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CORNWALL HILL COLLEGE

Physical Science Department

Preliminary Examinations 2024

Paper 2: Chemistry

NAME:	MARKING GUIDELINE
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Grade: 12

Time: 3h

Marks: 200

Examiner: PP van der Merwe

Moderator: M Labuschagne

Instructions:

1. The question paper consists of **20** pages. Please check that your paper is complete.
2. Answer **ALL** questions on the question paper provided
3. An information pamphlet with relevant information is available.
4. Round all FINAL answers to **TWO DECIMAL NUMBERS**.
5. All formulae used and substitutions in formulae must be indicated.
6. Additional workspace is provided on page **20** of this paper should it be required. Clearly indicate at the relevant question that you used page **20**.
7. Work neatly and legibly.

QUESTION 1

Four options are given as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and make a cross on the answer sheet provided below that corresponds with your choice.

1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D

- 1.1 Which one of the following combinations of the formula and name of a compound is correct?

	Formula	Name
A.	$\text{Na}_3(\text{PO}_4)_2$	Sodium phosphide
B.	AlSO_4	Aluminium sulphate
C.	$\text{Fe}_2(\text{SO}_4)_3$	Iron(III) sulphate
D.	$\text{Cu}(\text{NO}_2)_2$	Copper(II) nitrate

(2)

- 1.2 Carbon dioxide (CO_2) is partially soluble in water. Consider the following statements regarding CO_2 .

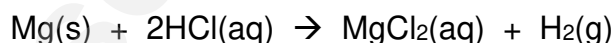
- I CO_2 is a gas at room temperature because it has strong intermolecular forces between its particles.
- II The intramolecular bond between C and O is polar in nature.
- III The CO_2 molecule is non polar in nature.
- IV The intermolecular force between water and CO_2 is dipole-dipole

Which statement(s) is/are correct?

- A. I, II and III
- B. II and III
- C. I and IV
- D. II, III and IV

(2)

- 1.3 Consider the reaction:

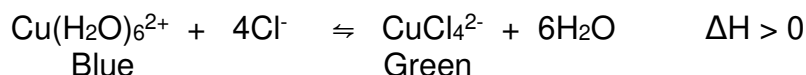


Which one of the following combinations will lead to the fastest reaction?

- A. 10 g Mg powder; pressure of 101,3 kPa, 20 cm^3 of HCl with concentration of 2 $\text{mol}\cdot\text{dm}^{-3}$, 35°C
- B. 10 g Mg powder, pressure of 50 kPa, 20 cm^3 of HCl with concentration of 2 $\text{mol}\cdot\text{dm}^{-3}$, 25°C
- C. 10 g Mg ribbon, pressure of 101,3 kPa, 20 cm^3 of HCl with concentration 1 $\text{mol}\cdot\text{dm}^{-3}$, 25°C
- D. 10 g Mg ribbon; pressure of 101,3 kPa, 20 cm^3 of HCl with concentration of 2 $\text{mol}\cdot\text{dm}^{-3}$, 15°C

(2)

- 1.4 Consider the reaction that has reached chemical equilibrium below:



The colour of the equilibrium mixture becomes blue. Which change listed below is responsible for this change in colour?

- A. Heat the reaction.
- B. Add concentrated sulphuric acid as a dehydrating agent.
- C. Add concentrated hydrochloric acid.
- ☒ D. Add a solution of silver nitrate. (2)

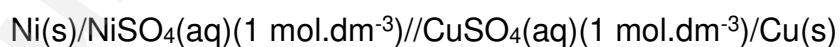
- 1.5 0,1 mol.dm⁻³ solutions of H₂SO₄, HCl and CH₃COOH are prepared. When comparing the three solutions, which one of the following statements is correct?

- A. The CH₃COOH solution has the lower pH
- ☒ B. The H₂SO₄ solution has the highest [H₃O⁺]
- C. The HCl solution has the lowest [OH⁻]
- D. CH₃COOH has the highest K_a-value (2)

- 1.6 Which **one** of the following statements is always **true** concerning a sample of distilled water at **all** temperatures?

- A. pH = 7
- ☒ B. [H₃O⁺] = [OH⁻]
- C. [OH] = 10⁻⁷ mol.dm⁻³
- D. [OH].[H₃O⁺] = 1 x 10⁻¹⁴ (2)

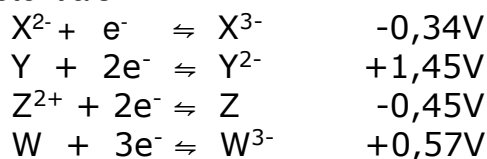
- 1.7 A standard nickel/copper cell has the following cell notation:



The salt bridge contains a saturated solution of KNO₃. Which one below, best describes the ions in the salt bridge after the current has flown for a minute or two?

- A. K⁺, NO₃⁻, SO₄²⁻ and Ni²⁺ ions only
- B. K⁺, NO₃⁻ and SO₄²⁻ ions only
- ☒ C. K⁺, NO₃⁻ and Ni²⁺ only
- D. K⁺ and NO₃⁻ only (2)

- 1.8 Consider the following half reactions with their corresponding Standard Reduction Potentials:



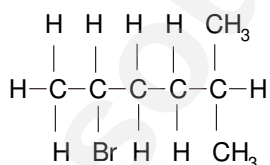
Which arrangement below shows the correct order of the substances from weakest to strongest reducing agents?

- A. X^{2+} , Y, Z^{2+} and W
B. X^{2-} , Y^{2-} , Z^{2+} and W
C. Z^{2+} , X^{2-} , W and Y
D. Y^{2-} , W^{3-} , X^{3-} and Z
- (2)

- 1.9 1-bromobutane reacts with concentrated NaOH and ethanol at 200°C
This reaction is an example of:

- A. Hydrolysis
B. Dehydrohalogenation
C. Hydration
D. Dehydration
- (2)

- 1.10 Consider the compound below:

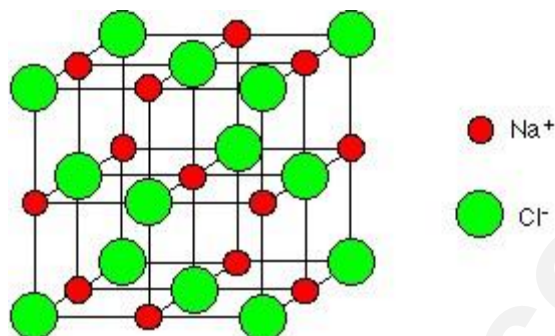


The IUPAC name for this compound is:

- A. 2-bromo-5,5-dimethylpentane
B. 5-bromo-1,1-dimethylpentane
C. 2-bromo-5-methylhexane
D. 5-bromo-2-methylhexane
- (2)
[20]

QUESTION 2

Sodium chloride is a white crystalline substance formed when sodium metal is heated and placed in a gas cylinder containing chlorine gas. The crystal structure can be represented by the diagram below:



- 2.1 Define *ionic bond* (2)

Ionic bonding involves a transfer of electrons to form cations and anions which are electrostatically attracted in an ionic crystal lattice

- 2.2 Will sodium chloride have a high or low meltingpoint? Choose from HIGH or LOW and explain your choice. (3)

High✓

Electrostatic forces between Positive and negative ions are strong✓
Lots of energy required to break the electrostatic attraction✓

- 2.3 When sodium chloride dissolves in water a *homogenous solution* is formed. Define *homogenous solution*. (2)

A solution where the solute and solvent cannot be distinguished from each other.

- 2.4 Sodium chloride will, however, not dissolve in carbon tetrachloride (CCl₄). Explain by referring to the intermolecular forces between particles of NaCl and CCl₄ why NaCl will not dissolve. (4)

NaCl – electrostatic forces of attraction between opposite ions ✓

CCl₄ – London forces ✓

Electrostatic forces stronger than London forces✓

IMF cannot form between ions and CCl₄✓

- 2.5 25 g of NaCl is mixed with 25 g of Na₃PO₄. Distilled water is added and a solution with volume of 250 cm³ is prepared. Determine the concentration of the sodium ions in this solution. (6)

$$n_{NaCl} = \frac{m}{M} = \frac{25}{58,5} = 0,43 \text{ mol} \quad NaCl \rightarrow Na^+ + Cl^- \quad \therefore [Na^+] = 0,43 \text{ mol} \checkmark$$

$$\checkmark$$

$$n_{Na_3PO_4} = \frac{m}{M} = \frac{25}{164} = 0,15 \text{ mol} \quad Na_3PO_4 \rightarrow 3Na^+ + PO_4^{3-} \quad \therefore [Na^+] = 3 \times 0,15 = 0,45 \text{ mol} \checkmark$$

$$c_{new} = \frac{n_{NaCl} + n_{Na_3PO_4}}{V} = \frac{(0,43 + 0,45)}{0,25} = 3,52 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

- 2.6 Sodium chloride is defined as a *salt*. Define the term a *salt*. (2)
Salt is an ionic product due the reaction of an acid and a base

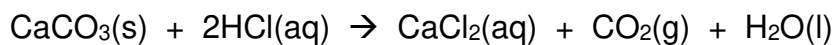
- 2.7 Can a sodium chloride solution act as an electrolyte? Explain your choice. (3)
 Yes $\checkmark$

*NaCl dissociates into ions according to $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ $\checkmark$
 Ions are free to move $\checkmark$*

[22]

QUESTION 3

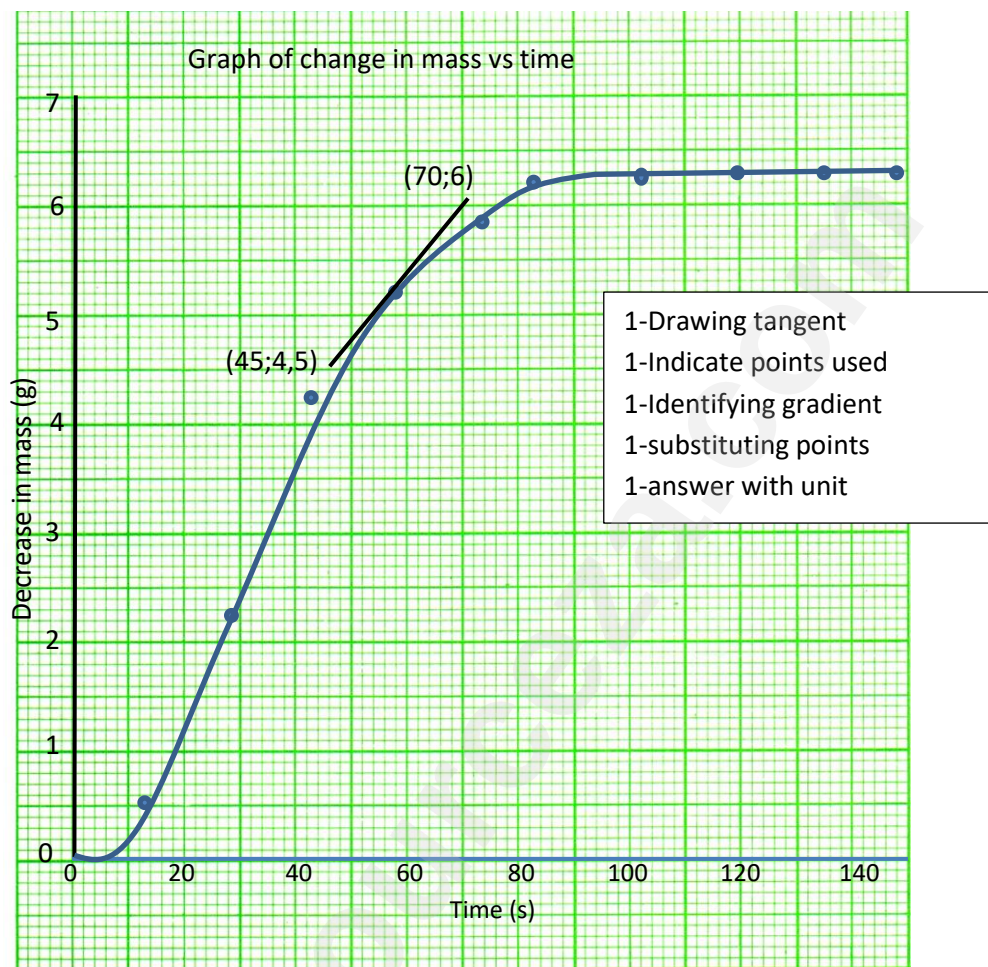
Koekie wants to investigate the rate at which a reaction proceeds. She places calcium carbonate in a glass beaker on a sensitive balance. She then adds 500 cm³ of HCl with a concentration of 0,5 mol.dm⁻³. The reaction taking place is:



The mass readings are recorded every 15 s, from the moment that the acid is dropped on the calcium carbonate until it is all reacted. The results are indicated below:

Time(s)	Mass of beaker and content (g)	Decrease in mass (g)
0	114,6	0,0
15	114,0	0,6
30	112,4	2,2
45	110,4	4,2
60	109,4	5,2
75	108,7	5,9
90	108,4	6,2
105	108,3	6,3
120	108,3	6,3
135	108,3	6,3
150	108,3	6,3

- 3.1 Represent the results in the table, using the decrease in mass and time, on a suitable graph using the graph paper below. (7)



- 3.2 Give a reason why the mass of the beaker and its content DECREASES. *CO₂ gas escapes* (2)

- 3.3 Use the graph and determine the instantaneous rate of the reaction at 60 s. Clearly indicate how you used the graph to calculate the rate. (5)

$$m = \frac{\Delta y}{\Delta x} = \frac{6 - 4,5}{70 - 45} = 0,06 \text{ g} \cdot \text{s}^{-1}$$

- 3.4 Give a reason why the reaction rate DECREASES between 45 and 105 s. *The concentration of reactants are decreasing* (2)

- 3.5 Use the collision theory to explain your answer in QUESTION 3.4. (3)

Concentration decrease implies less particles available to reaction

Less successful collisions per unit time ✓

Less particles that have energy greater than activation energy ✓

Less chance of molecules with correct molecular orientation to react ✓

- 3.6 Calculate the mass of CaCO_3 that was initially placed on the scale. (4)

6,3 g CO_2 escaped

$$n = \frac{m}{M} = \frac{6,3}{44} = 0,14 \text{ mol}$$

$\text{CaCO}_3 : \text{CO}_2$

1 : 1

0,14 : 0,14

$$n = \frac{m}{M} \therefore m = n \times M = 0,14 \times 100 = 14 \text{ g}$$

- 3.7 Without calculation, explain which one of the CaCO_3 or the HCl was the limiting reactant in this experiment. (2)

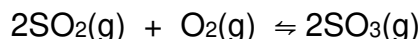
CaCO_3 ✓

Amount of CO_2 released remained constant after 105 s ✓

[25]

QUESTION 4

A key reaction in the production of sulphuric acid in the Contact process is:



- 4.1 State the *Principle of Le Chatelier*. (2)

When an external stress (change in pressure, temperature or concentration) is applied to a system in dynamic chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress

- 4.2 State the meaning of *dynamic equilibrium*. (2)

Dynamic chemical equilibrium refers to a reversible reaction in which the forward and the reverse reactions are taking place at the same rate, and hence the concentrations of reactants and products are constant

- 4.3 What must be done to ensure that the process is a *closed system*? (1)

Used a sealed container

- 4.3 When the reaction is cooled down the production of $\text{SO}_3(\text{g})$ increased. Make use of the Principle of Le Chatelier and explain if this reaction is exothermic or endothermic. (4)

Temperature is decreased

Acc to LCP system wants to increase temperature ✓

Exothermic reaction is favoured ✓

But forward reaction was favoured ✓

∴ Forward reaction is exothermic ✓

- 4.4 During a routine monitoring of the process, a sample of the equilibrium mixture is analysed at 400°C . The following data was obtained:

Volume of the reactor vessel: 200 dm^3

Quantity of SO_2 present: 33 mol

Quantity of SO_3 present: 58 mol

K_c at 400°C : 7,33

From the information above, calculate the mass of oxygen present in the reactor. (8)

$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 \cdot [\text{O}_2]} = 7,33 \quad \checkmark$$

$$[\text{O}_2] = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 \cdot 7,33} = \frac{(0,29)^2}{(0,17)^2 \cdot 7,33} = 0,397 \text{ mol} \cdot \text{dm}^{-3} \quad \checkmark$$

✓

$$c = \frac{n}{v} \quad \therefore n = cv = 0,397 \times 200 = 79,4 \text{ mol} \quad n = \frac{m}{M} \quad \therefore m = nM = 79,4 \times 32 = 2540,8 \text{ g}$$

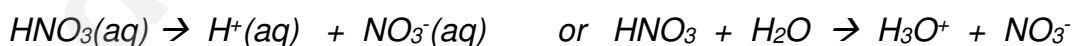
- 4.5 What must be done to the pressure of the system to ensure a productive process? State INCREASE, DECREASE or KEEP IT CONSTANT. (2)
INCREASE ✓✓
- 4.6 The temperature of the system is now increased to 500°C. What effect will this change have on the value of the K_c ? State INCREASE, DECREASE or STAY CONSTANT and explain your choice. (4)
DECREASE ✓
Increase in temperature favours the reverse reaction ✓
[Reactants] increase ✓
 $K_c \propto \frac{[\text{Products}]}{[\text{Reactants}]}$ ✓
- 4.7 Why does the addition of a catalyst not disturb the equilibrium process? (2)
Catalyst speeds up both forward and reverse reaction ✓
Lowers time to form activated complex for both forward and reverse reactions ✓

[25]

QUESTION 5

Nitric acid (HNO_3) is a *strong* mineral *acid* prepared during the Ostwaldt process. The acid *ionises* when placed in water.

- 5.1 Define the meaning of the term *strong acid*. (2)
Strong acid as an acid that ionises completely in an aqueous solution
- 5.2 Explain the term *ionisation* and support your answer by writing the ionisation reaction for nitric acid (4)
The breaking of a covalent bond in a molecular compound to form ions in solution



Nitric acid is used in a titration to determine the concentration of an ammonium carbonate solution. 25 cm³ of the ammonium carbonate is fully neutralise 20cm³ of nitric acid. The *endpoint* of the titration is indicated by means of a *indicator* colour change.

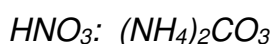
- 5.3 Write a balanced chemical equation for the reaction between nitric acid and ammonium carbonate. (3)
 $2 \text{HNO}_3 + (\text{NH}_4)_2\text{CO}_3 \rightarrow 2 \text{NH}_4\text{NO}_3 + \text{CO}_2 + \text{H}_2\text{O}$

5.4 Define what is meant by the term *endpoint* of a titration. (2)
Neutralisation point (or the equivalence point) as the point where an acid and base have reacted so neither is in excess

5.5 Which indicator must be used during this titration? Choose from LITMUS, BROMOTHYMOLO BLUE, METHYL ORANGE or PHENOLPHTHALEIN (2)
METHYL ORANGE

5.6 If the concentration of the nitric acid is 5 mol.dm^{-3} determine the concentration of the ammonium carbonate solution. (4)

$$c = \frac{n}{V} \therefore n = cV = 5 \times 0,02 = 0,1 \text{ mol} \quad \checkmark$$



$$2 : 1$$

$$0,1 : 0,05 \text{ mol} \quad \checkmark$$

1 mark for converting volume correctly

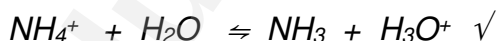
$$c = \frac{n}{V} = \frac{0,05}{0,025} = 2 \text{ mol.dm}^{-3} \quad \checkmark$$

The salt formed during this titration is ammonium nitrate that undergoes *hydrolysis* at the endpoint.

5.7 Define the concept *hydrolysis*. (2)
The reaction of the ions of a salt with water

5.8 Identify if ammonium nitrate is an ACID SALT, BASE SALT or NEUTRAL SALT. Explain your choice and support your answer with appropriate chemical equations. (4)
Acid salt $\checkmark$

NH_4^+ is the conjugate acid of the weak base $(\text{NH}_4)_2\text{CO}_3$ $\checkmark$



$[\text{H}_3\text{O}^+]$ increase $\checkmark$

5.9 None of the indicators mentioned in QUESTION 5.5 is available for the titration. Which one of the following indicators will be most suitable to use to get an accurate answer for the concentration of the ammonium carbonate solution?

Bromocresol green pH: 3,8 – 5,4
 Phenol red: pH: 6,8 – 8,4
 Alizarin yellow: pH: 10,0 – 12,0
Bromo cresol green

(1)

[24]

QUESTION 6

Lead reacts with nitric acid according to the following reaction:



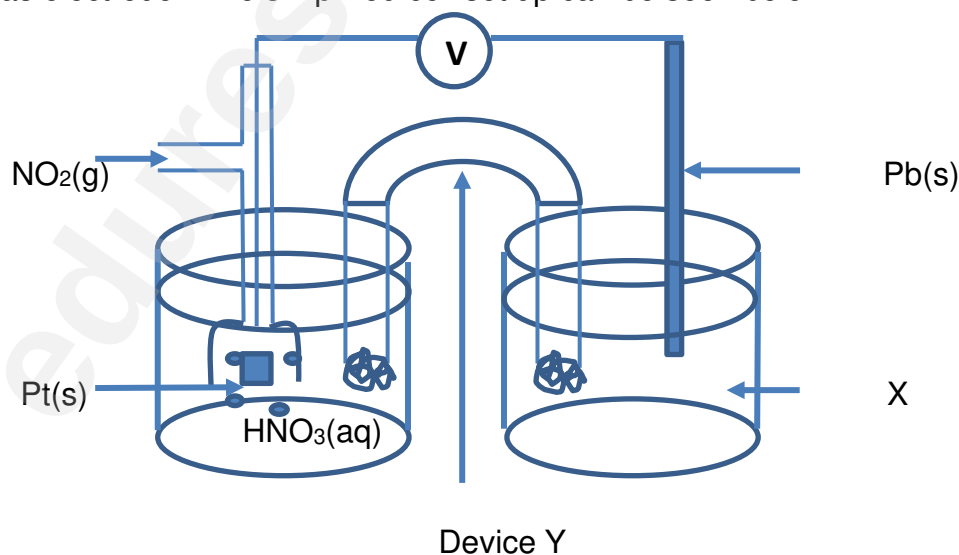
- 6.1 Define *reduction*. (2)
Reduction is the gaining of electrons

- 6.2 Prove, by making use of oxidation numbers, that although the reaction above is between an acid and a metal, it is also classified as a redox reaction. (4)
Ox no of N in HNO₃: +5 ✓
Ox no of N in NO₂: +4 ✓
Change in oxidation number is a redox process ✓✓

- 6.3 Define *oxidising agent*. (2)
Oxidises another substance but reduce itself
or
Substance that gains electrons

- 6.4 Identify the oxidising agent in the reaction above. (1)
N in HNO₃

An electrochemical cell can also be established using a lead electrode and a NO₃⁻/NO₂ gas electrode. The simplified cell set up can be seen below:



- 6.5 State the energy conversion taking place when this cell is in operation. (2)
✓
✓
Chemical energy to electrical energy

- 6.6 Identify the anode of this cell and explain your choice. (2)

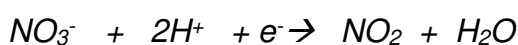
Pb-electrode ✓

Pb is the best reducing agent ✓

- 6.7 X is an aqueous solution. Give a possible formula for the salt used to prepare the solution. (1)

Any soluble Pb-salt solution ✓

- 6.8 Write a balanced equation for the reaction taking place at the cathode. (2)



- 6.9 Identify device Y and explain its purpose in the operation of the cell. (3)

Salt bridge

Maintains electrical neutrality when the cell operates

- 6.10 Determine the reading on the voltmeter attached in this cell. (3)

$$E_{\text{cell}}^0 = E_{\text{OA}}^0 - E_{\text{RA}}^0$$

$$= (+0,8) - (-0,13)$$

$$= +0,93 \text{ V} \quad \checkmark$$

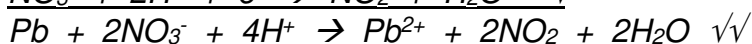
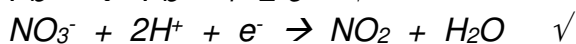
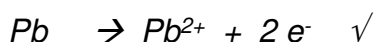
- 6.11 State the standard conditions needed to ensure that the voltmeter reading corresponds to the emf of this cell. (3)

Gas pressure : 101,3 kPa

Temperature: 25°C

Electrolyte concentration: 1 mol.dm⁻³

- 6.12 Make use of the Table of Reduction Potentials and write a balanced ionic equation for the cell reaction taking place when this cell is in operation. Clearly show the relevant half reactions as well as the balanced overall ionic equation. (4)



6.13 Explain why a platinum electrode must be used in the cell with the $\text{NO}_2(\text{g})$ (1)
 NO_2 gas cannot conduct charge

6.14 A solution of magnesium sulphate is added to the lead half-cell and a white precipitate is immediately formed. What effect will this have on the emf of the cell? Choose from INCREASE, DECREASE or NO EFFECT. Explain your choice with the aid of a relevant half reaction. (4)

INCREASE ✓

$\text{Pb} \rightleftharpoons \text{Pb}^{2+} + 2\text{e}^-$ ✓

Removing Pb^{2+} speeds up forward reaction ✓

More e^- are released ✓

6.15 Write the cell notation that can represent this cell. No standard conditions need be included in this cell. (4)

$\text{Pb}(\text{s})/\text{Pb}^{2+}(\text{aq})//\text{NO}_3^-(\text{aq})/\text{NO}_2(\text{g})/\text{Pt}(\text{s})$

[38]

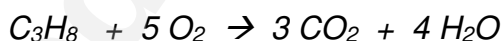
QUESTION 7

Propane is the gas commonly used in camping gas cylinders while butane is found in cigarette lighters. Propane and butane belong to the same *homologous series*.

7.1 Define *homologous series*. (2)

A series of similar compounds which have the same functional group and have the same general formula, in which each member differs from the previous one by a single CH_2 unit

7.2 When 9 kg of propane gas burns in oxygen a large amount of energy is released. Write a balanced chemical equation for the complete combustion of propane. (3)



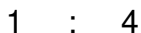
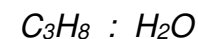
1-Reactants

1-Products

1-Balancing

- 7.3 Determine the mass of water that will be released when the 9 kg propane gas in QUESTION 7.2 fully combusts. (4)

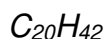
$$n = \frac{m}{M} \therefore n = \frac{9000}{44} = 204,54 \text{ mol}$$



$$204,54 : 818,16 \quad \checkmark$$

$$n = \frac{m}{M} \therefore m = n \times M = 818,16 \times 18 = 14727,88 \text{ g}$$

- 7.4 Isocane also belongs to the same homologous series as propane and butane and contains 20 carbon atoms in each molecule of isocane. Write the molecular formula for isocane. (2)



Propane and butane have different *vapour pressures*.

- 7.5 Define the concept *vapour pressure*. (2)

The pressure that the vapour of a liquid exert on the surface of a liquid

- 7.6 Which one of propane or butane will have the highest *vapour pressure*? Explain your choice. (4)

Propane $\checkmark$

Propane and butane have London IMF $\checkmark$

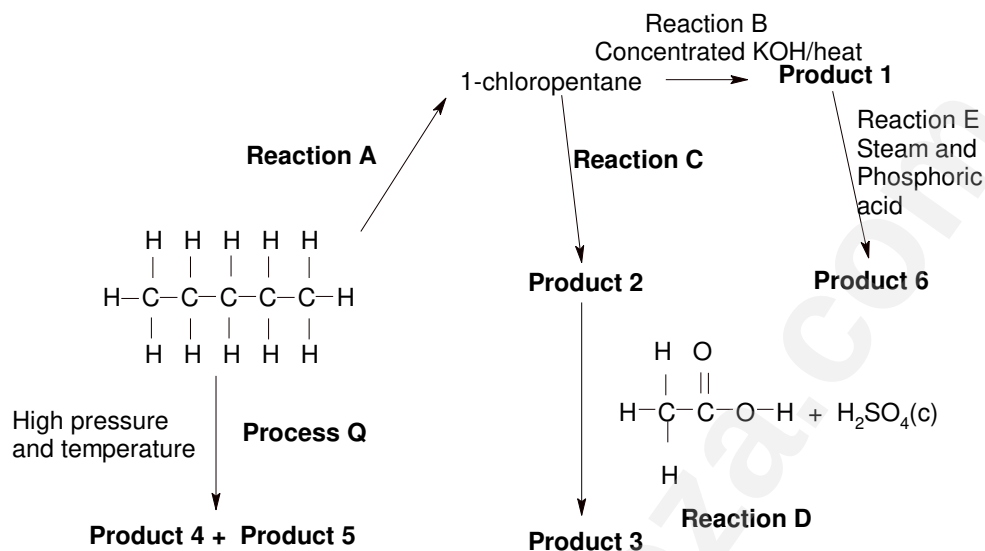
Propane has smaller contact surface therefor weaker IMF $\checkmark$

Easier for propane to evaporate $\checkmark$

[17]

QUESTION 8

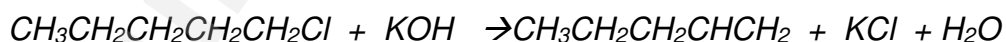
The organic chemistry industry makes use of multistep synthesis, where a simple reactant is used as the starter to produce more complex compounds. The flow diagram below shows a multistep synthesis using pentane as the starting reactant.



- 8.1 Reaction A involves the treatment of pentane with chlorine in the presence of ultraviolet light. Name this reaction. (2)

Halogenation/ Substitution ✓✓

- 8.2 1-chloropentane reacts with concentrated KOH and ethanol, whilst being heated strongly. Make use of condensed formula and write a balanced chemical equation for the reaction taking place. (3)



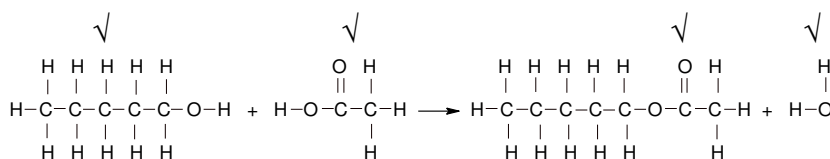
- 8.3 Give the name for the reaction taking place in QUESTION 8.2. (2)

Dehydrohalogenation/ Elimination ✓

- 8.4 When 1-chloropentane reacts in reaction C, an alcohol is formed. What are the reaction conditions needed for reaction C to take place? (2)

Dilute NaOH/KOH, ethanol, moderate temperature

- 8.5 Product 2 reacts with ethanoic acid when a few drops of concentrated H_2SO_4 is added, as represented by reaction D. Make use of full structural formula and write the chemical equation that represents Reaction D. (4)



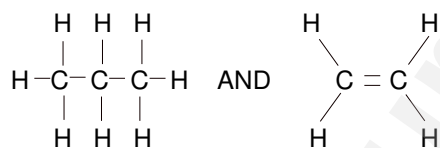
- 8.6 Write down the IUPAC name for Product 3. (2)

$\sqrt{} \qquad \sqrt{}$
Pentyl ethanoate

- 8.7 Write down the name for process Q. (2)

Cracking

- 8.8 Give the structural formula for products 4 and 5. (2)



- 8.9 Give the name for the type of reaction taking place in Reaction E. (2)

Addition

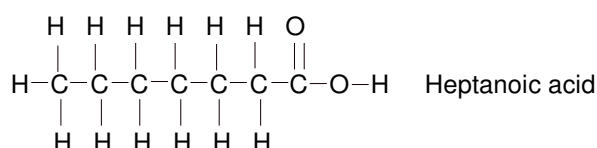
- 8.10 Give the IUPAC name for Product 6. (2)

$\sqrt{} \qquad \sqrt{}$
Pentan-1-ol or Pentan-2-ol

- 8.11 Define the concept *functional isomer*. (2)

Same molecular formula but belong to different homologous series

- 8.12 Draw the functional isomer of Product 3 and give the IUPAC name for the functional isomer. (4)



1-7 carbons
1-carboxyl group
1-heptan
1-oic acid

TOTAL: 200

[29]

ADDITIONAL SPACE (ALL QUESTIONS)

REMEMBER TO CLEARLY INDICATE AT THE QUESTION, THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL QUESTIONS ARE MARKED.

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