2015

TRIAL HSC

EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of the response sheet on page11 and on the Elective answer booklet.
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided.

.

Total Marks – 100

Section I Pages 2 – 22

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 23-24

25 marks

•Attempt Question 32

•Allow about 45 minutes for this section

Mark your answers on the ANSWER grid on page 11

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

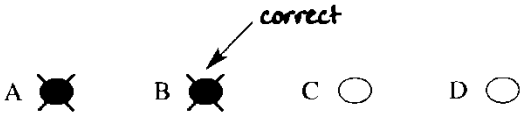
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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



A ⊗ B ⊗ C ○ D ○

1. Which layer of the atmosphere is closest to the Earth?

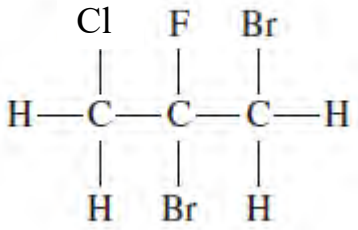
(A) Thermosphere

(B) Stratosphere

(C) Mesosphere

(D) Troposphere

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



(A) 1-chloro-2-fluoro-2,3-dibromopropane

(B) 1,2-dibromo-2-fluoro- 3- chloropropane

(C) 1,2-dibromo-3-chloro-2-fluoropropane

(D) 2,3-dibromo-1-chloro-2-fluoropropane

3. Which of the following is a renewable resource?

(A) Aluminium

(B) Cellulose

(C) Petroleum

(D) Polyethylene

4. What is the oxidation state of sulfur in the hydrogensulfite ion, HSO_3^{-1}?

(A) +4

(B) +3

(C) -3

(D) -4

5. Ethanol is often called a "universal solvent".

Which property of ethanol makes it a suitable solvent for both organic and inorganic substances?

(A) It is a small polar molecule.

(B) It is a small non-polar molecule

(C) It is a small molecule with polar and non-polar ends.

(D) It is a small molecule with low density.

6. Ethylene is obtained in industry from petroleum fractions.

$$C_{10}H_{22}\,(l) \xrightarrow{AlSi_2O_6} C_8H_{18}(l) + C_2H_4(g)$$

What is the name of this process?

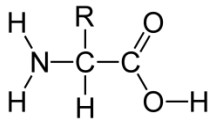
(A) catalysis

(B) cracking

(C) breaking

(D) polymerisation

7. Amino acids undergo polymerisation to produce proteins. A general formula for amino acids is given below.



Which substance is one of the products of this process?

(A) water

(B) carbon dioxide

(C) ammonium ion

(D) oxygen

8. An organic liquid, when reacted with concentrated sulfuric acid, produces a compound that immediately decolourises bromine water.

What is the formula of the organic liquid?

(A) C_5H_{10}

(B) C_5H_{12}

(C) $C_5H_{11}OH$

(D) $C_5H_{11}O$

9. The reaction of ammonia and phosphine in a closed container over water is shown in the equation.

$$NH_3(g) + PH_3(g) \rightleftarrows PH_4^+(aq) + NH_2^-(aq)$$

Identify a conjugate acid/base pair in this reaction.

(A) NH_3/PH_3

(B) PH_4^+/NH_2^-

(C) PH_3/NH_2^-

(D) PH_3/PH_4^+

10. What is the purpose of using concentrated sulfuric acid in esterification reactions?

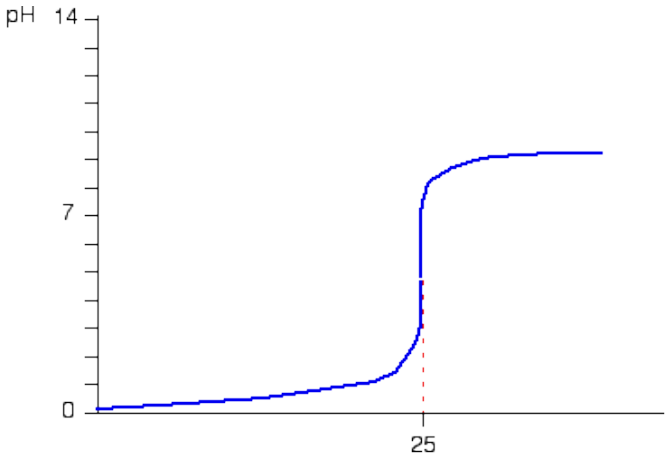
(A) to dehydrate the system

(B) to catalyse the reaction

(C) to be a reactant

(D) to hydrate the system

Consider the titration curve below to answer questions 11 and 12



Volume of base added (mL)

11. This graph could represent the reaction between which two chemicals?

(A) HCl and NaOH

(B) HCl and NH_3

(C) CH_3COOH and NaOH

(D) CH_3COOH and Na_2CO_3

12. Which indicator would be most effective for this titration?

(A) methyl orange

(B) phenolphthalein

(C) bromothymol blue

(D) litmus

13. In recent times, much research has gone into the production and use of biopolymers.

What is one major reason for this?

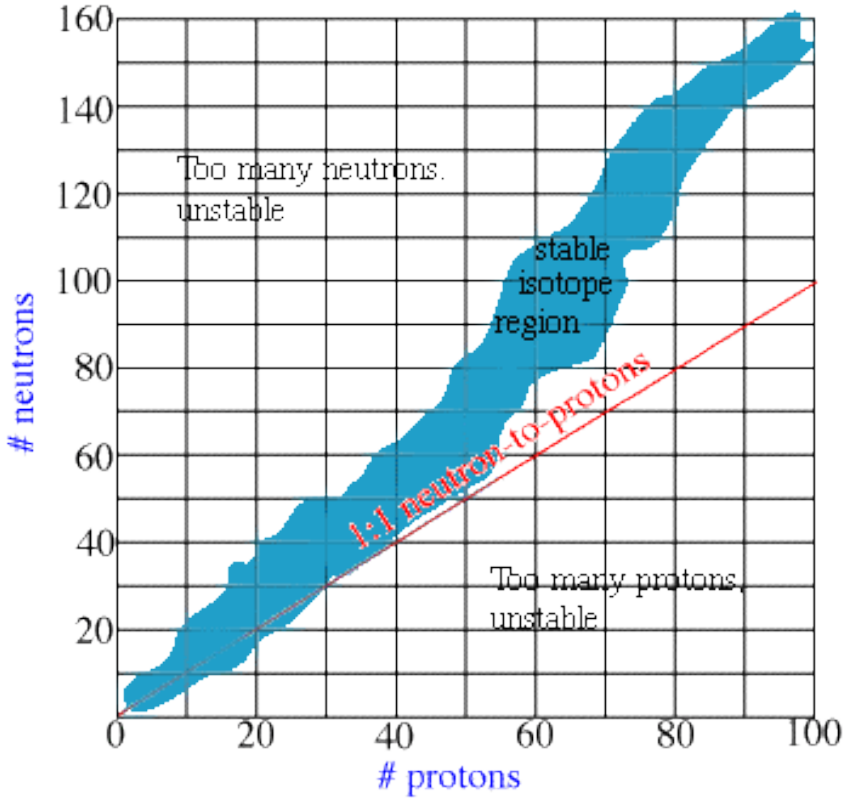
(A) Biopolymers are biodegradable.

(B) Biopolymers are cheap to produce.

(C) Biopolymers are more energy efficient in production.

(D) Biopolymers are easy to produce.

14. The zone of isotope stability is graphed below.



Use the graph to determine which of the isotopes is stable.

(A) Uranium-230

(B) Strontium-74

(C) Antimony-123

(D) Lead- 184

15. A 0.1 mol L^{-1} HCl solution has a pH of 1.0. What volume of water must be added to 10.0 mL of this solution to obtain a final pH of 2.0?

(A) 90 mL

(B) 100 mL

(C) 810 mL

(D) 900 mL

16. Calculate the volume of ethanol produced from the fermentation of 45.0 g of glucose at 25°C. The density of ethanol is 0.79 g mL^{-1}.

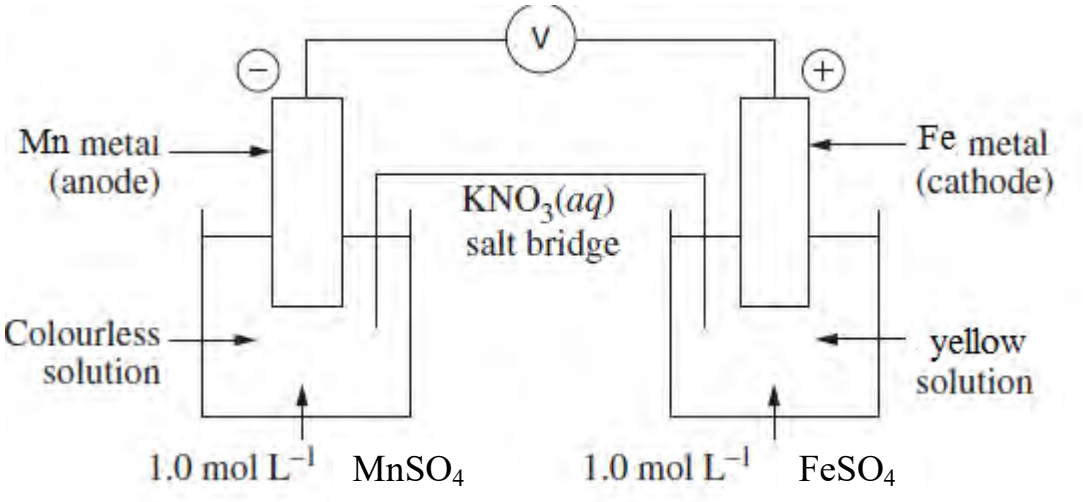
(A) 9.09 mL

(B) 12.4 mL

(C) 18.2 mL

(D) 23.0 mL

17. What is the cell potential for this galvanic cell?



(A) -1.62 V

(B) +1.62 V

(C) - 0.74 V

(D) +0.74 V

18. In a reaction, 30.0mL of a 0.106 $molL^{-1}$ NaOH is added to 25.0 mL of 0.100 $molL^{-1}$ HCl solution.

What will be the pH of the final solution?

(A) 4.00

(B) 7.00

(C) 10.0

(D) 12.1

19. Solutions of citric acid and hydrochloric acid are both found to have a pH of 3.0.

Which combination of concentrations could explain this observation?

	Citric acid mol L^{-1}	Hydrochloric acid mol L^{-1}
(A)	0.030	0.003
(B)	0.01	0.001
(C)	3.00	3.00
(D)	0.001	0.001

20. A mixture of brown NO_2 and N_2O_4 gases in a rigid vessel reaches equilibrium according to the equation:

$$\underset{\text{brown}}{2NO_2(g)} \rightleftarrows \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -57.2 \text{ kJ/mol}$$

What effect does raising the temperature have on the colour of gases in the vessel?

(A) There will be no change in the colour as the system is in equilibrium.

(B) The brown colour will fade because the forward reaction is exothermic.

(C) The brown colour will intensify because the forward reaction is exothermic.

(D) The brown colour will intensify because the forward reaction is endothermic.

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Student Number …….

Mark.....

Section I 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*

Question 21 (6 marks) **Marks**

(a) Draw a flow chart diagram to show the industrial processes involved in the production of ethanol from sugar cane. **4**

(b) Justify ONE condition required to promote the fermentation of sugar. **2**

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Question 22 (5 marks)

The yield of product in the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium.

Justify the conditions used in this process. **5**

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Question 23 (7 marks)

(a) Outline ONE use of esters. **1**

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(b) Write a balanced chemical equation using structural formula to show the reaction between 1-hexanol and butanoic acid. **3**

(c) Name the organic product formed in this reaction. **1**

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(d) Identify a risk associated with the laboratory production of esters and explain the safety precaution taken to minimise the risk. **2**

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Question 24 (4 marks) **Marks**

A student determined the molar heat of combustion of ethanol using a spirit-burner, an aluminium can containing 300.0g water, a thermometer and an electronic balance.

The following results were recorded.

Initial mass of burner	133.20g
Final mass of burner	132.05g
Initial temperature of water	25.0^0C
Final temperature of water	45.5^0C

(a) Use the data to calculate the molar heat of combustion of ethanol. **3**

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(b) The calculated molar heat of combustion is much less than the correct value. Apart from heat loss to the surroundings, suggest another reason for the low value obtained. **1**

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Question 25 (7 marks)

(a) Ozone has a coordinate covalent bond.

Define what is meant by a coordinate covalent bond and draw a Lewis electron dot diagram for ozone indicating, with an arrow, the coordinate covalent bond. **3**

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(b) Compare TWO properties of ozone and oxygen and explain these in terms of their structure and/or bonding. **4**

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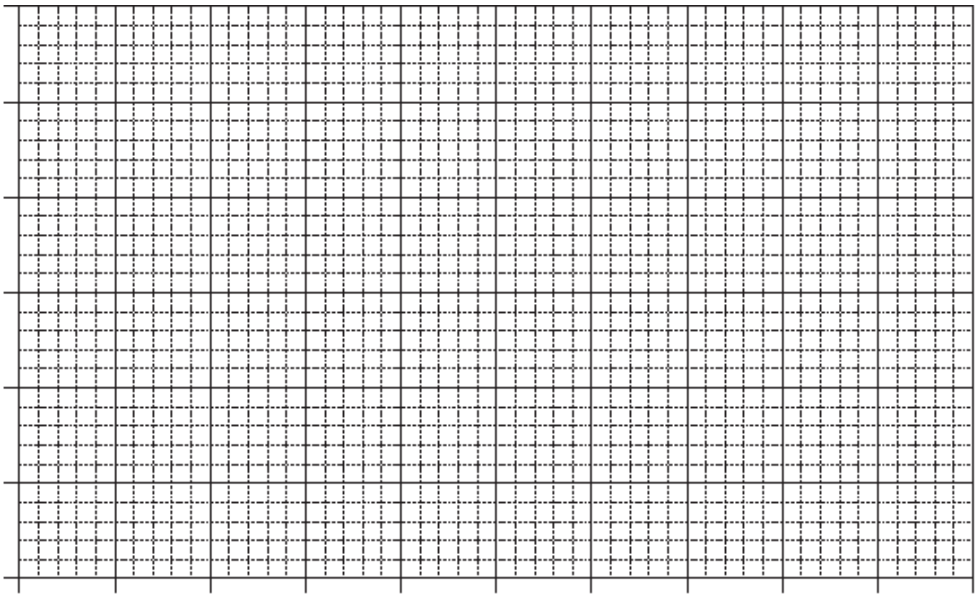
Question 26 (5 marks)

The concentration of lead ions in a river was determined using atomic absorption spectroscopy.

The following standard solutions were prepared and the sample tested.

Standard Pb^{2+} solution ppm	Absorbance reading
0.0	0.00
10.0	0.14
20.0	0.28
30.0	0.42
40.0	0.56
sample	0.22

(a) Plot and draw a calibration curve for the standard lead ion solutions. **3**



(b) Use the absorbance of the water sample to calculate the concentration of lead ions in $molL^{-1}$. **2**

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Question 27 (7 marks)

An analytical chemist was employed to test the water quality of a river.

She used the following information to analyse her results.

Table 1

pH	3 4 5	6 7	8 9 10 11
PO_4^{3-}	Insoluble salts form with Fe^{2+} and Al^{3+}	Maximum availability to plants	Ca^{2+} form insoluble phosphates
NO_3^-	Not available to plants	Maximum availability to plants	
Mg^{2+}	Maximum availability		Forms insoluble carbonates

A 600 mL sample of river water was collected and the results of her tests are in the table below.

Table 2

Procedure	Result
Added soap to a 100 mL sample	No froth observed
Inserted pH probe to measure pH	7.5
Bubbled O_2 *(g)* into the remaining 500 mL sample at 25°C to saturate it with oxygen. The final concentration was measured.	0.009g/L in the saturated sample
Sample was left for 5 days in the dark and was then analysed with the Winkler titration.	1.1×10^{-5} mol O_2 remained

Give an overall assessment of the health of the river by analysing the biochemical oxygen demand, hardness and risk of eutrophication. **7**

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Question 28 (3 marks)

The list below contains acids, bases and salts.

H_2SO_4 Na_2CO_3 NH_4Cl HCl CH_3COOH NaOH NH_3

(a) Identify the two species which would react together to form a basic salt. **1**

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(b) Outline how a buffer solution could be prepared from two or more of the above compounds. **2**

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Question 29 (3 marks)

During a reaction between solid sodium hydrogen carbonate and sulfuric acid 328.35 mL of a gas were collected. The reaction was carried out at 25^oC and 100 kPa.

Calculate the mass of solid sodium hydrogen carbonate that reacted to produce this volume of gas. **3**

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Question 30 (4 marks)

(a) Describe TWO methods of producing commercial radioactive isotopes. **4**

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Question 31 (4 marks)

In an investigation to determine the concentration of acetic acid in vinegar, the following steps were undertaken:

1. 50.00 mL sample of vinegar was diluted with demineralised water to make 500.0 mL of dilute vinegar solution.

2. 25.00 mL aliquots of the diluted vinegar were then titrated against 0.105 $molL^{-1}$ sodium hydroxide solution.

3. The results were tabulated.

Titration	Volume of 0.105 $molL^{-1}$ NaOH (mL)
1	28.60
2	26.10
3	25.90
4	29.50
5	26.00

Calculate the original concentration of acetic acid in the vinegar in $molL^{-1}$. **4**

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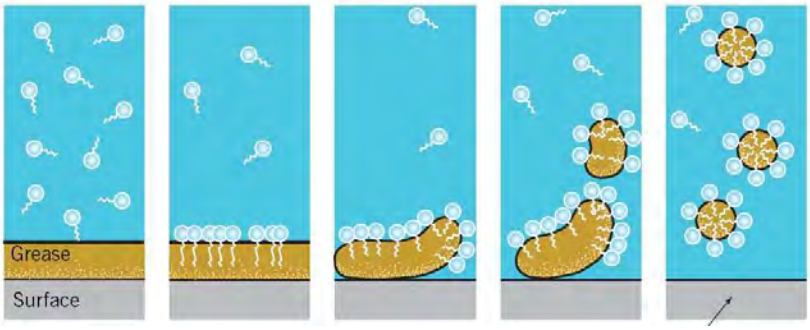
Question 32 – Industrial Chemistry (25 marks) (a) – (e) **Marks**

(a) Glyceryl trilaurate can be used in the production of the soap sodium laurate.

(i) What is the other product of this saponification reaction? **1**

(ii) The diagram below models the cleaning action of soap



Step 1 Step 2 Step 3 Step 4 Step 5

Use the models to account for the cleaning action of soap. **5**

(b) Consider the following reaction:

$2NO(g) + 2H_2(g) \rightleftarrows N_2(g) + 2H_2O(g)$

Initially, a mixture of 0.100 $molL^{-1}$ NO, 0.050 $molL^{-1}$ H_2 and 0.100 $molL^{-1}$ H_2O was allowed to reach equilibrium. At equilibrium the concentration of NO was found to be 0.062 $molL^{-1}$. Calculate the value of the equilibrium constant for the reaction. **3**

(c) The following reaction conditions are used in the production of sulfur trioxide from sulfur dioxide in the Contact process: an excess of oxygen, atmospheric pressure, a vanadium (V) oxide catalyst and temperatures of 550°C and 400°C.

Select from the reaction conditions above to explain each of these effects. **6**

(i) Accelerates the reaction without affecting the yield.
(ii) Increases the yield without changing the equilibrium constant.
(iii) Changes the equilibrium constant.

(d) (i) Describe valid procedures that could be used to identify TWO products of the electrolysis of concentrated sodium chloride solution. **2**

(ii) Justify the use of ONE safety precaution, other than wearing safety goggles, when carrying out these procedures. **2**

Continued over the page…….

(e) (i) Describe two environmental issues associated with the Solvay process and outline how these issues are addressed. **4**

(ii) Calculate the mass of sodium chloride required to produce 2.0 tonnes of sodium carbonate. **2**

End of exam

Chemistry Trial answers 2015

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 ○

1. Which layer of the atmosphere is closest to the Earth?

(A) Thermosphere

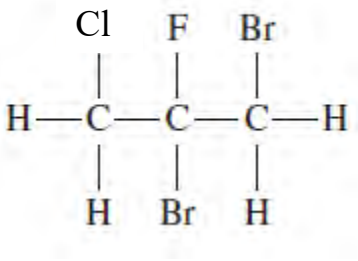
(B) Stratosphere

(C) Mesosphere

(D) Troposphere

Outcomes : H4

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



(A) 1-chloro-2-fluoro-2,3-dibromopropane

(B) 1,2-dibromo-2-fluoro- 3- chloropropane

(C) 1,2-dibromo-3-chloro-2-fluoropropane

(D) 2,3-dibromo-1-chloro-2-fluoropropane

Outcomes : H9

3. Which of the following is a renewable resource?

(A) Aluminium

(B) Cellulose

(C) Petroleum

(D) Polyethylene

Outcomes : H4,H9

4. What is the oxidation state of sulfur in the hydrogensulfite ion, HSO_3^{-1}?

(A) +4

(B) +3

(C) -3

(D) -4

Outcomes : H6

5. Ethanol is often called a "universal solvent".

Which property of ethanol makes it a suitable solvent for both organic and inorganic substances?

(A) It is a small polar molecule.

(B) It is a small non-polar molecule

(C) It is a small molecule with polar and non-polar ends.

(D) It is a small molecule with low density.

Outcomes : H6, H9

6. Ethylene is obtained in industry from petroleum fractions.

$$C_{10}H_{22}\,(l) \xrightarrow{AlSi_2O_6} C_8H_{18}(l) + C_2H_4(g)$$

What is the name of this process?

(A) catalysis

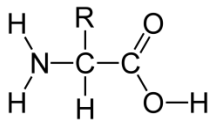
(B) cracking

(C) breaking

(D) polymerisation

Outcomes : H4,H9

7. Amino acids undergo polymerisation to produce proteins. A general formula for amino acids is given below.



Which substance is one of the products of this process?

(A) water

(B) carbondioxide

(C) ammonium ion

(D) oxygen

Outcomes : H9

8. An organic liquid, when reacted with concentrated sulfuric acid, produces a compound that immediately decolourises bromine water.

What is the formula of the organic liquid?

(A) C_5H_{10}

(B) C_5H_{12}

(C) $C_5H_{11}OH$

(D) $C_5H_{11}O$

Outcomes : H9

9. The reaction of ammonia and phosphine in a closed container over water is shown in the equation.

$$NH_3(g) + PH_3(g) \rightleftarrows PH_4^+(aq) + NH_2^-(aq)$$

Identify a conjugate acid/base pair in this reaction.

(A) NH_3/PH_3

(B) PH_4^+/NH_2^-

(C) PH_3/NH_2^-

(D) PH_3/PH_4^+

Outcomes : H6

10. What is the purpose of using concentrated sulfuric acid in esterification reactions?

(A) to dehydrate the system

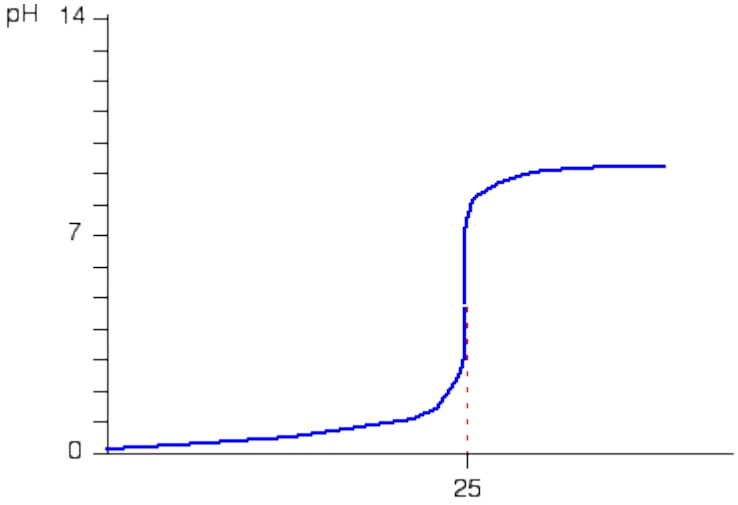
(B) to catalyse the reaction

(C) to be a a reactant

(D) to hydrate the system

Outcomes : H8, H9

Consider the titration curve below to answer questions 11 and 12



Volume of base added (mL)

11. This graph could represent the reaction between which two chemicals?

(A) HCl and NaOH

(B) HCl and NH_3

(C) CH_3COOH and NaOH

(D) CH_3COOH and Na_2CO_3

Outcomes : H8

12. Which indicator would be most effective for this titration?

(A) methyl orange

(B) phenolphthalein

(C) bromothymol blue

(D) litmus

Outcomes : H8

13. In recent times, much research has gone into the production and use of biopolymers. What is one major reason for this?

(A) Biopolymers are biodegradable.

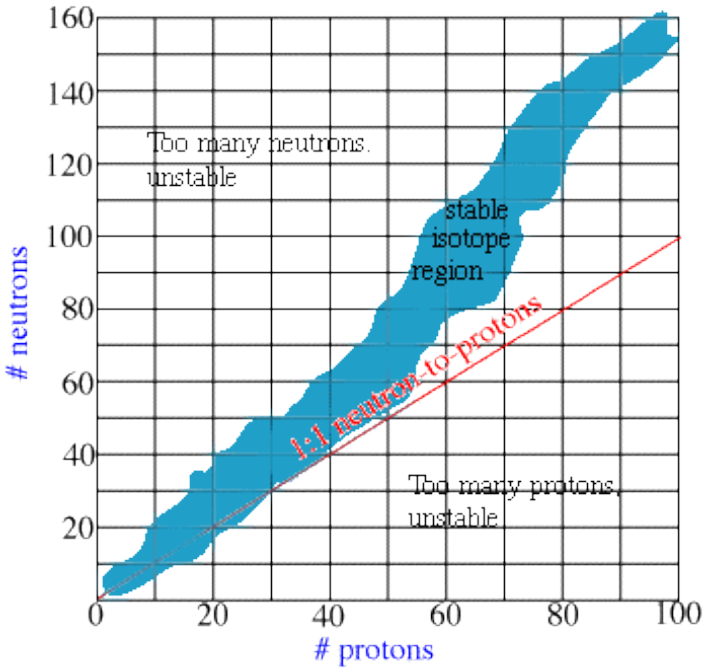
(B) Biopolymers are cheap to produce.

(C) Biopolymers are more energy efficient in production.

(D) Biopolymers are easy to produce.

Outcomes : H3, H9

14. The zone of isotope stability is graphed below.



Use the graph to determine which of the isotopes is stable.

(A) Uranium-230

(B) Strontium-74

(C) Antimony-123

(D) Lead- 184

Outcomes : H6

15. A 0.1 mol L^{-1} HCl solution has a pH of 1.0. What volume of water must be added to 10.0 mL of this solution to obtain a final pH of 2.0?

(A) 90 mL

(B) 100 mL

(C) 810 mL

(D) 900 mL

Outcomes : H10

16. Calculate the volume of ethanol produced from the fermentation of 45.0 g of glucose at 25°C. The density of ethanol is 0.79g/mL.

(A) 9.09 mL

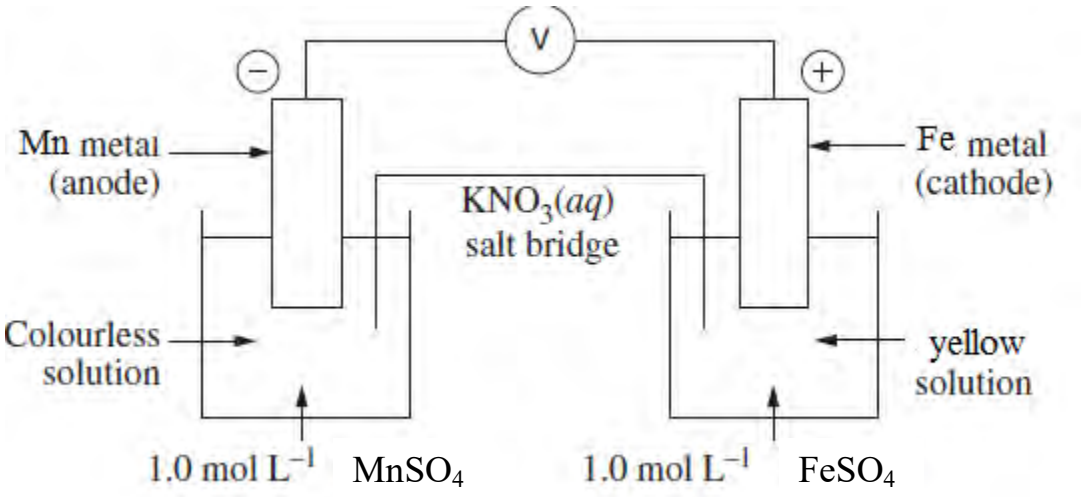
(B) 12.4 mL

(C) 29.1 mL

(D) 18.2 mL

Outcomes : H10, H9

17. What is the cell potential for this galvanic cell?



(A) -1.62 V

(B) +1.62 V

(C) - 0.74 V

(D) +0.74 V

Outcomes : H10

18. In a reaction, 30.0mL of a 0.106 molL^{-1} NaOH is added to 25.0 mL of 0.100 molL^{-1} HCl solution.

What will be the pH of the final solution?

(A) 4.00

(B) 7.00

(C) 10.0

(D) 12.1

Outcomes : H10

19. Solutions of citric acid and hydrochloric acid are both found to have a pH of 2.0.

Which combination of concentrations could explain this observation?

	Citric acid mol L^{-1}	Hydrochloric acid mol L^{-1}
(A)	0.030	0.003
(B)	0.01	0.001
(C)	3.00	3.00
(D)	0.001	0.001

Outcomes : H10

20. A mixture of brown NO_2 and N_2O_4 gases in a rigid vessel reaches equilibrium according to the equation:

$$\underset{\text{brown}}{2NO_2(g)} \rightleftarrows \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -57.2 \text{ kJ/mol}$$

What effect does raising the temperature have on the colour of gases in the vessel?

(A) There will be no change in the colour as the system is in equilibrium.

(B) The brown colour will fade because the forward reaction is exothermic.

(C) The brown colour will intensify because the forward reaction is exothermic.

(D) The brown colour will intensify because the forward reaction is endothermic.

Outcomes : H8

Question 21 (6 marks) **Marks**

(a) Draw a flow chart diagram to show the industrial processes involved in the production of ethanol from sugar cane. **4**

Sugar cane harvested →cutting and crushing to extract cellulose→acid hydrolysis of cellulose→ filtration to remove solid waste→fermentation of glucose with yeast at 37^0C→distillation to obtain pure ethanol

Marking Criteria	*Mark(s)*
• *Complete diagram showing minimum of four correct steps in thorough detail*	*4*
• *One step missing or incorrect or insufficient detail*	*3*
• *Two steps missing or incorrect or insufficient detail*	*2*
• *Three steps missing or incorrect or insufficient detail*	*1*

(b) Justify ONE condition required to promote the fermentation of sugar. **2**

Any one of the following :

suitable grain mashed with water to provide glucose, or yeast added for zymase to catalyse the reaction, air(oxygen) excluded to allow for anaerobic conditions so glucose converts to ethanol and not ethanoic acid, temperature about 37^0C to allow for optimal function of zymase or yeast to grow at an optimal rate.

Marking Criteria	*Mark(s)*
• *Justification of one correct condition*	*2*
• *Describes one correct condition*	*1*

Outcomes : H2, H4, H8, H9

Question 22 (5 marks)

The yield of product in the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium.

Justify the conditions used. **5**

Sample Answer :

$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)} \quad \Delta H = -92\ kJmol^{-1}$

Reaction energy – high enough energy(temp) for high % of molecules to collide successfully.

Reaction rate – high enough rate so reaction proceeds at suitable speed (not too slow)

Equilibrium – not too high temp as reaction is exothermic and too high temp will favour backward reaction thus decrease yield.

Thus compromised conditions used for optimal yield are :

Temperature of 400-500^{0}C so reaction occurs at fast enough rate but reverse reaction does not occur to a great degree as this is an exothermic reaction.

Pressure of 250atm as too high a pressure is dangerous and expensive equipment required but high pressure is required to push reaction in the forward direction as high pressure favours RHS as gas mole ratio is 4:2

Magnetite(iron) catalyst is used to speed up the reaction by lowering the activation enrgy and providing an alternate pathway for the reaction.

Marking Criteria	*Mark(s)*
• *Thorough justification of the need for the conditions used, must specify conditions AND* • *An equation for the production of ammonia*	*5*
• *Explanation with no equation and some specific details missing*	*4*
• *Description of conditions and some specific details missing*	*3*
• *Outline of conditions and specific details missing*	*2*
• *Identifying one correct condition*	*1*

Outcomes : H7, H8, H4

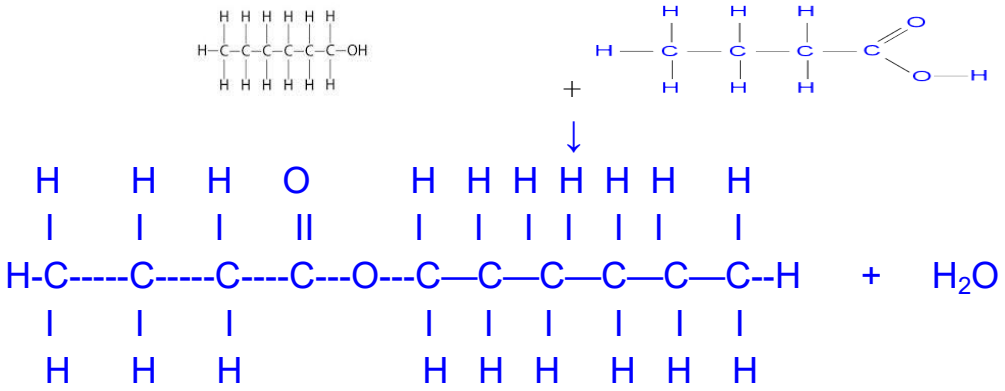
Question 23 (7 marks)

(a) Outline ONE use of esters. **1**

Sample Answer :

(a) Esters are used as flavours of fruits, perfumes, solvents for non-polar substances.

(b) Full structural formula for hexanol + butanoic acid -→ hexyl butanoate + water



(c) Hexyl butanoate

(d) Any risk associated with the production of an ester in the lab eg use of concentrated sulphuric acid is dangerous thus use safety goggles and apron for protection from splashes and spills.

Marking Criteria	Marks
One correct outline of esters	1

(b) Write a balanced chemical equation using structural formula to show the reaction between 1-hexanol and butanoic acid. **3**

Marking Critera	
• Correct balanced equation using structural formula for reactants and products	3
• One incorrect structural formula or reactant or product missing	2
• Two incorrect formula or reactants or products missing	1

(c) Name the organic product in the reaction. **1**

Marking criteria	Mark
Correct name for organic product	1

(d) Identify a risk associated with the laboratory production of esters and explain the safety precaution taken to minimise the risk. **2**

Marking Criteria	*Mark(s)*
• *Correct risk and explanation of minimisation of the risk in relation to the production of an ester*	*2*
• *Identify one risk*	*1*

Outcomes : H9, H11

Question 24 (8 marks)

A student determined the molar heat of combustion of ethanol using a spirit-burner, an aluminium can containing 300.0g water, a thermometer and an electronic balance. The following results were recorded.

Initial mass of burner	133.20g
Final mass of burner	132.05g
Initial temperature of water	25.0^0C
Final temperature of water	45.5^0C

(a) What is the molar heat of combustion calculated from the data above? **3**

Mass ethanol used = 133.2-132.05 = 1.15 g

ΔH = $-mC\Delta T$

= *-300 x 4.18 x (45.5 – 25.0)*

= *-25,707J*

= *-25.707 kJ*

1.15 g → *25.707 kJ*

46 g → *x kJ where x is the heat released for 1 mole of ethanol*

x = *46 x 25.707 / 1.15*

$= 1028.28\ kJ$

$= 1.03 \times 10^3\ kJ$

$\Delta Hc = -1.03 \times 10^3\ kJ$ $\Delta Hc = -1.03 \times 10^3\ kJ$

Marking Criteria	*Mark(s)*
• *Calculates ΔH for ethanol and the moles of ethanol and m.m of ethanol*	*3*
• *Correct method for calculating but minor error in calculation of ΔH or moles*	*2*
• *Calculates ΔH or the moles of ethanol*	*1*

N.B. Students must remember to use 4.18×10^3 J kg^{-1} K^{-1} many refer to 4.2,

(b) The calculated heat of combustion is much less than the correct value. Apart from heat loss to the surroundings, suggest another reason for the low value obtained. **1**

Incomplete combustion of the ethanol would release less heat to the calorimeter so the temperature change would be less.

Marking Criteria	*Mark(s)*
• Provides valid reason	*1*

Outcomes: H 10, H11

N.B. It is not enough to state 'inaccurate measuring' or human error' as these statements do not provide sufficient detail to be awarded a mark.

Question 25 (7 marks)

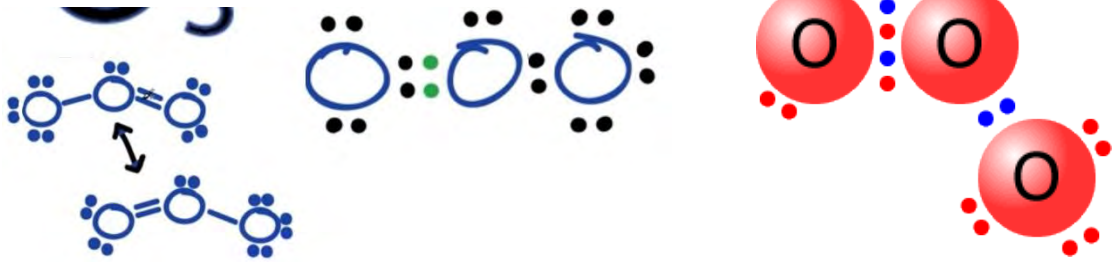
(a) Ozone has a coordinate covalent bond. Define what is meant by a coordinate covalent bond and draw a Lewis electron dot diagram for ozone showing the position of the coordinate covalent bond. **3**

Outcomes Assessed: H2 and H10
Targeted Performance Bands: 3-4

Marking Criteria	**Marks**
• Correctly defines what is meant by a coordinate covalent bond AND • Correctly draws the electron dot structure of Ozone AND • indicates clearly the coordinate covalent bond in the diagram	3
• Correctly defines what is meant by a coordinate covalent bond AND Correctly draws the electron dot structure of ozone OR	2

• Correctly defines what is meant by a coordinate covalent bond AND indicates clearly the coordinate covalent bond in the diagram OR • Correctly defines what is meant by a coordinate covalent bond AND indicates clearly the coordinate covalent bond in the diagram	
• Correctly defines what is meant by a coordinate covalent bond OR • Correctly draws the electron dot structure of ozone	1

SAMPLE ANSWER:
A coordinate covalent bond is one where one atom donates both electrons for the bond.



Actual shape of O_3 | Actual Electron dot arrangement of O_3 | Actual electron dot arrangement and shape of O_3

(b) Compare TWO properties of ozone and oxygen and explain these in terms of their structure and/or bonding. **4**

Outcomes Assessed: H7
Targeted Performance Bands: 2-4

Marking Criteria	**Marks**
• Compares two properties of ozone to that of oxygen in terms of their structure and/or bonding	4
• Compares two of ozone to that of oxygen but does not completely relate this fully to the respective structure and bonding of the substances	2/3
• Correctly states two or more properties of ozone and of oxygen OR • Correctly outlines differences between oxygen and ozone in terms of their structure and bonding	1

Ozone (O_3) has a higher density (2.0g/mL) than oxygen gas (O_2) (1.3g/mL) because it has an extra atom per molecule.

Ozone has a higher BP (-111^oC) because it is a polar molecule that will give rise to stronger intermolecular forces than oxygen gas (-183^oC), which is totally non-polar.

Ozone is more reactive than oxygen because it has a lower bond energy.

Ozone is more soluble than oxygen gas, which is only sparingly soluble because of its non-polar nature at 4.9mL in 100mL of water.

Question 26 (5 marks)

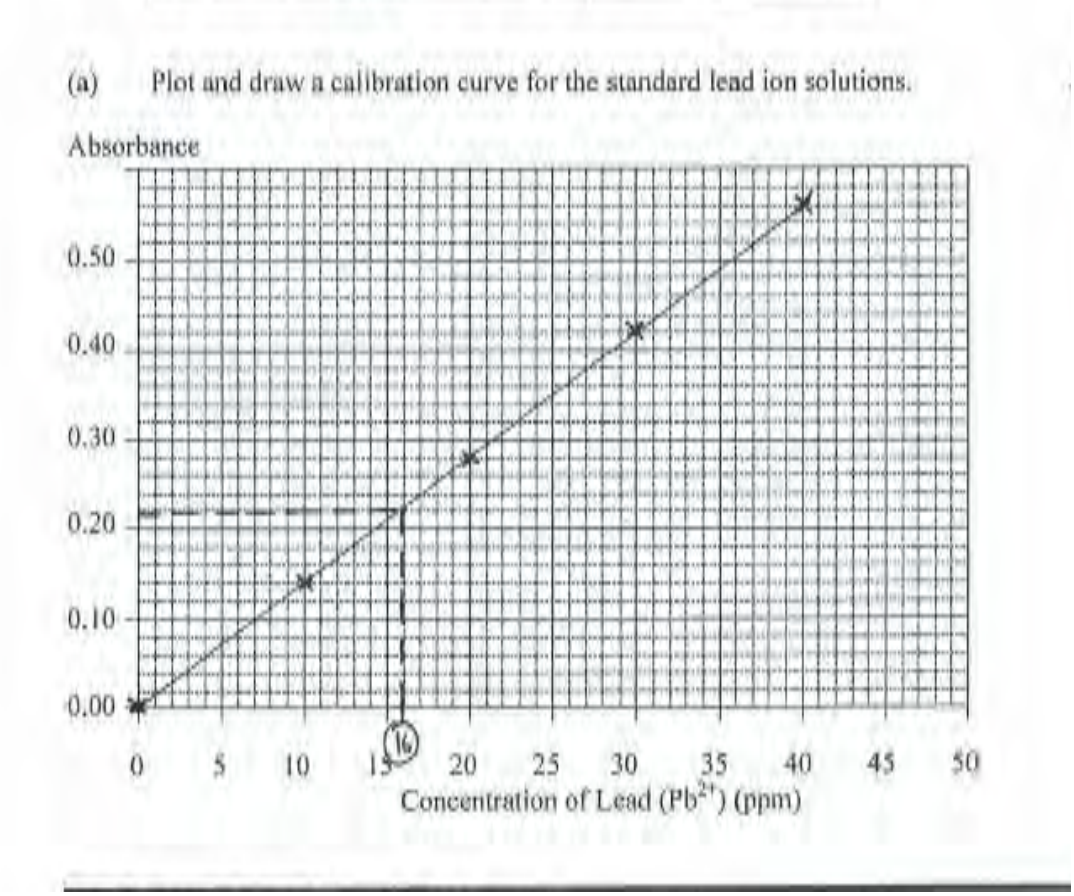
The concentration of lead ions in a river was determined using atomic absorption spectroscopy.

The following standard solutions were prepared and the sample tested.

Standard Pb^{2+} solution ppm	Absorbance reading
0.0	0.00
10.0	0.14
20.0	0.28
30.0	0.42
40.0	0.56
sample	0.22

(a) Plot and draw a calibration curve for the standard lead ion solutions. **3**

(a) Plot and draw a calibration curve for the standard lead ion solutions.



(b) Use the absorbance of the water sample to calculate the concentration of lead ions in $molL^{-1}$.

An absorbance of 0.22 = 16ppm.

16ppm = 16mg/L OR 0.016g/L OR g/m.m = 0.016/207.2 = 7.722 * 10-5 mol/L

Marking Criteria	*Mark(s)*
• *Correctly states the ppm of lead AND converts the answer to mol/L*	*2*
• *Correctly states ppm OR mol/L*	*1*

Outcomes : H3, H4,H10

Question 27 (7 marks)

An analytical chemist was employed to test the water quality of a river.

She used the following information to analyse her results.

Table 1

pH	3 4 5 6 7 8 9 10		
PO_4^{3-}	Insoluble salts form with Fe^{2+} and Al^{3+}	Maximum availability to plants	Ca^{2+} forms insoluble phosphates
NO_3^-	Not available to plants	Maximum availability to plants	
Mg^{2+}	Maximum availability		Forms insoluble carbonates

A 600 mL sample of river water was collected and the results of her tests are in the table below.

Procedure	Result
Added soap to a 100 mL sample	No froth observed
Inserted pH probe to measure pH	7.5
Bubbled O_2 *(g)* into the remaining 500 mL sample at 25^0C to saturate it with oxygen. The final concentration was measured.	0.009g/L in the saturated sample
Sample was left for 5 days in the dark and was then analysed with the Winkler titration.	1.1×10^{-5} mol O_2 remained

Give an overall assessment of the health of the river by analysing the biochemical oxygen demand, hardness and risk of eutrophication. **7**

Outcomes: H1,H4, H6, H10

Assessment : Make a judgement of value, quality, outcomes, results or size

The pH measured is 7.5 and this has implications for other measurements.

The water doesn't lather with soap indicating water hardness. From table 1 we can see that below a pH of 8, Mg^{2+} are available and not locked up as precipitates, so the Mg^{2+} are causing the water hardness. Above pH 7, calcium ions will be locked up as phosphate precipitates.

As any phosphates will be precipitated with calcium ions above pH 7, (and the pH is 7.5), there will be no phosphates available to plants so there is little risk of eutrophication that can be result from excessive phosphates in the waterway. Nitrates are available at this pH, but without phosphates, eutrophication is unlikely.

The BOD can be calculated from the experimental data.

Initially, the water is saturated with oxygen at 0.009g/L = 9ppm .

After 5 days 1.1×10^{-5} mol O_2 remained

Mass of remaining oxygen = mol x molar mass = 1.1 x 10^{-5} x 32 = 0.00035g in 500 mL

= 0.00070g / L= 0.7 ppm

The BOD of the river = 9ppm - 0.7 ppm = 8.3 ppm

A BOD > 4 ppm indicates a polluted waterway. As this BOD is 8.3, there is considerable pollution of organic material in the river.

Assessment: Although the river is not prone to eutrophication at this time, there is evidence of water hardness and the calculated BOD indicates organic material polluting the river. Therefore, the quality of the water is poor and not very healthy.

Marking Criteria	*Mark(s)*
• *Gives a thorough analysis of the water quality using the data* • *Provides a calculation for BOD* • *Gives a valid assessment based on the 3 criteria analysed*	*6/7*
• *Gives an analysis of the water quality using the data* • *Provides some calculation for determining BOD* • *Gives a valid assessment based on the criteria analysed*	*5*
• *Gives an analysis of the water quality using some of the data* • *May provide a valid assessment*	*4*
• *Outlines the implications of some of the measurements or the criteria, on the health of the river*	*3*
• *Gives some relevant information based on the data or criteria*	*2*
• *Gives one piece of relevant information*	*1*

Marking scaffold

T	T	T or S	S	S	S	Any 3 of	Any 2 of	Any 1 of
T	T	S	S	S	S	H	H	H
T	S	S	S	S	H/T/or B	B	B	B
A	A	A	A			S	S	S
	Some calculation for BOD	Some calculation for BOD	No BOD calculation			R	R	R
7	6	5	4	4	4	3	2	1

T = thorough **S = sound** **A = assessment**

H = hardness **B = BOD** **E = eutrophication**

Eg HT = through analysis of water hardness using the data.

Question 28 (3 marks)

The list below contains acids, bases and salts.

H_2SO_4 Na_2CO_3 NH_4Cl HCl CH_3COOH NaOH NH_3

(a) Identify the two species which would react together to form a basic salt. **1**

CH_3COOH and NaOH

Almost universally correct

No other details required.

(b) Outline how a buffer solution could be prepared from two or more of the above compounds. **2**

NH_3 is a weak base and NH_4Cl gives NH_4^+ which is the conjugate acid. Combining equimolar solutions would form a buffer solution that inhibits the change in pH

Marking Criteria	*Mark(s)*
• *Identifies correct solutions to form a buffer* ***AND*** • *Outlines the preparation of the buffer solution* ***OR*** • *Identifies correct solutions to form a buffer* ***AND*** *correctly identifies the dynamic nature of a buffer solution and in maintaining pH*	*2*
• *Identifies correct solutions to form a buffer* ***OR*** • *Outlines the role of a buffer solution* ***OR*** • *Recognises that $CH_3COOH_{(aq)}$ (from list) will ionise to form a solution of a weak acid and its conjugate base.(thus indicating an understanding of the mechanics of a buffer solution).* *OR* • *Incorrectly identifies solutions that could form buffer solutions* ***BUT*** *correctly identifies the dynamic nature of a buffer solution in maintaining pH*	*1*

Outcomes: H8

Question 29 (3 marks)

During a reaction between solid sodium hydrogen carbonate and sulfuric acid 328.35 mL of a gas were collected. The reaction was carried out at 25^{o}C and 100kPa.

Calculate the mass of solid sodium hydrogen carbonate that reacted to produce this volume of gas.

$2NaHCO_{3(s)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2CO_{2(g)} + 2H_2O_{(l)}$

Number of moles of the gas = v/24.79 = 0.32835/24.79 = 0.0130

From balanced chemical equation Number of moles of the $NaHCO_3$ = 0.013mol

Molar mass $NaHCO_3$ = 84.007g

Mass of $NaHCO_3$ reacted = 84.007 x 0.013g

= 1.11g

Marking criteria	Mark
*Correct equation: All species correct, balanced appropriately with correct subscripts.**AND*** *Number of moles of CO_2 correctly calculated. **AND*** *Mass of $NaHCO_3$ reacted correctly calculated. This question was not marked for sig. figs. Units are essential for all steps BUT no marks were lost on this occasion.*	3
*Incorrect equation (details listed above omitted or incorrect)**BUT*** *Number of moles of CO_2 correctly calculated based on the incorrect equation.**AND*** *Mass of $NaHCO_3$ based on the incorrect equation correctly calculated **OR*** *Correct equation All species correct, balanced appropriately with correct subscripts.**AND*** *Mass of $NaHCO_3$ reacted correctly calculated **BUT*** *No working shown**OR*** *Correct equation All species correct, balanced appropriately with correct subscripts.**BUT***	2

Number of moles of CO_2 incorrectly calculated ***AND*** *Mass of $NaHCO_3$ reacted correctly calculated based on incorrect number of moles of CO_2*	
Correct equation ***OR*** *Number of moles of CO_2 correctly calculated (no further calculations)* ***OR*** *Mass of $NaHCO_3$ reacted correctly calculated (no further calculations)*	1

Outcomes: H 10

Question 30 (4 marks)

Describe TWO methods of producing commercial radioactive isotopes. **4**

Outcomes Assessed: H3
Targeted Performance Bands: 2-3

Commercial radioactive isotopes can be created in a nuclear reactor where neutrons are bombarded at a fissionable material in a controlled nuclear reaction.

The other way commercial radioactive isotopes are produced is in a cyclotron, which is an electromagnetic device where positive particles are accelerated through positive and negative magnetic fields in a circular motion until they are allowed to collide.

Marking Criteria	Marks
• Correctly states the processes of how radioisotopes are made in nuclear reactors with some correct descriptive details. **AND** • by bombarding targeted nuclei with neutrons. • Correctly states the processes of how radioisotopes are made in cyclotrons with some correct descriptive details. **AND** • By bombarding targeted nuclei with charged particles such as the helium nucleus.	4
• Any 3 of the above	3
• Any 2 of the above	2
• Any 1 of the above	1

Question 31 (4 marks)

In an investigation to determine the concentration of acetic acid in vinegar, the following steps were undertaken:

1. 50.00 mL sample of vinegar was diluted with demineralised water to make 500.0 mL of dilute vinegar solution.

2. 25.00 mL aliquots of the diluted vinegar were then titrated against 0.105 $molL^{-1}$ sodium hydroxide solution.

3. The results were tabulated.

Titration	Volume of 0.105 $molL^{-1}$ NaOH (mL)
1	28.60
2	26.10
3	25.90
4	29.50
5	26.00

Calculate the original concentration of acetic acid in the vinegar in $molL^{-1}$.

$NaOH + CH_3COOH \rightarrow NaCH_3COO + H_2O$

Average titre = (26.1 + 25.9 + 26.00)/ 3 = 26.00mL

mol NaOH = M x V = 0.105 x 0.025 = 2.625 x 10^{-3}mol

Therefore mol CH_3COOH = 2.625 x 10^{-3}mol

Diluted $[CH_3COOH]$ = mol/ V = 2.625 x 10^{-3}/ 0.026 = 0.10096 $molL^{-1}$

Original concentration = concentration x 10 = 1.009 $molL^{-1}$

Outcomes: H10

Marking Criteria	Marks
• Correct balanced chemical equation **AND** • Average titre correct (26.00mL) i.e. appropriate titres omitted. **AND** • Molarity of diluted solution **AND** • Molarity of original solution	4
• Correct balanced chemical equation **AND** • Average titre correct (26.00mL) i.e. appropriate titres omitted. **AND** • Original concentration = concentration x 10 = 1.009 $molL^{-1}$. Molarity of diluted solution omitted (working step) **OR** —————————————————— • Correct balanced chemical equation **AND** • Average titre incorrect i.e. appropriate titres not omitted. **AND** • Original concentration correct based on incorrect average titre. Molarity of diluted solution omitted (working step) ***Plus a variety of other combinations appropriate within the prescribed context.***	3
• Incorrect balanced chemical equation **AND** • Average titre incorrect i.e. appropriate titres not omitted. **AND** • Diluted concentration correct based on incorrect average titre. **AND** • Original concentration correct based on incorrect average titre. ***Plus a variety of other combinations appropriate within the prescribed context.***	2

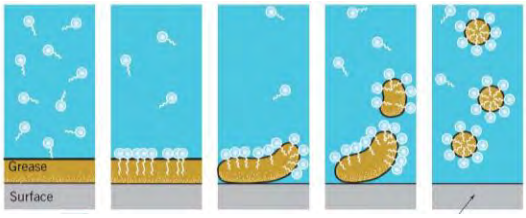
NB: All marking was done with follow on errors considered.

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

(a) Glyceryl trilaurate can be used in the production of the soap sodium laurate.

(i) What is the other product of this saponification reaction? *Glycerol* **1**

(ii) The diagram below models the cleaning action of soap



Step 1 Step 2 Step Step 4 Step 5

Use the models to account for the cleaning action of soap. **5**

Step 1. The soap anion has a carboxylate anionic polar head (O)and a non-polar hydrocarbon tail(. )

Step 2. The non-polar tail forms dispersion forces with the non-polar grease leaving the carboxylate head of the anion in the polar water forming H-bonds.

Step 3, Agitation lifts the grease droplet from the surface and as it lifts, more soap anions attached to the grease.

Step 4. The grease droplet is cleaned off the surface and is surrounded by the soap anions, forming a micelle.

Step 5. The negatively charged carboxylate heads on the outer surface of the droplets repel other droplets preventing them from joining up. The droplets are suspended in the water forming an emulsion of grease in water. The soap anion is an emulsifier.

Marking Criteria	*Mark(s)*
• *Thorough explanation of the processes linking the models to the structure of the soap, AND* • *Accounts for the cleaning action of soap in terms of structure of the anion AND* • *Identifies the ability of soap to form an emulsion in water with grease*	*5*
• *Describes the cleaning action of soap and identifies the formation of an emulsion OR* • *Explains the cleaning action of soap with no identification of an*	*4*

emulsion.	
• *Describes the cleaning action of soap*	*3*
• *Identifies some features of the soap anion OR* • *Basic outline of the action of soap as a cleaning agent*	*2*
• *Identifies that an emulsion is formed OR* • *identifies a feature of the soap anion*	*1*

Outcomes:H2,H4,H9

(b) Consider the following reaction:

$2NO_{(g)} + 2H_{2(g)} \rightleftarrows N_{2(g)} + 2H_2O_{(g)}$

Initially, a mixture of 0.100 $molL^{-1}$ NO, 0.050 $molL^{-1}$ H_2 and 0.100 $molL^{-1}$ H_2O was allowed to reach equilibrium. At equilibrium the concentration of NO was found to be 0.062 $molL^{-1}$. Determine the value of the equilibrium constant for the reaction. **3**

	NO	***H_2***	***N_2***	***H_2O***
Initial Concentration ($molL^{-1}$)	*0.100*	*0.0500*	*0*	*0.100*
Change in Concentration ($molL^{-1}$)	*- 0.038*	*- 0.038*	*+ 0.019*	*+ 0.038*
Equilibrium Concentration ($molL^{-1}$)	*0.062*	*0.012*	*0.019*	*0.138*

Substitute the equilibrium concentrations into the equilibrium expression and solve for K

$$K = [N_2][H_2O]^2 / [NO]^2[H_2]]^2$$

$$K = \frac{(0.019)\,(0.138)^2}{(0.062)^2(0.012)^2}$$

$$= 650 \text{ (or } 6.5 \times 10^2\text{)}$$

Marking Criteria	*Mark(s)*
• *Correct answer with relevant working shown including an expression for K*	*3*
• *Correct answer with some relevant working* • *Incorrect concentrations correctly substituted into a given K expression*	*2*
• *Correct K expression OR* • *Some relevant working*	*1*

Outcomes: H8,H10

(c) The following reaction conditions are used in the production of sulfur trioxide from sulfur dioxide in the Contact process: an excess of oxygen, atmospheric pressure, a vanadium (V) oxide catalyst, and temperatures of 550°C and 400°C.

Select from the reaction conditions to explain each of these effects. **6**

$2SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g) + heat$

(i) Accelerates the reaction without affecting the yield.

The vanadium(V)oxide catalyst increases the rate of reaction by lowering the activation energy. This allows equilibrium to be achieved faster at a lower temperature but doesn't affect the position of equilibrium or the yield of sulfur trioxide..

(ii) Increases the yield without changing the equilibrium constant.

An excess of oxygen will cause equilibrium to shift to oppose the change (Le Chatelier), i.e to remove oxygen. The reaction that uses oxygen is the forward reaction and equilibrium will shift to the right, increasing the yield of sulfur trioxide. A change in concentration has no effect on the equilibrium constant which will remain unchanged

(iii) Changes the equilibrium constant.

A change in temperature from 550°C to 400°C will change the equilibrium constant. A decrease in temperature will cause K to increase as the exothermic, forward reaction is favoured (Le Chatelier), more products are formed so the numerator in K increases and the value of K increases.

Marking Criteria	*Mark(s)*
• *Correctly chooses conditions to explain all THREE effects AND* • *Gives the equilibrium equation.*	*6*
• *Correctly chooses conditions to explain all THREE effects(no equation)* • *Correctly chooses and explains TWO conditions and identifies or outlines the third(with equation)*	*5*
• *Correctly identifies and outlines all three conditions OR* • *Correctly chooses and explains TWO conditions*	*4*
• *Correctly identifies each conditions for (i), (ii) and (iii) OR* • *Correctly chooses and explains ONE condition and identifies another.*	*3*
• *Correctly chooses and explains ONE condition OR* • *Correctly identifies TWO conditions for (i), (ii) and/or (iii)*	*2*
• *Correctly identifies ONE condition for (i), (ii) or (iii) OR* • *Gives the equilibrium equation*	*1*

Outcomes: H3, H7, H8

(d) (i) Describe valid procedures that could be used to identify TWO products of the electrolysis of concentrated sodium chloride. **2**

In the electrolysis of concentrated sodium chloride, water is reduced at the cathode producing hydrogen gas. The production of hydrogen can be identified by performing the pop test. A lit match held over the gas collected at the cathode will ignite the gas with a popping sound.

For concentrated sodium chloride, chlorine gas will be produced at the anode. With universal indicator in the solution, the green colour will be bleached to colourless at the anode in the presence of chlorine gas.

Marking Criteria	*Mark(s)*
• *Describes two procedures for identifying two products of the electrolysis of concentrated sodium chloride*	*2*
• *Correctly identifies two products OR* • *Describes one valid procedure*	*1*

(ii) Justify the use of ONE safety precaution, other than wearing safety goggles when carrying out these procedures. **2**

Chlorine gas is toxic and can cause respiratory problems so the electrolysis needs to be carried out in a fume cupboard or a well ventilated area to avoid the build up of chlorine.

Marking Criteria	*Mark(s)*
• *Justifies a relevant safety precaution*	*2*
• *Outlines a relevant safety precaution*	*1*

Outcomes: H7, H11

(e) (i) Describe two environmental issues associated with the Solvay process and outline how these issues are addressed. **4**

One of the products of the Solvay process is calcium chloride, It can be used to help deice roads but its consumption is in less demand than its production. Solvay plants near the ocean can return the calcium chloride to the sea without a significant change to ocean salt concentrations, however, inland plants will need to create burial sites for the salt solution that is evaporated to dryness before burial. The solution cannot be disposed of in local waterways as it would increase the dissolved salt concentration and have a negative impact on aquatic organisms use to less salty conditions.

Waste heat in cooling waters needs to be dissipated before water can be released into local waterways. Thermal pollution from too hot water can trigger a number of environmental issues including reduced dissolved oxygen causing respiratory problems for aquatic organisms or raising the metabolic rate of aquatic organism that are already struggling in a reduced dissolved oxygen environment. Heating water must be cooled in cooling ponds before it is discharged into local waterways.

Marking Criteria	*Mark(s)*
• *Describes TWO relevant environmental issues and outlines how they are addressed in the Solvay process*	*4*
• *Describes TWO relevant environmental issues and outlines how one is addressed in the Solvay process*	*3*
• *Outlines TWO issues OR* • *Describes ONE relevant environmental issues and outlines how it is addressed in the Solvay process*	*2*
• *Outlines ONE relevant issue*	*1*

Outcomes: H4(ii) Calculate the mass of sodium chloride required to produce 2.000 tonnes of sodium carbonate. **2**

$2NaCl + CaCO_3 \rightarrow Na_2CO_3 + CaCl_2$

Mol Na_2CO_3 = *mass/molar mass = 2,000,000/106 = 18,868 mol*

Therefore, mol NaCl = 2 x mol Na_2CO_3 = *2 x 18,868 = 37,736 mol*

Mass NaCl = mol x molar mass = 37,736 x (35.45 + 22.99) = 2,205 tonnes

Marking Criteria	*Mark(s)*
• *Correct calculation with relevant working*	*2*
• *Some relevant working*	*1*

Outcomes: H4,H10