, H12, H13, H14

Sample answer:
The reliability for the analysis of the unknown was high since it was repeated several times and consistent result were obtained, that is, the analysis had a high reliability because it had high precision.

Criteria	*Mark(s)*
Related reliability to repetition of determination and the high precision obtained	1

(b) The diagram below shows a graph of the results obtained by the students.



Use the graph and the data table to determine the average concentration of aluminium in ppm in the tea infusion. **1**

Outcome(s): H13, H10

Sample answer: Reading off the graph and rounding off 3.9 ppm (1 mark for the correct reading ±0.1 ppm)

(c) 2.0 grams of black tea is required to make a 220-mL cup of tea and the daily tolerable limit for aluminium in tea is 7.0 mg/kg body weight.
How many cups of tea a day can a 55 kg person drink without exceeding the tolerable limit of aluminium?

Outcome(s): H13, H14

Sample answer:

The sample was a tea infusion of 10.00 g tea in 500.00 mL of water. This amounts to 0.0200 g mL^{-1} of water. According to the result of the current analysis, this infusion contains 3.9 ppm of aluminium ions.

The mass of tea/mL of water in a cup of tea = $\frac{2.00\,g}{220\ mL} = 9.09\ x10^{-3}\ g/mL$ (1 mark)

The concentration of aluminium in the 220 mL infusion can be obtained by ratio and proportion:

$$\frac{0.02000\,g/mL}{3.9\,ppm} = \frac{9.09\ x10^{-3}\,g/mL}{x}\ ;\ \ x = \frac{(9.09\,x10^{-3})\ (\ 3.9)}{0.02000} = 1.77\,ppm$$ (1 mark)

The allowed level of aluminum is 7.0 mg/ kg of body weight.

The total mass of aluminium allowed for a 55 kg person is = $\frac{7.00\,mg}{kg}\ x\ 55\,kg = 385\ mg$ *(1 mark)*

The volume of tea infusion that contains this mass of aluminium = $\frac{385\ mg}{1.77\,mg/L} = 217.514\ L$

This amounts to $\frac{217{,}514\,mL}{220\,mL} \approx 989\ cups$!!! *(1 mark)*

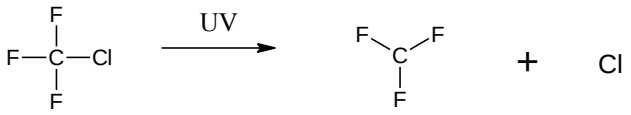
Question 31 (6 marks)

Discuss how some manufactured products have had a damaging impact with the composition of the atmosphere and evaluate the measures being done to eradicate the damage.

Outcome(s):H3, H4, H6,H16

Sample answer:

CFCs, chlorinated hydrocarbons and halons are manufactured products that have been found to deplete the ozone in the stratosphere through a mechanism which involves the release of chlorine atoms by reaction of CFCs with high energy UV. ***P and D***



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

$$OCl + O \longrightarrow Cl + O_2$$

The presence of chlorine disturbs the natural production and destruction of ozone in the atmosphere. In both processes (of production and destruction of ozone) high energy UV_C and UV_B radiations from the sun are mostly removed.

*A global concerted effort was necessary to alleviate the global problem. This was done mainly through the binding provisions of the 1987 and subsequent Montreal Protocols participated by many countries. The provisions were mainly; the gradual phasing out of the manufacture and use of CFCs (**M1)**replacing them with HCFCs and HFCs **(M2)**which are much less damaging to the ozone layer but are less efficient and more expensive to manufacture**. (A2)***

*Atmospheric chemists have shown that CFCs are damaging the ozone layer and banning their production and use are positive steps. These measures are working since, although the ozone hole has not decreased considerably in size, it has not grown bigger continuously. **(A1)**It is being predicted that the ozone hole can close up within the next 50 years with the strategies in place.*

Marking Guidelines

Criteria	*Marks*
▪Identification of at least two manufactured products causing damage **P**	1
▪Discussion of the process by which CFCs, halons, etc damage the ozone layer **D**	1
▪Discussion of the measures being done to alleviate the situation **(M1 and M2)**	2
▪An evaluation of the effect of the positive measures on the ozone hole **(A1 and A2)**	2

Question 32 (3 marks)

A water sample in a waterway was found to have high levels of turbidity and high dissolved solids together with increased biochemical oxygen demand.

Assses the ability of this waterway to sustain aquatic life.

Outcome(s): H9,H11,H13,

Sample answer:

This waterway will not be able to support aquatic life. The high turbidity can clog fish gills with sediments which can cause distress or fish kills. The increased turbidity can also lessen the extent of photosynthesis by aquatic plants and hence, less food for all other organisms. The high dissolved solids (high salinity) can cause death due to cell lysis due to increased osmotic pressure. A high BOD indicates the presence of pollutants that are consuming oxygen. This may not leave enough for the fish to survive.

Criteria	*Mark(s)*
Assessment of effect of high turbidity	1
Assessment of effect of high biochemical oxygen demand	1
Assessment of effect of high TDS	1

Section II

25 marks
Attempt question 33
Allow about 45 minutes for this section

Answer the question in a writing booklet.
Show all relevant working in questions involving calculations.

(a) The Solvay Process is used to produce sodium carbonate.

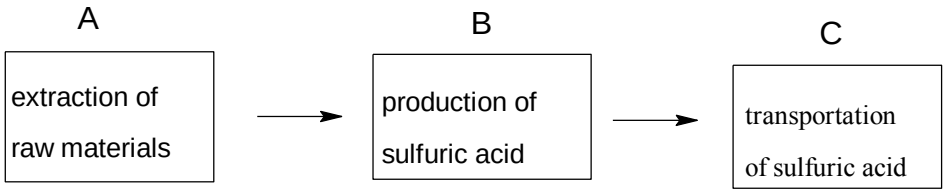
One step in the process involves the decomposition, by heat, of sodium hydrogen carbonate.

(i) Give an equation for this reaction. **1**

(ii) If 10 100 tonnes of sodium hydrogen carbonate is heated, what volume of gas will be produced at 25^0C? **3**

(iii) What happens to the gas produced in this step of the Solvay Process? **1**

(b) The flowchart shows the production and distribution of sulfuric acid.



(i) Identify one safety or environmental issue associated with A, B and C.
(ii) Describe the precautions taken to avoid the consequence of each issue identified. **6**

(c) An impurity in natural gas is hydrogen sulfide or rotten egg gas.

This gas can be removed from natural gas by the following process.

$2H_2S\,(g) + SO_2\,(g) \rightarrow 3S\,(s) + 2H_2O\,(g) \qquad \Delta H = -145\ kJ\ mol^{-1}$

(i) Give the equilibrium expression for this reaction. **1**

(ii) Calculate the equilibrium constant when 2.00 mol of H_2S and 2.00 mol of SO_2 react in a 1.00L vessel at 373K to give 1.00 mol of water vapour under equilibrium conditions **2**

(iii) What conditions of temperature and pressure would favour the removal of hydrogen sulfide gas? Explain these conditions in terms of Le Chatelier's principle **4**

(d) You performed a first-hand investigation to identify the products of electrolysis of aqueous sodium chloride.

Identify the product at either the cathode or the anode and describe the test you performed to identify that product. **3**

(e) Distinguish between cationic and non-ionic detergents in terms of their chemical composition and usage. **4**

Trial Answers

(a) The Solvay Process is used to produce sodium carbonate.
One step in the process involves the decomposition by heat of sodium hydrogen carbonate.

(i) Give an equation for this reaction. (1 mark)

$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

(ii) If 10,100 tonnes of sodium hydrogen carbonate is heated, what volume of gas will be produced at 25^0C? (3 marks)

Mol $NaHCO_3$ = mass/molar mass = $10{,}100 \times 10^6 / 84.008 = 1.20 \times 10^8$
Mol CO_2 = ½ x mol $NaHCO_3$ = ½ $1.2 \times 10^8 = 6.0 \times 10^7$
Volumes CO_2 = mol x 24.79 = $6.0 \times 10^7 \times 24.79 = 1.49 \times 10^9$ L

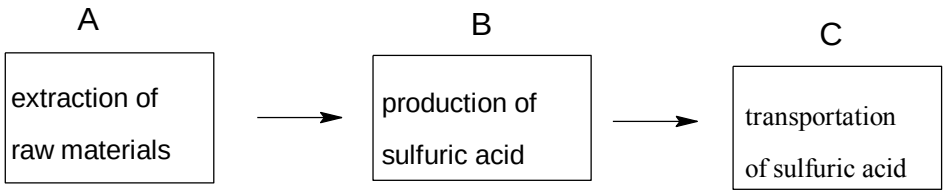
Marking criteria	*Marks*
• *Calculates mol $NaHCO_3$* • *Correct molar relationship* • *Calculates volume of CO_2*	*3*
• *Two of the above*	*2*
• *One of the above*	*1*

(iii) What happens to the gas produced in this step of the Solvay Process? (1 mark)

The carbon dioxide is recycled and reused in the Solvay tower.

Outcomes: H4,10

(b) The flowchart shows the production and distribution of sulfuric acid.



(i) Identify one safety or environmental issue associated with A, B and C.
(ii) Describe the precautions taken to avoid the consequence of each issue identified. **6**

Raw materials.

A raw material in the production of sulfuric acid is sulfur. This can be extracted from the ground using the Frasch process. Care needs to be taken to avoid pumping cooled superheated water from the process into local rivers as it may contain dissolved mineral salts which can cause stress to aquatic organisms.

Production

One step in the production of sulfuric acid is the formation of oleum. Sulfur trioxide can be added directly to water to form sulfuric acid but this process is strongly exothermic and produces an acid mist. Acid is corrosive so this need to be avoided. Sulfur trioxide is added first to sulfuric acid to make oleum which is then safely added to water to produce sulfuric acid.

Transportation

Sulfuric acid is transported concentrated and can be safely transported in sealed steel tanks. Exposure to air would lead to dilution with water vapour a strongly exothermic reaction resulting in a very corrosive solution. Tanks need to be sealed.

Marking criteria	*Marks*
• *Identifies a different issue for each step and describes the precautions taken to avoid the consequences.*	*6*
• *Identifies a different issue for each step and outlines the precautions taken to avoid the consequences*	*5*
• *Identifies two different issues and describes the precautions taken to avoid the consequences*	*4*
• *Identifies 3 issues Or* • *Outlines the precautions taken to avoid the consequences of two issues*	*3*
• *Identifies two issues OR* • *Identifies one issue and describes the precaution taken to avoid the consequences*	*2*
• *Identifies one issue*	*1*

Outcomes:H4,7,8

(c) An impurity in natural gas is hydrogen sulphide or rotten egg gas.
This gas can be removed from natural gas by the following process.

$2H_2S\ (g) + SO_2\ (g) \rightleftharpoons 3S\ (s) + 2H_2O\ (g) \qquad \Delta H = -145\ kJ\ mol^{-1}$

(i) Give the equilibrium expression for this reaction. (1 mark)

$$K = \frac{[H_2O]^2}{[H_2S]^2[SO_2]}$$

(ii) Calculate the equilibrium constant when 2.00 mol of H_2S and 2.00 mol of SO_2 react in a 1.00L vessel at 373K to give 1.00 mol of water vapour under equilibrium conditions.(2 marks)

	$2H_2S\ (g)$	*+ $SO_2\ (g)$*	*$\rightleftharpoons$*	*$3S\ (s)$*	*+ $2H_2O\ (g)$*
Initial [ ]	*2*	*2*			*0*
Used	*1*	*0.5*			
Final [ ]	*1*	*1.5*			*1*

$$K = \frac{1^2}{1^2 \times 1.5} = 0.667$$

Marking criteria	*Marks*
• *Correctly calculates K*	*2*
• *Correct calculation for incorrect concentrations*	*1*

(iii) What conditions of temperature and pressure would favour the removal of hydrogen sulphide gas? Explain these conditions in terms of Le Chatelier's principle.(4 marks)

Low temperature and high pressure.

The forward reaction is exothermic. A decrease in temperature will favour the reaction that makes heat, the forward reaction, equilibrium will shift to the right.
An increase in pressure will favour the reaction that produces less pressure. There are 3 mols of gas on the left side of the equation and only two mols of gas on the right, so equilibrium will shift right.

Marking criteria	***Marks***
• *Correct conditions explained in terms of Le Chatelier's principle*	*4*
• *Correct condition with one explained in terms of Le Chatelier's principle*	*3*
• *Correct temperature or pressure explained in terms of Le Chatelier's principle*	*2*
• *Correct temperature or pressure*	*1*

Outcomes:H7,10

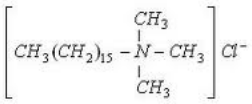
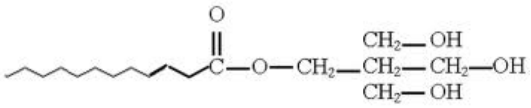
(d) You performed a first-hand investigation to identify the products of electrolysis of aqueous sodium chloride.
Identify the product at either the cathode or the anode and describe the test you performed to identify that product. (3 marks)

Sample answer
Cathode. The reaction at the cathode is the reduction of water to produce hydrogen and hydroxide ions. Addition of phenolphthalein shows the solution turning pink at the cathode confirming the production of hydroxide ions.

Marking criteria	***Marks***
• *Correct product at anode or cathode* • *Description of a test that confirms the product*	*3*
• *Correct product at anode or cathode OR* • *Description of a test that confirms the product at incorrect electrode*	*2*
• *Identifies a correct product*	*1*

Outcomes:H11

(e) Distinguish between cationic and non-ionic detergents in terms of their chemical composition and usage. (4 marks)

	Cationic detergent	Non-ionic detergent
Chemical composition		
Usage	Used as fabric softeners	Low foaming and used in dish washers

Marking criteria	***Marks***
• *Correct structures and uses*	*4*
• *3 correct*	*3*
• *2 correct*	*2*
• *1 correct*	*1*

Outcomes: H3,4,9