Western Cape Government
Education

METRO CENTRAL EDUCATION DISTRICT

GRADE 12

PHYSICAL SCIENCES: PAPER 2 (CHEMISTRY)

SEPTEMBER 2016

MARKS: 150

TIME: 3 hours

This question paper consists of 14 numbered pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION.

1. Write your name on the top of your ANSWER PAGE.
2. Answer ALL the questions on your ANSWER PAGE.
3. You may use a non-programmable calculator.
4. You may use appropriate mathematical instruments.
5. Number the answers correctly according to the numbering system used in this question paper.
6. YOU ARE ADVISED TO USE THE ATTACHED DATA SHEETS.
7. Give brief motivations, discussions, et cetera where required.
8. Round off your final numerical answers to a minimum of TWO decimal places.

QUESTION 1

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 PAGE.

1.1 The following organic compound is part of a homologous series that has a carboxyl group as the functional group.

A propanol

B propanal

C propanone

D propanoic acid (2)

1.2 Which ONE of the following compounds will have the lowest boiling point?

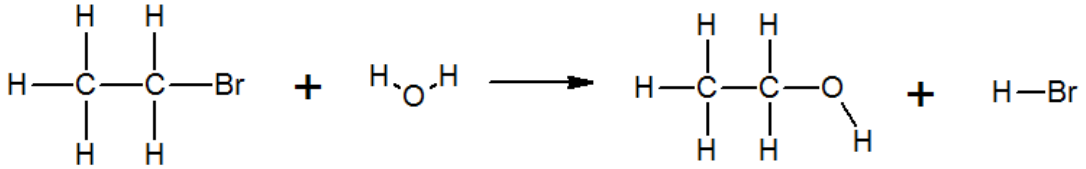
A butane

B butanal

C butan-1-ol

D methylpropane (2)

1.3 Consider the following reaction:



This reaction is an example of

A Hydrolysis

B Hydration

C Hydrogenation

D Hydrohalogenation (2)

1.4 Consider the reaction:

$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$

The rate of production of $MgC\ell_2$, can be increased by

A Decreasing the concentration of $HC\ell$ (aq)

B Increasing the volume of $H_2(g)$

C Increase the temperature

D Decreasing the surface area of Mg (2)

1.5 Consider the following hypothetical reaction in a closed container:

$$A(s) + B(g) \rightleftharpoons C(g) + H_2O(\ell) \qquad \Delta H = -150 \text{ kJ}$$

Which ONE of the following changes will increase the yield of C?

A Add water to the reaction

B Add more A(s) to the reaction if B is in excess

C Increase the pressure in the container

D Increase the temperature of the reaction. (2)

1.6 Consider the chemical reaction represented by the following equation:

$$2A + 3B \rightleftharpoons 4C \qquad \Delta H < 0$$

If the temperature increases

A the rate of the forward reaction only increases.

B the rate of the reverse reaction only increases.

C the increase of the rate of the forward reaction is more than the increase of the rate of the reverse reaction

D the increase of the rate of the reverse reaction is more than the increase of the rate of the forward reaction (2)

1.7 In the reaction

$$X + H_2O \rightarrow HSO_4^- + H_3O^+$$

The formula for X is

A SO_3 B SO_4^{2-}

C H_2SO_4 D $H_2SO_4^-$ (2)

1.8 Consider the following reaction:

$$NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$$

An example of a conjugate acid-base pair for this reaction is

A NH_3 and H_2O B NH_3 and OH^-

C NH_3 and NH_4^+ D NH_4^+ and OH^- (2)

1.9 In the reaction

$$2A\ell_2O_3 \rightarrow 4\ A\ell + 3O_2$$

the reducing agent is

A $A\ell^{3+}$ B $A\ell$

C O^{2-} D O_2 (2)

1.10 Consider the following hypothetical cell

$$X \mid X^{2+} \| Y^{2+} \mid Y, Pt$$

Which statement, regarding this cell is true?

A Both electrodes in this reaction are active electrodes

B Both electrodes in this reaction are inert electrodes

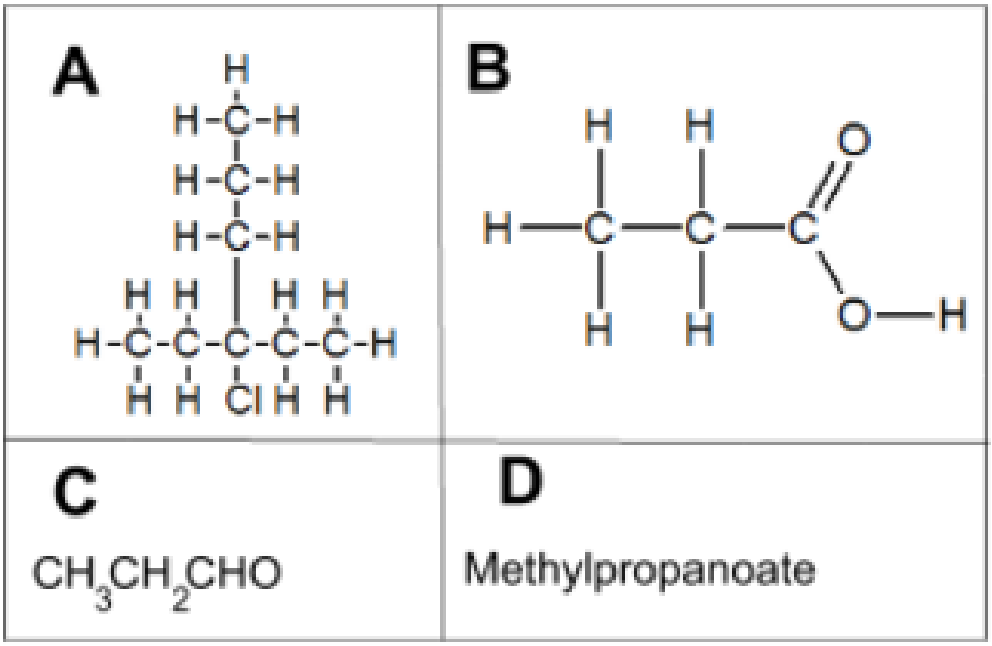
C The cathode is an active electrode and the anode is an inert electrode

D The anode is an active electrode and the cathode is an inert electrode (2)

[20]

QUESTION 2 **(START ON A NEW PAGE)**

2.1 Consider the organic compounds represented by the letters A to D below.



2.1.1 Explain why compound **A** is a saturated compound. (1)

2.1.2 Write down the IUPAC name of compound **A**. (3)

2.1.3 Write down the IUPAC name of compound **C**. (1)

2.1.4 Name the homologous series to which compound **B** belongs. (1)

2.1.5 Write down the IUPAC name of the alcohol needed to prepare compound **D**. (1)

2.1.6 Write down the structural formula for a functional isomer of compound **D.** (2)

2.2 An ester contains 9,81% hydrogen (H), 58,85% carbon (C) and 31,34 % oxygen (O). The molecular mass of the ester is 102 $g \cdot mol^{-1}$.

2.2.1 The alcohol used to prepare this ester is ethanol. What is the name of the other reagent used to prepare the ester? (1)

2.2.2 Calculate the molecular formula of the ester. (6)

[16]

QUESTION 3 (START ON A NEW PAGE)

The relationship between strength of intermolecular forces and boiling point is investigated using four organic compounds. The compounds and their boiling points are given in the table below.

Compound	Boiling point (^{o}C)
butane	-1
2-methylbutane	27,7
pentane	36,1
2-methylpropan-2-ol	82

3.1 Write down the definition of the term "*boiling point*." (2)

3.2 Which substance(s) will be a liquid at 50 ^{o}C? (1)

3.3 Name the type of intermolecular force(s) found between butane molecules. (1)

3.4 Refer to the strength of intermolecular forces, the type of intermolecular forces and/or structure of the molecules and energy in order to explain the difference between the boiling points of the following substances:

3.4.1 pentane and 2-methylbutane (4)

3.4.2 pentane and 2-methylpropan-2-ol (4)

3.5 Which substance will have the lowest vapour pressure at 50 ^{o}C? (1)

3.6 A sample of butane (C_4H_{10}) of mass 26 g burns in excess oxygen.
34 g of CO_2 forms. The balanced equation for this reaction is given below:

$$2C_4H_{10}\,(g) + 13O_2\,(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

Calculate the percentage by mass of pure butane gas in the sample. (5)

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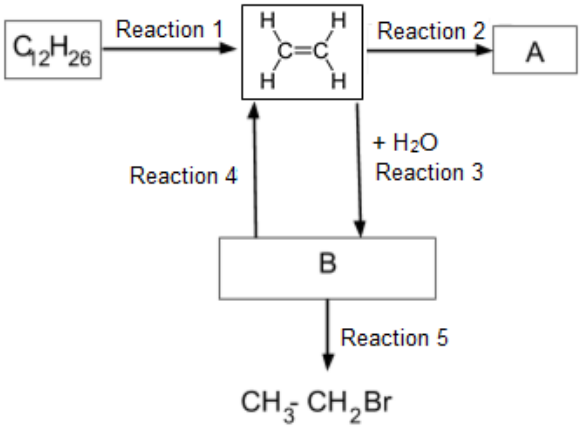
QUESTION 4 **(START ON A NEW PAGE)**

The flow diagram below shows different organic reactions. A and B represent different organic compounds.



4.1 Write down the name of the type of elimination reaction that occurs in **Reaction 1**. (1)

4.2 During **Reaction 2**, $CH_2 = CH_2$ undergoes polymerisation to form compound A. For this reaction, write down the:

4.2.1 type of polymerisation (1)

4.2.2 NAME of compound **A** (1)

4.2.3 condensed structure of a monomer of compound **A**. (1)

4.3 Use structural formulae to write a balanced chemical equation for **Reaction 3**. (3)

4.4 What is the name for the type of addition reaction that is represented by **Reaction 3**? (1)

4.5 Write down the IUPAC name for compound **B**. (1)

4.6 Write down TWO reaction conditions that will favour **Reaction 4**. (2)

4.7 Consider **Reaction 5**:

4.7.1 Name the type of reaction that occurs. (1)

4.7.2 State the reaction conditions for this reaction. (2)

4.7.3 Except for bromoethane, give the name of another product that forms during this reaction. (1)

[15]

QUESTION 5 (START ON A NEW PAGE)

A chemist wishes to determine the rate of reaction of zinc with hydrochloric acid. The unbalanced equation for the reaction is:

$$Zn(s) + HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

A piece of zinc is dropped into 0,1 cm^3 of 0,1 $mol \cdot dm^{-3}$ $HC\ell$ and the following data were obtained at 4 second intervals.

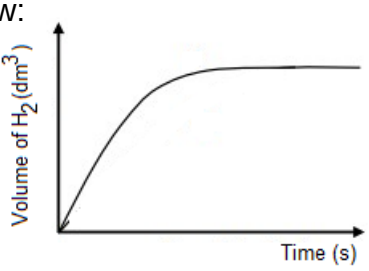
Time (s)	Mass of zinc (g)
0	0,016
4	0,012
8	0,010
12	0,009
16	0,008
20	0,008

5.1 Calculate the average rate of the reaction for the first 12 s in $mol \cdot s^{-1}$. (4)

5.2 Explain why the mass of the zinc remained constant after 16 s. (1)

5.3 Explain how the rate of the reaction changes as the time passes. Answer only INCREASES, DECREASES or REMAINS THE SAME. (1)

5.4 A graph that shows the amount of H_2 gas that was produced against time for this reaction is shown below:

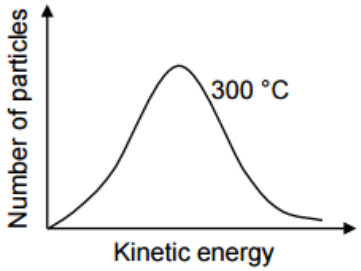


Redraw the graph and indicate on the same set of axes

5.4.1 a second graph, labelled **Y** that will be obtained if zinc powder of the same mass, instead of zinc granules was used. (2)

5.4.2 a third graph, labelled **X** that will be obtained if the same volume of $HC\ell$ with a **lower** concentration was used. (2)

The Maxwell-Boltzmann distribution curve below represents the number of particles against kinetic energy at 300 °C.



5.5 Redraw this curve in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained at a temperature of 400 °C. Clearly label the curves as 300 °C and 400 °C respectively. (2)

5.6 Using the collision theory, explain how an increase in temperature affects the rate of reaction. (2)

[14]

QUESTION 6 (START ON A NEW PAGE)

33,6 g of N_2 and 24 g of H_2 are placed in a 5 dm^3 sealed container and react according to the following balanced equation until dynamic equilibrium is reached.

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2NH_3(g)$$

6.1 Explain the term "*dynamic chemical equilibrium*" (2)

At 573 K when equilibrium is reached, there is 5,6 g of N_2 gas left inside the container.

6.2 Calculate the concentration of both reactants when the reaction reached equilibrium for the first time. (6)

6.3 Calculate the equilibrium constant (K_c) when this reaction reached equilibrium. (3)

6.4 How would the yield of NH_3 change if a smaller container than the 5 dm^3 is used? Write only INCREASES, DECREASES or REMAINS THE SAME. (1)

The temperature of this reaction increases from 573 K to 700 K. At this new temperature the equilibrium constant for this reaction decreases.

6.5 Is the forward reaction endothermic or exothermic? (1)

6.6 Explain your answer to QUESTION 6.5. (3)

[16]

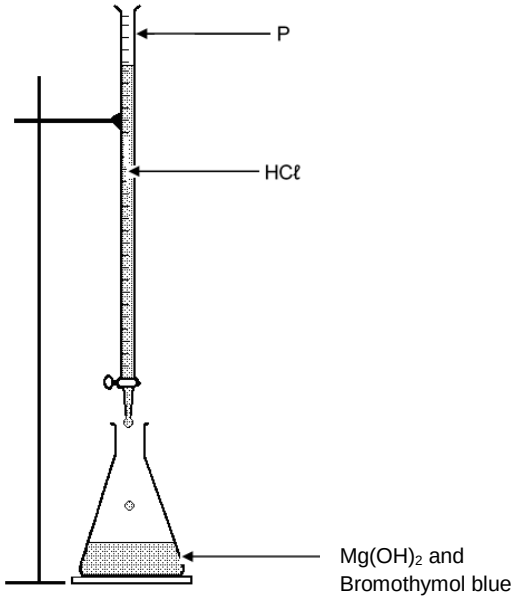
QUESTION 7 (START ON A NEW PAGE)

27 g of $Mg(OH)_2$ is dissolved in 2 ℓ of water at 25 ^oC. A drop of bromothymol blue is added to the solution and it turns blue.

7.1 Explain why $Mg(OH)_2$ is classified as a strong base. (2)

7.2 Calculate the pH of the $Mg(OH)_2$ solution (7)

HCℓ with a concentration of 2,5 $mol \cdot dm^{-3}$ is added to the $Mg(OH)_2$-solution as shown in the sketch below.



The balanced equation for this reaction is

$$Mg(OH)_2 + 2HC\ell \rightarrow MgC\ell_2 + 2H_2O$$

7.3 Write down the name of the apparatus labelled **P**. (1)

7.4 Write down the Lowry-Brønsted definition of an acid. (2)

7.5 Calculate the minimum volume of HCℓ that must be added to the reaction so that it just changes colour from blue to yellow. (4)

7.6 Explain why bromothymol blue is a better choice than phenolphthalein to indicate the neutralization in the reaction above. (2)

7.7 What would happen to the colour of the solution if 20 cm^3 water is added after the HCℓ was added and the solution turned yellow? Write only REMAINS YELLOW or CHANGES TO BLUE. (1)

[19]

QUESTION 8 (START ON A NEW PAGE)

A galvanic cell contains an aluminium electrode and a platinum electrode (in a cobalt solution). The cell operates under standard conditions. The half reaction that occur at the platinum electrode in the cobalt half-cell is given below:

HALF REACTION	$E^{\ominus}$ (V)
$Co^{3+} + e^{-} \rightleftharpoons Co^{2+}$	+1,81

8.1 At which electrode are electrons released to the external circuit? Write only **Pt** or **Aℓ.** (1)

8.2 Write down the

8.2.1 oxidation half-reaction that occurs in this cell. (2)

8.2.2 the FORMULA of the oxidising agent in this reaction. (1)

8.3 How does the mass of the anode change during this reaction? Write only INCREASES , DECREASES or REMAINS THE SAME. (1)

8.4 Write down the standard cell notation for this cell. (3)

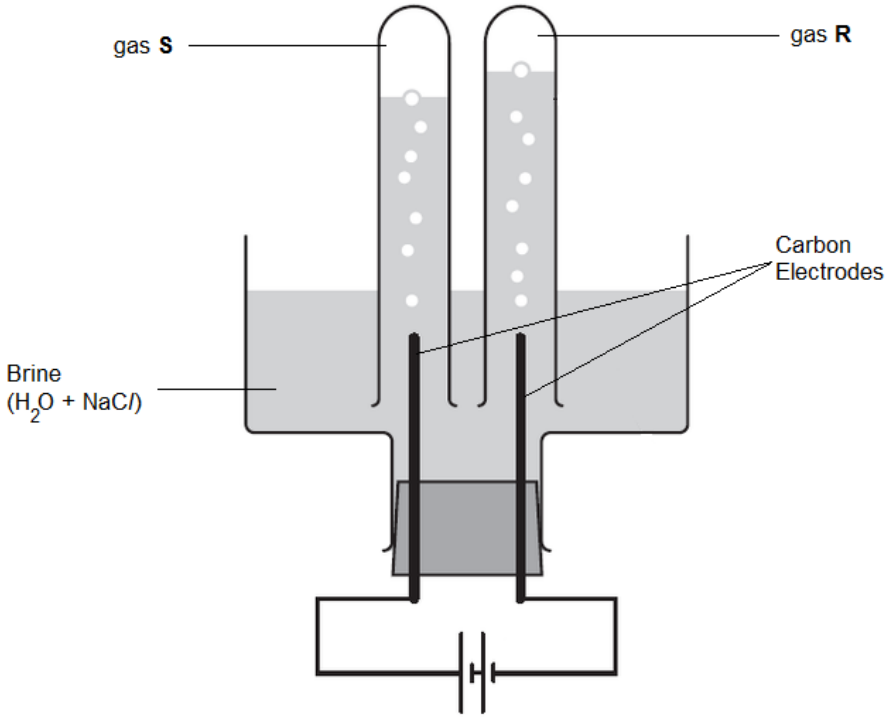
The aluminium electrode is replaced by a zinc electrode

8.5 Calculate the initial cell potential of this new cell when it operates under standard conditions. (3)

[11]

QUESTION 9 (START ON A NEW PAGE)

A solution of sodium chloride in water (NaCℓ + H_2O) is used as an electrolyte in an electrolytic cell that is set up as shown in the sketch below:



The equation for the net cell reaction that occurs, is

$$2NaC\ell(aq) + 2H_2O(\ell) \rightarrow 2NaOH(aq) + H_2(g) + C\ell_2(g)$$

9.1 Define the term "*electrolysis".* (2)

9.2 Identify

9.2.1 gas **S** (1)

9.2.2 gas **R** (1)

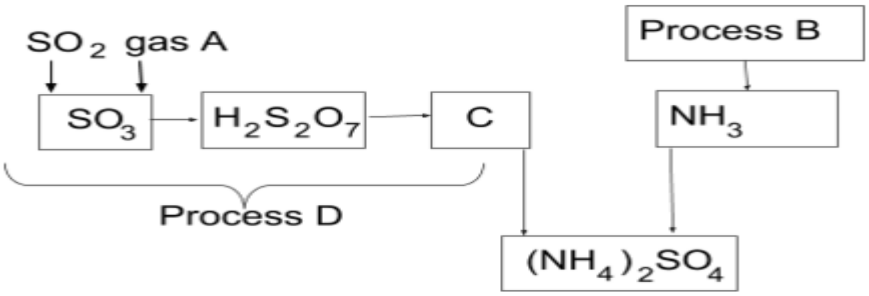
9.3 Explain why sodium metal, Na(s), does not form during the electrolysis of NaCℓ. (2)

9.4 Initially 0,5 dm^3 of the NaCℓ electrolyte with a concentration of 2,5 $mol \cdot dm^{-3}$ is used. How many moles of the electrolyte will be left after 2,24 dm^3 $C\ell_2$ formed at STP? (4)

[10]

QUESTION 10

10.1 The diagram below describes the process for making $(NH_4)_2SO_4$. Study the diagram and answer the questions that follows:



10.1.1 Identify **gas A** that is used to produces $SO_3(g)$. (1)

10.1.2 Give the name of **Process B** that is used for the industrial production of NH_3. (1)

10.1.3 Write down the FORMULA for acid **C** that is used to produce $(NH_4)_2SO_4$ as shown in the diagram. (1)

10.1.4 Explain why SO_3 is not added directly to water to produce H_2SO_4. (2)

10.2 A certain bag of fertilizer is labelled as shown below:

10.2.1 Name two primary nutrients that are contained in this fertilizer. (2)

10.2.2 Calculate the number of moles of phosphorous present in 40 g fertilizer if the nutrients make up 35% of the total mass of the bag. (4)

[11]

TOTAL: 150