CAPE WINELANDS PLC COMMON PAPER

PHYSICAL SCIENCES - PAPER 2 **SEPTEMBER 2018**

GRADE 12 **TIME: 3 HOURS**

EXAMINERS: CWED PLC **TOTAL: 150**
MODERATORS: A WESSELS & MZ MOERAT

INSTRUCTIONS AND INFORMATION

1. Write your name in the space below and submit the Examination Paper with your Answer Book.

   NAME: ……..

2. This question paper consists of 10 questions. Answer ALL the questions in the ANSWER BOOK.

3. Number the answers correctly according to the numbering system used in this question paper

4. Leave ONE line between two sub questions, for example between QUESTION 2.1 and QUESTION 2.2.

5. You may use a non-programmable calculator.

6. You may use appropriate mathematical instruments.

7. You are advised to use the attached DATA SHEETS.

8. Show ALL formulae and substitutions in ALL calculations.

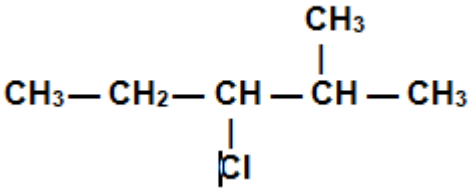
9. Round off your final numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions etc where required.

QUESTION 1 (Multiple-choice)

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A – D) next to the question number (1.1 – 1.10) on your ANSWER BOOK.

1.1 The correct IUPAC name of the following compound is:



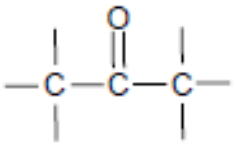
A 3-chloro-4-methylpentane
B 3-chloro-2-methylpentane
C 2-methyl-3-chloropentane
D 4-methyl-3-chloropentane.

(2)

1.2 When ethene reacts with hydrogen gas in the presence of a catalyst, the product is …

A ethane.
B ethyne.
C ethanol.
D ethanal. (2)

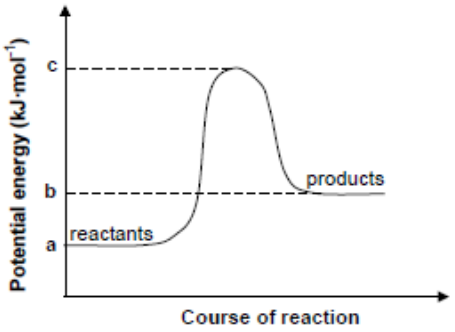
1.3 Study the structural formula of the functional group below.
The structure above is the functional group of …



A esters.
B ketones.
C aldehydes.
D carboxylic acids.

(2)

1.4 The potential energy graph for a hypothetical chemical reaction is shown below.



What type of reaction is taking place and what are the correct methods to calculate H and Ea?

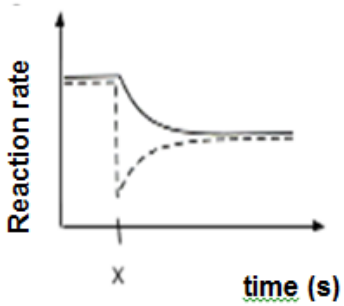
	TYPE OF REACTION	ΔH	Ea
A	Exothermic	b - a	c - b
B	Endotermies	b - a	c - a
C	Endotermies	a - b	a - c
D	Exothermic	a - b	b - c

(2)

1.5 Consider the reversible reaction:

$$N_2(g) + 3\,H_2(g) \rightleftarrows 2\,NH_3(g) \qquad \Delta H < 0.$$

The graph of *reaction rate vs time* for the above reaction is shown below.



The solid line reflects the forward reaction, while the broken line depicts the reverse reaction. Which one of the changes below explains the change in the graph at time X?

A Temperature is decreased
B Temperature is increased
C Concentration of H_2 is decreased
D Concentration of N_2 is increased.

(2)

1.6 The reaction represented by the balanced equation below reaches equilibrium in a closed container.

$$H_2(g) + I2(g) \rightleftharpoons 2HI(g) \qquad \Delta H < 0$$

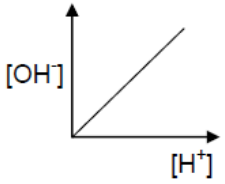
How will the equilibrium be affected if, first the volume of the container is decreased and then the temperature is increased?

A At first no effect and then the reverse reaction is favoured.
B The reverse reaction is favoured by both changes.
C At first no effect and then the forward reaction is favoured
D A first the reverse reaction is favoured and then the forward reaction is favoured. (2)

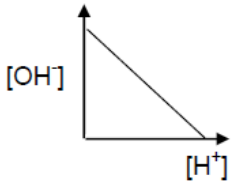
1.7 A few drops of concentrated sulphuric acid are gradually added to 1 dm^3 of water at 25 °C.

Which ONE of the following graphs illustrates the relationship between $[H^+]$ and $[OH^-]$ as the acid is added to the water?

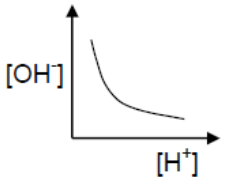
A



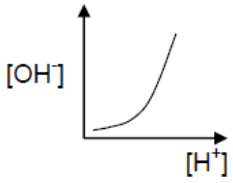
B



C



D



(2)

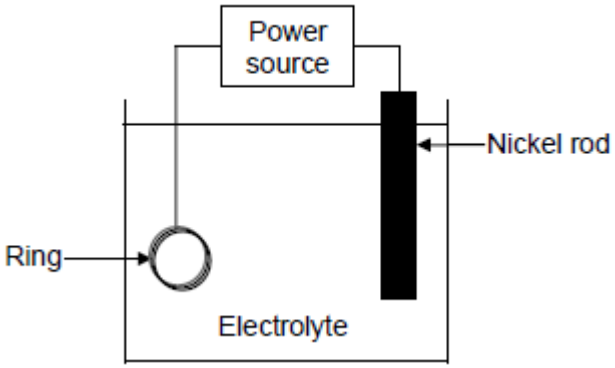
1.8 A galvanic cell consists of the following half-cells:

$Pt(s)\,|C\ell_2(g)\,|C\ell^-(aq)$ AND $Cu^{2+}(aq)\,|Cu(s)$

Which ONE of the following statements is TRUE while the cell is functioning?

A Cu(s) is oxidised.
B $C\ell^-(aq)$ is reduced.
C $C\ell_2(g)$ acts as reducing agent.
D Cu(s) acts as oxidising agent. (2)

1.9 A learner wants to electroplate a copper ring with nickel. He uses the experimental set-up shown in the simplified diagram below.



Which ONE of the following is CORRECT?

	ANODE	CATHODE	ELECTROLYTE
A	Copper ring	Nickel rod	$CuSO_4$
B	Nickel rod	Copper ring	$CuSO_4$
C	Copper ring	Nickel rod	$NiSO_4$
D	Nickel rod	Copper ring	$NiSO_4$

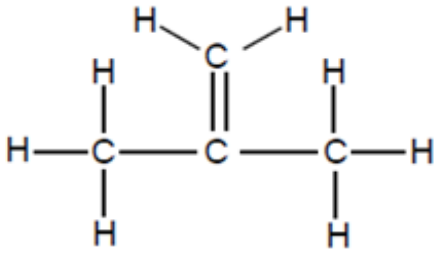
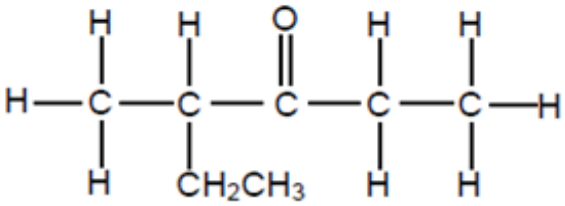
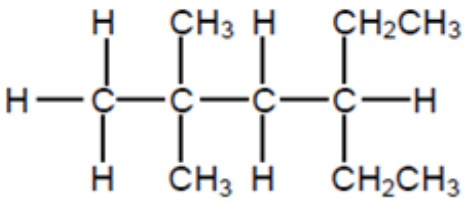
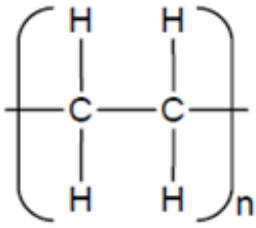
(2)

1.10 Which ONE of the following compounds is produced in the Ostwald process?

A $N_2(g)$
B $NH_3(g)$
C $HNO_3(\ell)$
D $NH_4NO_3(s)$ (2)

QUESTION 2 (Start on a new page)

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	2-methylbutanoic acid
C		**D**	
E	But-2-ene	**F**	

2.1 Write down the:

2.1.1 NAME of the functional group of compound **B**. (1)

2.1.2 Homologous series to which compound **C** belongs. (1)

2.1.3 Type of polymerisation reaction that produces compound **F**. (1)

2.2 Write down the IUPAC name of:

2.2.1 The monomer used to prepare compound **F**. (1)

2.2.2 Compound **C**. (2)

2.2.3 Compound **D.** (2)

2.2.4 An unsaturated compound. (1)

2.3 Write down the NAME or FORMULA of each product formed during the complete combustion of compound **D**. (2)

2.4 Write down the structural formula of:

2.4.1 Compound **B.** (2)

2.4.2 A chain isomer of compound **A.** (2)

2.5 A laboratory assistant uses bromine water to distinguish between compounds **D** and **E** (in the table above). She adds bromine water to a sample of each in two different test tubes. She observes that the one compound decolourises the bromine water immediately, whilst the other one only reacts after placing the test tube in direct sunlight.

Write down the:

2.5.1 Letter (**D** or **E**) of the compound that will immediately decolourise the bromine water. (1)

2.5.2 Name of the type of reaction that takes place in the test tube containing compound **D**. (1)

2.5.3 Structural formula of the organic product formed in the test tube containing compound **E**. (2)

[19]

QUESTION 3 (Start on a new page)

3.1 **Table 1** below shows the results obtained from **Investigation 1** to determine the boiling point of three alkanes.

Table 1		
Alkane	**Molecular mass ($g.mol^{-1}$)**	**Boiling point (°C)**
ethane	30	-89
propane	44	-42
butane	58	0

Table 2		
Alcohol	**Molecular mass ($g.mol^{-1}$)**	**Boiling point (°C)**
methanol	32	65
ethanol	46	78
propan-1-ol	60	97

3.1.1 Give one word for: *The temperature where the vapour pressure of a substance is equal to the atmospheric pressure.* (1)

3.1.2 Write down the independent variable for **Investigation 1**. (1)

3.1.3 Describe the trend in the boiling points of the three alkanes. (1)

3.1.4 Explain the trend in the boiling points of the three alkanes. Refer to intermolecular forces and energy in the answer. (3)

3.2 **Table 1** and **Table 2** also show the results obtained from **Investigation 2** to obtain the boiling points of alkanes and alcohols with comparable mass.

3.2.1 Other than molecular mass, state another control variable in **Investigation 2**. (1)

3.2.2 The boiling point of each alcohol is much higher than that of the alkane of comparable molecular mass. Explain this observation by referring to intermolecular forces and energy in the answer. (3)

3.3 In **Table 3** the vapour pressure of two alcohols are determined at 20 °C.

Table 3	
Alcohol	**Vapour pressure at 20 °C (kPa)**
ethanol	5,8
alcohol **X**	2,4

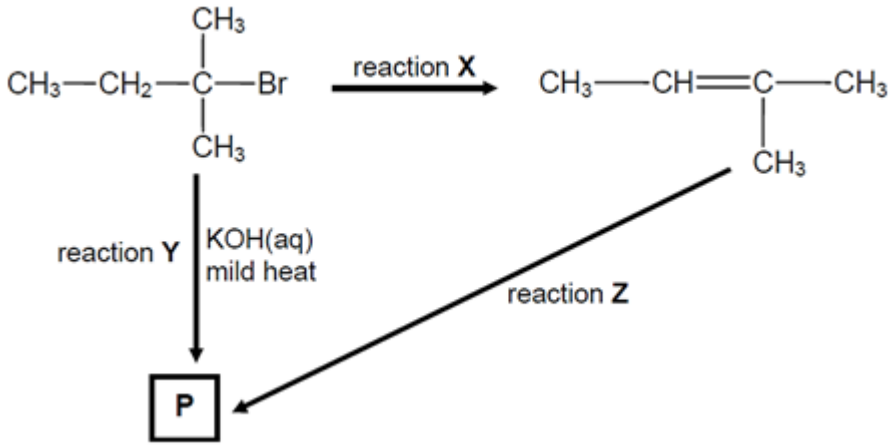
3.3.1 Choose between ethanol and alcohol **X** the alcohol that evaporates the slowest at 20 °C. (1)

3.3.2 Identify alcohol **X** as either methanol or propan-1-ol. (1)

[12]

QUESTION 4 (Start on a new page)

4.1 In the flow diagram below, **X**, **Y** and **Z** represent three different types of organic reactions. **P** represents an organic compound.



Write down:

4.1.1 the IUPAC name of the organic by-product formed in Reaction **X**. (2)

4.1.2 the solvent needed for Reaction **X**. (1)

4.1.3 the structural formula of compound **P**. (2)

4.1.4 apart from the organic reactant, the name or formula of the other reactant needed in Reaction **Z**. (1)

4.2 Esters are natural compounds found in plants causing the pleasant fragrance of flowers and fruits. Such a compound is methyl butanoate which is present in pineapple oil.

4.2.1 Write a balanced equation, using structural formulas, for the formation of methyl butanoate. (5)

4.2.2 Pentanoic acid is a structural isomer of methyl butanoate. Name the type of structural isomer. (1)

[12]

QUESTION 5 (Start on a new page)

NOTE: The graph for QUESTION 5.3.2 must be drawn on the GRAPH SHEET attached at the end of the QUESTION PAPER.

Methanol and hydrochloric acid react according to the following balanced equation:

$$CH_3OH\ (aq) + HC\ell\ (aq) \rightarrow CH_3C\ell\ (aq) + H_2O\ (\ell)$$

5.1 Give two ways how the rate of this reaction can be increased. (2)

5.2 Define the term *reaction rate*. (2)

5.3 The rate of the reaction between methanol and hydrochloric acid is investigated. The concentration of HCℓ (aq) was measured at different time intervals. The following results were obtained:

TIME (MINUTES)	HCℓ CONCENTRATION ($mol \cdot dm^{-3}$)
0	1,90
15	1,45
55	1,10
100	0,85
215	0,60

5.3.1 Calculate the average reaction rate, in $(mol \bullet dm^{-3}) \bullet min^{-1}$ during the first 15 minutes. (3)

5.3.2 Use the data in the table to draw a graph of concentration versus time on the attached graph sheet.
NOTE: The graph is not a straight line.
(ATTACH THIS GRAPH SHEET TO YOUR ANSWER BOOK.) (3)

5.3.3 From the graph, determine the concentration of HCℓ (aq) at the 40^{th} minute. (1)

5.3.4 Use the collision theory to explain why the reaction rate decreases with time. Assume that the temperature remains constant. (3)

5.3.5 Calculate the mass of $CH_3C\ell$ (aq) in the flask at the 215^{th} minute. The volume of the reagents remains 60 cm^3 during the reaction. (5)

[19]

QUESTION 6 (Start on a new page)

Many industries in South Africa rely on sulphuric acid and the compounds it is used to produce. The large-scale production of sulphuric acid involves the following equilibrium:

$$\mathbf{2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)} \qquad \Delta H < 0$$

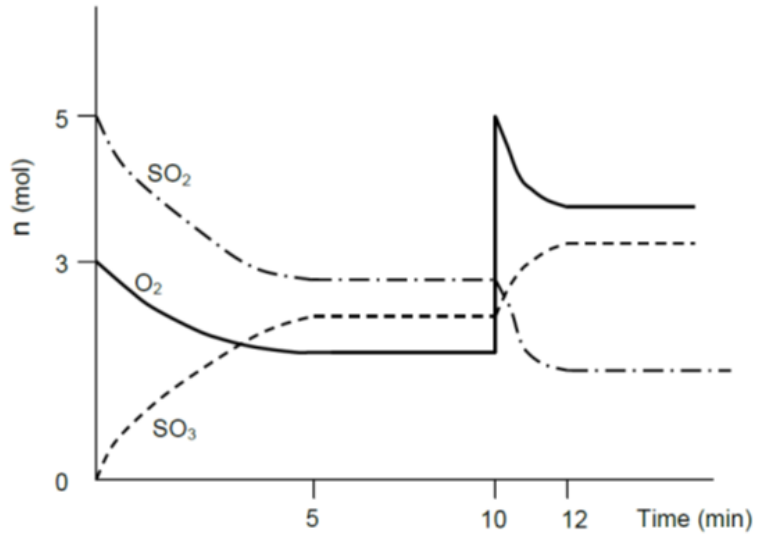
6.1 State *Le Chatelier's Principle*. (2)

6.2 How will each of the following changes affect the yield of SO_3 (g) at equilibrium?
Choose from INCREASES, DECREASES andREMAINS THE SAME.
Explain by using Le Chatelier's Principle.

6.2.1 An increase in pressure by decreasing the volume. (3)

6.2.2 An increase in temperature. (3)

6.3 In a laboratory experiment, 5 mol SO_2 and 3 mol O_2 are sealed in a 2 dm^3 container. The graph below shows how the number of moles of reactants and products change over a 15 minute period.

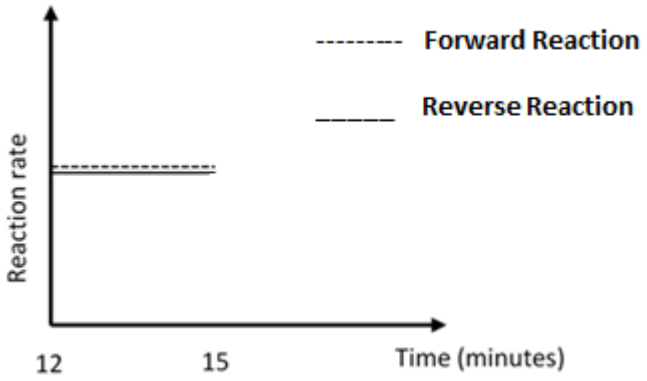


6.3.1 After 5 minutes, the concentration of oxygen gas in the container was found to be 0,9 $mol.dm^{-3}$. Calculate the value of Kc between 5 and 10 minutes. (7)

6.3.2 What disturbance occurred at t = 10 minutes? (1)

6.3.3 How does the disturbance at t = 10 minutes affect the value of Kc? Write down only INCREASES or DECREASES or NO CHANGE. (1)

After 12 minutes the following sketch graph of reaction rate against time isobtained for the equilibrium mixture.



6.3.4 A catalyst is added to the equilibrium mixture at time 15 minutes. Redraw the graph above in your ANSWER BOOK. On the same set of axes, complete the graph showing the effect of the catalyst on the reaction rates. (2)

[19]

QUESTION 7 (Start on a new page)

7.1 Sulphuric acid ionises in two steps as shown below:

		K_a at 25 °C
Step 1	$H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$	Very large
Step 2	$HSO_4^- + H_2O \rightarrow H_3O^+ + SO_4^{2-}$	$1,2 \times 10^{-2}$

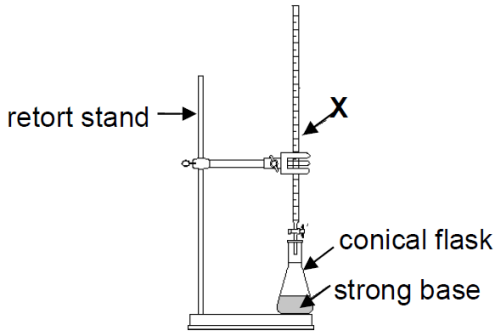
7.1.1 Explain why the K_a value for Step 1 is a very large number. (1)

7.1.2 H_2O is acting as a base in both reactions. Give the definition of a base according to Lowry-Bronsted. (1)

7.1.3 Write down the FORMULA of a substance that acts as an ampholyte in these reactions. (1)

7.1.4 Write down the NAME for the conjugate base of HSO_4^-. (1)

7.2 A titration between solutions of a strong base and oxalic acid $(COOH)_2$ is performed. The oxalic acid is added from apparatus **X** into a conical flask until a point where the indicator changes colour is reached.



7.2.1 Write down a term for the underlined phrase. (1)

7.2.2 Name apparatus **X** from which the oxalic acid is added. (1)

7.2.3 How is the pH of the content in the conical flask influenced while the acid is added to it? Choose from INCREASES, DECREASES and STAYS THE SAME. (1)

7.2.4 A learner performing the titration measures the pH of the solution just after the point where the indicator changes colour and finds that the solution has a pH groter as 7. Explain why the solution has a pH greater than 7. (2)

7.3 6 dm^3 H_2SO_4 solution with a concentration of 0,01 $mol.dm^{-3}$ is prepared in a container. A few drops of *bromothymol blue* are added to the solution. The mixture is yellow.

7.3.1 Calculate the number of moles of sulphuric acid present in the solution. (3)

4,4 g of sodium hydroxide pellets are added to the sulphuric acid. The colour of the mixture remains yellow, indicating the acid is not yet fully neutralized.

The reaction that takes place is:

$$\mathbf{2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O}$$

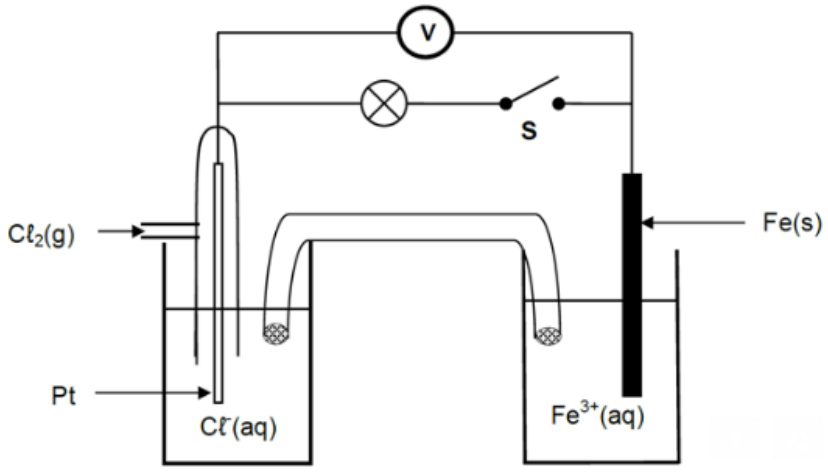
7.3.2 Calculate the number of moles of sulphuric acid that has reacted with the sodium hydroxide. (3)

7.3.3 Calculate the pH of the solution in the container. Assume that the acid ionizes completely and that the volume of the mixture is not significantly influenced by the addition of the pellets. (6)

[21]

QUESTION 8 (Start on a new page)

The diagram below shows a galvanic cell operating under standard conditions.



With switch **S** is OPEN, the voltmeter shows a reading.

8.1 Write down the:

8.1.1 NAME or FORMULA of the oxidising agent. (1)

8.1.2 Half reaction which takes place at the anode. (2)

8.1.3 Cell notation for this cell. (3)

8.2 Calculate the emf of this cell. (3)

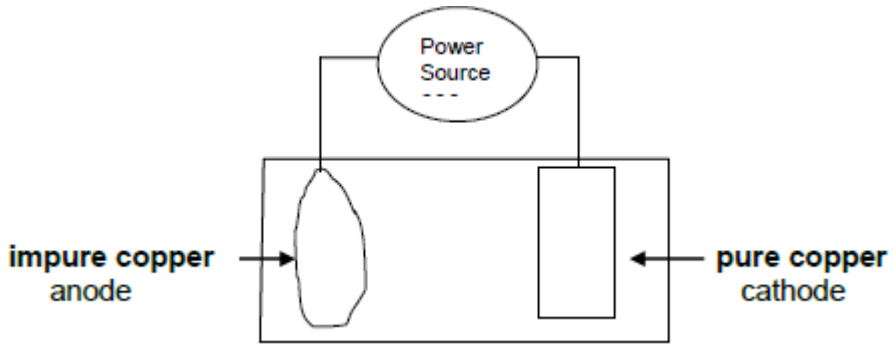
Switch **S** is now CLOSED and the bulb lights up.

8.3 How will the reading on the voltmeter now compare to the initial reading as calculated in QUESTION 8.2? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. Give a reason for the answer. (2)

[11]

QUESTION 9 (Start on a new page)

The electrolytic cell, represented in the diagram below, is set up to purify copper which contains platinum and silver impurities.



During the purification of 28 g of the impure copper, 0,8 mol of electrons are transferred from the anode to the cathode.

9.1 Calculate the mass of copper atoms formed at the cathode. (4)

9.2 The copper used for electrical wiring and cables must be 99,99% pure. Determine by calculation whether the impure copper sample is suitable for use in electrical wiring and cables. (Assume that all the copper at anode has reacted). (4)

During the purification, a sludge containing the metals platinum and silver forms at the bottom of the container.

9.3 Use the relative strengths of reducing agents to explain why platinum and silver atoms are not oxidised during the purification of copper. (1)

[9]

QUESTION 10 (Start on a new page)

Sulphuric acid is produced by the contact process and is used in the production of the fertilisers such as ammonium sulphate.

10.1 In one of the steps in this process, sulphur trioxide is dissolved in sulphuric acid rather than in water to produce oleum.

10.1.1 Write down a balanced equation showing how oleum is produced. (3)

10.1.2 Give a reason why sulphur trioxide is not dissolved in water to produce sulphuric acid. (1)

10.2 A farmer wants to use a fertiliser which promotes root growth in his vegetables garden. He must choose between ammonium sulphate, ammonium nitrate and ammonium phosphate.

The percentage of the elements in each of the fertilisers is given in the table below.

ELEMENT	AMMONIUM SULPHATE	AMMONIUM NITRATE	AMMONIUM PHOSPHATE
Nitrogen	21,21	35	28,19
Sulphur	24,24	0	0
Phosphorous	0	0	20,8

10.2.1 Which ONE of the above fertilizers will be the best choice? Refer to the data in the table to give a reason for the answer. (2)

10.2.2 Write down ONE negative impact of the overuse of fertilizer on the environment. (2)

[8]

TOTAL: 150

QUESTION 5.3.2 (Place in your answer book)

NAME OF LEARNER: ……