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MEMO
GRADE 12
PHYSICAL SCIENCES: PAPER 2
PRELIMINARY EXAM
19 September 2023



Examiner : East Rand Cluster
Moderator : East Rand Cluster

Time: 3 hours
Marks : 200

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 30 pages and a Data Sheet. Please check that your paper is complete.
2. Answer ALL the questions in the spaces provided on the paper.
3. Read the questions carefully and answer what is asked.
4. Use the data and formulae whenever necessary.
5. Show your workings in all calculations.
6. Units need not be included in the workings of your calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and present your work neatly.
10. Blank page 31 is provided at the end of the paper if more space is required. Clearly indicate the question number of your answer should you use this extra space. Extra graph paper is on page 32.

Name : MEMO

Question	Possible Mark	Mark Achieved
1	20	
2	26	
3	20	
4	16	
5	24	
6	24	
7	22	
8	16	
9	17	
10	15	
Total	200	

QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple choice answer sheet given below. Make a cross (X) in the box corresponding to the letter you consider to be correct.

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

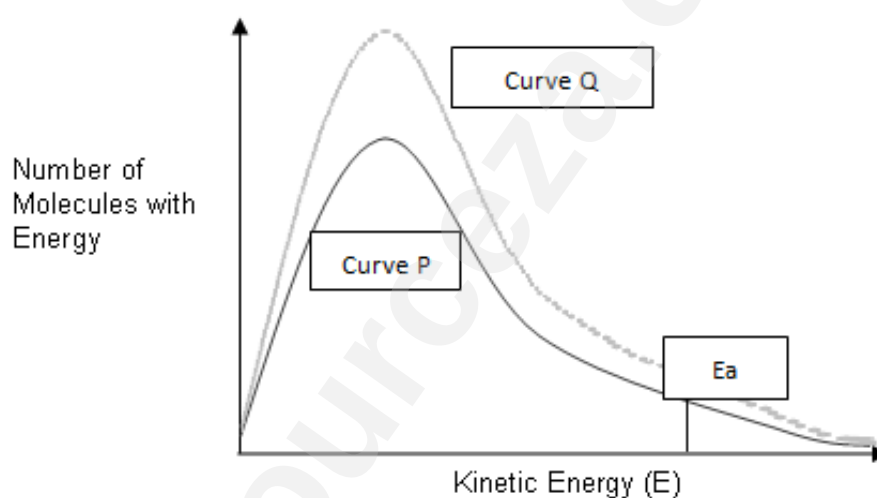
Here C is chosen as an example

1.1 The chemical formula for lithium permanganate is

- A LiMnO_3
- B LiMn_2O_7
- C LiMnO_2
- D LiMnO_4

D

1.2 The Boltzman-Maxwell curve below is representative of a chemical reaction where the concentration of a reactant was changed.



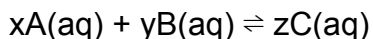
Source: <https://myalevels.co.uk/chemistry/maxwell-boltzmann-distribution/>

Which of the statements below is true for this graph?

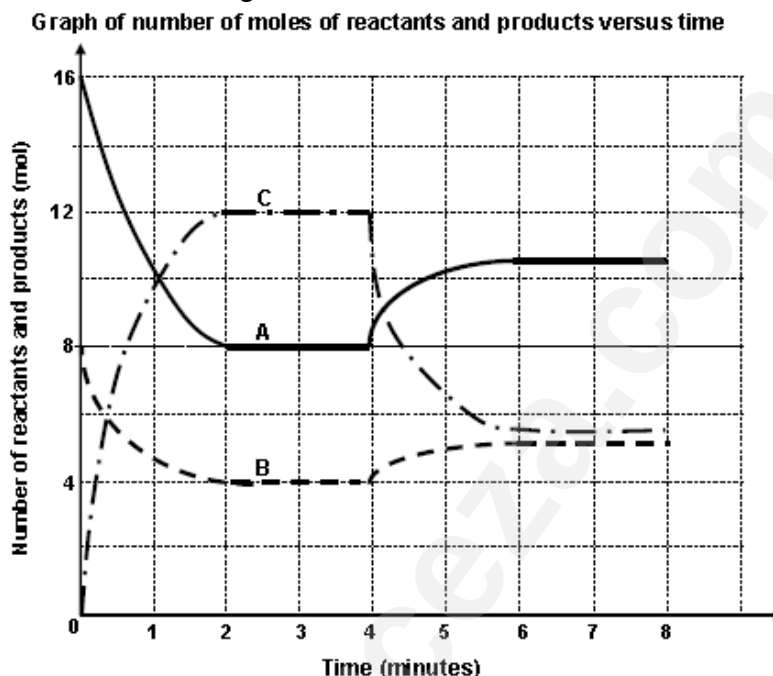
	CONCENTRATION	Ea
A	The concentration in P is greater than the concentration in Q	The Ea for P is different to the Ea for Q
B	The concentration in P is greater than the concentration in Q	The Ea for P is equal to the Ea for Q
C	The concentration in Q is greater than the concentration in P	The Ea for P is different to the Ea for Q
D	The concentration in Q is greater than the concentration in P	The Ea for P is equal to the Ea for Q

D

- 1.3 The equation below represents a hypothetical reaction that reaches equilibrium in a closed container after 2 minutes at room temperature. The letters x, y and z represent the number of moles in the balanced equation.



The graph below shows the change in the number of moles of reactants and products versus time during the reaction.



SOURCE:DBE 2018

From the graph it can be deduced that the values of x, y and z are best represented by:

	x	y	z
A	16	8	12
B	2	1	3
C	1	2	3
D	4	8	12

B

- 1.4 A beaker contains 20 cm³ of a 0,01 mol.dm⁻³ solution of NaOH. A spoonful of compound "X" is added to the solution and the pH of the solution decreases. Compound "X" could be

- A ammonium carbonate
- B sodium carbonate
- C sodium chloride
- D ammonium chloride

D

1.5 Which ONE of the following is a nonpolar molecule even though it contains at least one polar bond?

- A NCl_3
- B Carbon tetrachloride
- C Water molecule
- D HI

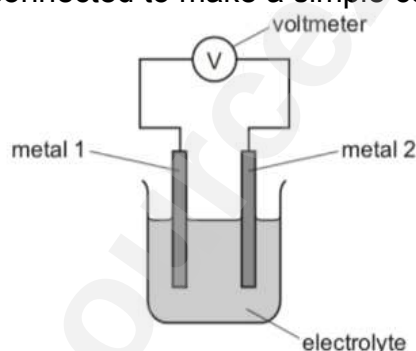
B

1.6 The conjugate base of $\text{CH}_3\text{CO}_2\text{H}$ is:

- A CH_3CO_2^-
- B CH_3CO_2^+
- C $\text{C}_5\text{H}_6\text{O}$
- D $\text{C}_5\text{H}_5\text{OH}^-$

A

1.7 Pairs of metals are connected to make a simple cell as shown below.



Some of the metals are not found on the redox table, but the table below shows the resulting emf when different metals were used. If metal 2 is more reactive, the resulting emf is positive.

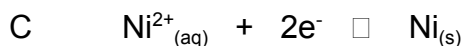
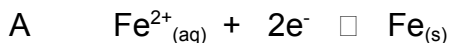
		metal 2			
		beryllium	cerium	cobalt	manganese
metal 1	beryllium	0.00 V	+0.64 V	-1.57 V	-0.67 V
	cerium		0.00 V	-2.21 V	-1.30 V
	cobalt			0.00 V	+0.90 V
	manganese				0.00 V

The correct order of reactivity for the metals is:

	Most reactive → least reactive			
A	cerium	beryllium	cobalt	manganese
B	cerium	beryllium	manganese	cobalt
C	cobalt	manganese	beryllium	cerium
D	cobalt	manganese	cerium	beryllium

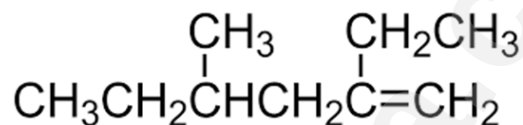
B

- 1.8 An electrochemical cell is used to electroplate an iron spoon with nickel. Which ONE of the following half-reactions takes place at the positive electrode of this cell?



D

- 1.9 The correct IUPAC name for the molecule shown below is...



A 5-ethyl-4-methylhex-5-ene

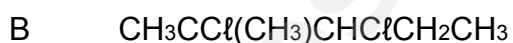
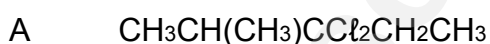
B 3-methyl-4-methylhept-3-ene

C 2-ethyl-4-methylhex-1-ene

D 3-butyl-3-methylbut-3-ene

C

- 1.10 Which is the correct formula of 2,3-dichloro-2-methylpentane?

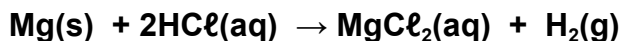


B

[20]

QUESTION 2 ENERGY AND RATES

Two experiments are carried out to investigate one of the factors that affects the reaction rate between magnesium and dilute hydrochloric acid. The balanced equation below represents the reaction that takes place.



The experiments that were carried out were as follows:

EXPERIMENT 1: an unknown mass of magnesium ribbon reacts with excess dilute hydrochloric acid.

EXPERIMENT 2: magnesium powder of the same unknown mass as the magnesium ribbon, reacts with the same volume of excess dilute hydrochloric acid.

The concentration of the acid is the same in both experiments.

The apparatus below is used for the investigation.



Source: DBE 2018

2.1 Define reaction rate. (2)

Reaction rate is the change in concentration per unit time of either a reactant or product ✓✓

2.2 For this investigation, write down the:

2.2.1 independent variable (1)

surface area/state of division of magnesium ✓

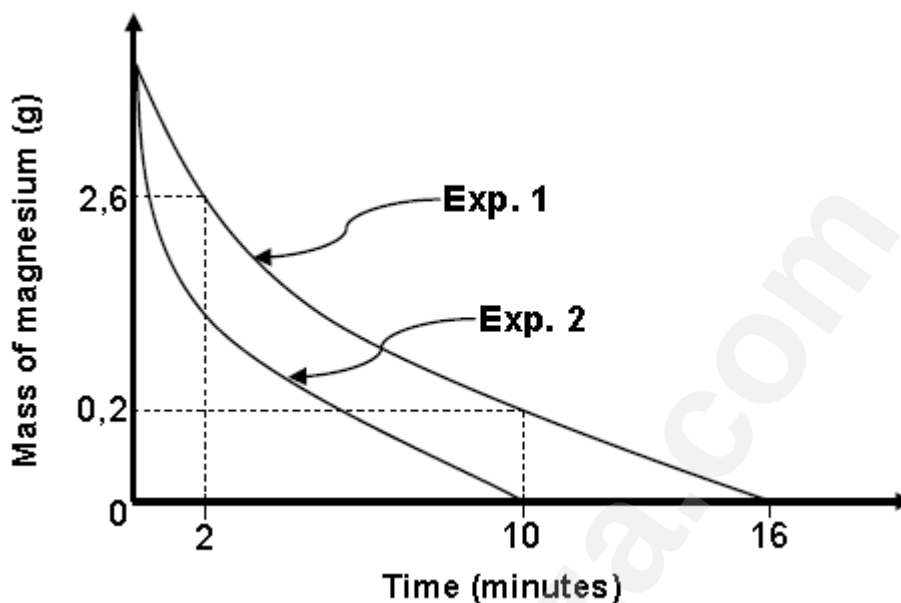
2.2.2 dependent variable (1)

rate of reaction/time for reaction to reach completion ✓

2.2.3 controlled variable (1)

mass of magnesium OR concentration of HCl OR temperature ✓

- 2.3 The change in mass of magnesium is calculated and recorded in 2 minute intervals for both experiments. The results obtained are shown in the graph below (NOT drawn to scale).



Source: DBE 2018

Use the information on the graph to:

- 2.3.1 calculate the volume of hydrogen gas produced in **EXPERIMENT 1** from $t = 2$ minutes to $t = 10$ minutes if the reaction occurs at STP. (5)

Marking criteria

- Calculate change in $m(\text{Mg})$ or $n(\text{Mg})$ ✓
- Substitute $24,3 \text{ g} \cdot \text{mol}^{-1}$ in $n = m/M$ ✓
- Use mol ratio: $n(\text{Mg}) = n(\text{H}_2) = 1:1$ ✓
- Substitute $22,45 \text{ dm}^3$ in $n = V/V_m$. ✓
- Final answer: $2,24 \text{ dm}^3$ ✓

$$\Delta m(\text{Mg}) = 2,6 - 0,2 = 2,4 \text{ g}$$

$$n(\text{Mg used}) = m/M = 2,4/24,3 = 0,0988 \text{ mol}$$

$$n(\text{H}_2) = n(\text{Mg}) = 0,0988 \text{ mol}$$

$$V(\text{H}_2) = nV_m$$

$$V(\text{H}_2) = (0,0988)(22,4) \\ = 2,21 \text{ dm}^3$$

- 2.3.2 calculate the initial mass of magnesium used if the average rate of formation of hydrogen gas in **EXPERIMENT 2** was $2,08 \times 10^{-4} \text{ mol} \cdot \text{s}^{-1}$. (5)

Marking criteria

- Substitute $2,08 \times 10^{-4}$ in ave rate = $\Delta n / \Delta t$ ✓
- Substitute $10 \times 60 \text{ s}$ (600 s) in ave rate equation ✓
- Use mol ratio: $n(\text{Mg}) = n(\text{H}_2) = 1:1$ ✓
- Substitute $24,3 \text{ g} \cdot \text{mol}^{-1}$ in $m = nM$. ✓
- Final answer: 3,03 g ✓

$$\begin{aligned} \text{ave rate} &= \Delta n / \Delta t \\ 2,08 \times 10^{-4} &= \Delta n / 10 \times 60 \\ \Delta n &= 0,1248 \text{ mol} \end{aligned}$$

$$n(\text{Mg}) = n(\text{H}_2) = 1:1$$

$$\begin{aligned} m(\text{Mg}) &= nM \\ &= 0,1248(24,3) \\ &= 3,03 \text{ g} \end{aligned}$$

- 2.4 Use the collision theory to explain why the curve of **EXPERIMENT 2** is steeper than that of **EXPERIMENT 1**. (4)

Larger surface area/greater state of division. ✓

More particles (per volume) for greater number of collisions per unit time ✓

More effective collisions (with correct orientation and kinetic energy) per unit time / Frequency of effective collisions increases. ✓

Therefore the rate of exp 2 is greater (steeper) than exp 1 and mass of Mg decreases faster ✓

- 2.5 Discuss another method that could have been used to measure the rate of this reaction. Include the apparatus needed and how to take readings for this method to be used effectively. (3)

Measure the volume of hydrogen gas produced.✓

Collect the gas by using a gas syringe ✓ (measuring cylinder/burette and the displacement of water)

Take the volume readings at regular intervals until the volume is constant.✓

- 2.6 **EXPERIMENT 1** is now repeated but a suitable catalyst is used.

- 2.6.1 How will the time taken for the reaction to be completed change? (1)

Time will be less✓

- 2.6.2 How will the change of mass of magnesium be affected? (1)

Remain the same✓

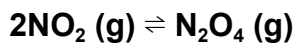
- 2.6.3 Discuss the function of a catalyst. (2)

Increases the rate of a reaction by decreasing the activation energy, but remains unchanged by the reaction.

[26]

QUESTION 3 EQUILIBRIUM

- 3.1 When NO_2 gas is collected in a flask, it has a dark brown colour. With time this colour becomes paler as NO_2 reacts to form N_2O_4 . Eventually the reaction reaches dynamic equilibrium according to the balanced equation below.



Brown Colourless

- 3.1.1 Explain the meaning of the underlined words. (2)

A reversible reaction where the forward and reverse reactions occur at the same rate. ✓✓

The flask of gas is then placed in a beaker full of ice, as shown in the diagram below. As a result, the gas turns a lighter colour.



Source: <https://www.sciencephoto.com/media/991837/view/nitrogen-dioxide-equilibrium>

- 3.1.2 Is this reaction exothermic or endothermic? (1)

Exothermic ✓

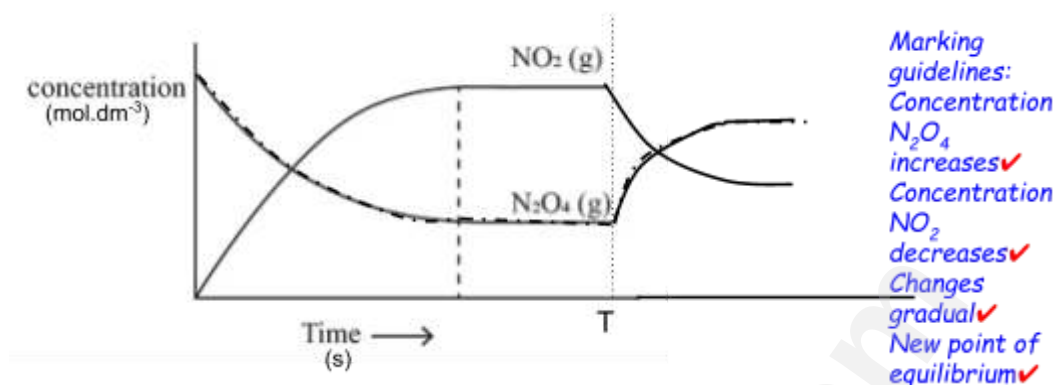
- 3.1.3 Use Le Chatelier's principle to explain your answer to question 3.1.2. (3)

Since the colour becomes lighter in colour, the concentration of N_2O_4 has increased. ✓

Therefore the forward reaction is favoured. ✓

According to Le Chatelier a decrease in temperature favours the exothermic reaction. ✓

3.1.4 The graph representing the equilibrium reaction is shown below.

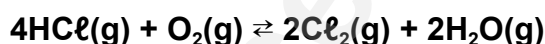


Source: DBE 2018

On the graph above, show how the concentrations will change when the flask has been placed in ice, at time T, until the colour remains constant once more.

(4)

3.2 A mixture of 0,2 moles of hydrogen chloride (HCl) and 0,11 moles of oxygen gas (O₂) is sealed in a 200 cm³ flask at a certain temperature. The reaction reaches equilibrium according to the balanced equation below:



When equilibrium is reached, it is found that 1,825 g of hydrogen chloride gas is present.

3.2.1 Calculate the equilibrium constant for this reaction at this temperature. (Answer space continues onto the next page.)

(9)

Calculate number of moles HCl at equilibrium

$$n = m/M$$

$$n = 1,825/36,5$$

$$n = 0,05 \text{ moles}$$

	HCl	O ₂	Cl ₂	H ₂ O
Ratio	4	1	2	2
Initial n	0,2	0,11	0	0
Change n	0,15 used	0,0375 used	0,075 made	0,075 made
Equilibrium n	0,05	0,0725	0,075	0,075
Equilibrium c = n/V	0,05/0,2 =0,25	0,0725/0,2 =0,3625	0,075/0,2 =0,375	0,075/0,2 =0,375

$$k_c = \frac{[\text{Cl}]^2 [\text{H}_2\text{O}]^2}{[\text{HCl}]^4 [\text{O}_2]}$$

$$k_c = \frac{[0,375]^2 [0,375]^2}{[0,25]^4 [0,3625]}$$

$$k_c = \frac{0,0198}{0,0014}$$

$$k_c = 13.9655$$

Marking guidelines

Substitution of 36,5 g·mol⁻¹ in n = m/M. ✓

Change n(HCl) = initial - equilibrium ✓

USING ratio 4 : 1 : 2 : 2 ✓

Equilibrium: n(O₂) & n(H₂O) & n(Cl₂) = initial ± change ✓

Divide by volume (0,2 dm³) ✓

Correct K_c expression (formulae in square brackets). ✓

Substitution of reactant concentrations ✓

Substitution of product concentrations. ✓

Final answer 13,97 ✓

3.2.2 How will this K_c value change if the concentration of the hydrogen chloride is increased?

State either INCREASES, DECREASES or REMAINS THE SAME.

(1)

Remains the same ✓

[20]

QUESTION 4 Chemical Bonding

4.1 Define the term *ionic bond*. (2)

A transfer of electrons, and subsequent electrostatic attraction. ✓✓

4.2 State the trends in electronegativity on the Periodic Table. (2)

Electronegativity increases from left to right across the Periods. ✓

Decreases from top to bottom down the Groups. ✓

OR Increases from bottom to top up the Groups.

4.3.1 State which of the following two gases would you expect to have a higher boiling point, N_2 or NO. (1)

NO ✓

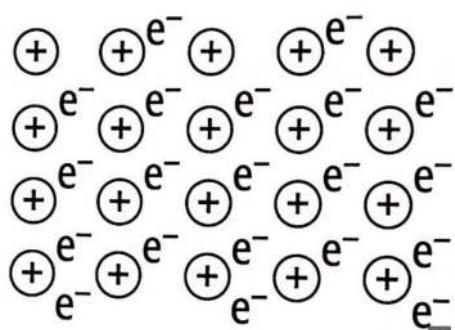
4.3.2 Explain the answer you gave in Question 4.3.1 fully, mentioning any specific forces, and their relative strengths. (3)

NO has dipole-dipole forces between molecules ✓, while N_2 has London forces. ✓ Dipole-dipole forces are stronger than London forces. More energy is needed to overcome the dipole dipole forces so the BP of NO is higher than N_2 . ✓

4.4 Is I_2 soluble in water? Give a reason for your answer. (2)

No, ✓ H-bond forces of water and London forces are too different in strength and water will not be attracted to I_2 . ✓

4.5.1 What type of substance is shown by the bonding in the diagram below? (1)



metal ✓

4.5.2 Does this substance have a high or low melting point? Explain. (3)

High melting point ✓

because the electrostatic attraction between the electrons and the positive cores of the atoms, holding the metal together, ✓ is very strong, and needs a lot of energy to overcome. ✓

4.5.3 Suggest why potassium is a better conductor of electricity than lithium. (2)

Potassium has a lower electronegativity (0,8) than lithium (1). ✓ The electrons move around more easily in potassium than in lithium. ✓

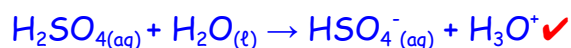
[16]

QUESTION 5 ACIDS AND BASES

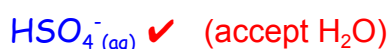
5.1 Define the term *ionisation*. (2)

The reaction of a molecular substance with water to produce ions. ✓✓

5.2.1 Write a reaction for the incomplete ionisation of H_2SO_4 . (1)



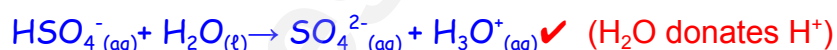
5.2.2 Write the formula of the ampholyte from the equation given in Question 5.2.1. (1)



5.2.3 Explain why the substance given in Question 5.2.2 is classified as an ampholyte. (2)

$\text{HSO}_4^{-}{}_{(\text{aq})}$ is able to donate a proton i.e. behave like an acid ✓ in a basic environment, or accept a proton i.e. behave like a base ✓ in an acidic environment.

5.2.4 Write a chemical equation which shows the ampholyte's behaviour as an acid in an aqueous medium. (1)



5.3 Define the term *weak acid*. (2)

An acid that only ionises partially in an aqueous solution. ✓✓

5.4.1 Calculate the hydronium ion concentration for a solution of $\text{Ca}(\text{OH})_2$ that has a concentration of $10^{-4} \text{ mol.dm}^{-3}$ at STP. (2)

$$[\text{H}_3\text{O}^{+}][\text{OH}^{-}] = 1 \times 10^{-14} \checkmark$$

$$[\text{H}_3\text{O}^{+}](10^{-4})(2) = 10^{-14}$$

$$[\text{H}_3\text{O}^{+}] = 10^{-14} / (10^{-4})(2) = 5 \times 10^{-11} \text{ mol.dm}^{-3} \checkmark$$

5.4.2 State whether this solution is acidic or basic. (1)

$5 \times 10^{-11} < 10^{-7}$, so therefore the solution is basic ✓

5.5 Washing soda contains sodium carbonate (Na_2CO_3) as its most important constituent. A sample of 5,13 g of washing soda crystals was dissolved in water to prepare a 250 cm^3 solution. Then, 25 cm^3 of this solution is neutralised by 36 cm^3 of a $0,05 \text{ mol.dm}^{-3}$ sulfuric acid solution. The balanced equation for the reaction is:



5.5.1 The table below shows some indicators and their pH sensitivity ranges. Which indicator could be used when sodium carbonate is titrated with sulfuric acid? Explain your choice. (2)

Indicator	pH range
Phenolphthalein	8,2 – 10,0
Bromothymol blue	6,8 – 7,6
Methyl orange	4,0 – 5,6

Methyl orange ✓ It changes colour in an acidic pH range, and this titration would have an end point that is acidic i.e strong acid and weak base. ✓

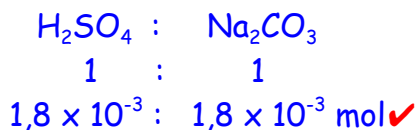
5.5.2 Calculate the number of moles of sulfuric acid that reacted with the sodium carbonate. (2)

$$n(\text{H}_2\text{SO}_4) = cV$$

$$= 0,05 \times 0,036 \text{ ✓}$$

$$= 1,8 \times 10^{-3} \text{ mols H}_2\text{SO}_4 \text{ ✓}$$

- 5.5.3 Calculate the mass of sodium carbonate in the sample of washing powder before the titration occurred. (5)



$$C_a V_a = n_a$$

$$C_b V_b = n_b$$

$$\frac{0,05(36)}{C_b(25)} = \frac{1}{1} \checkmark$$

$$C_b = 0,072 \text{ mol.dm}^{-3}$$

Concentration for the solution remains constant

✓

$$c = \frac{n}{V}$$

$$\frac{1,8 \times 10^{-3}}{0,025} = \frac{n}{0,25} \checkmark$$

$$(0,072)(106)(0,25) \checkmark \checkmark$$

$$n = 0,018 \text{ mol}$$

$$m = cMV$$

$$=$$

$$= 1,91 \text{ g} \checkmark$$

$$M(\text{Na}_2\text{CO}_3) = 2(23) + 12 + 3(16) = 106 \text{ g.mol}^{-1}$$

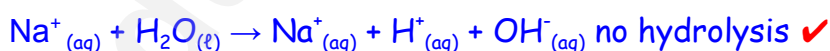
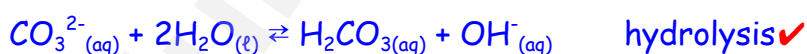
$$m = nM$$

$$= 0,018 (106) \checkmark \checkmark$$

$$= 1,91 \text{ g Na}_2\text{CO}_3 \checkmark$$

- 5.5.4 Write hydrolysis reactions to show whether an aqueous solution of sodium carbonate is acidic or basic. (3)

Na_2CO_3 forms Na^+ and CO_3^{2-} in aqueous solution.



$[\text{H}^+] < [\text{OH}^-]$ so solution is basic ✓

[24]



$2 \text{Na}^+ + 2\text{OH}^-$ form a strong base so stay as ions (no hydrolysis)

$\text{H}_2\text{CO}_3 + 2 \text{H}_2\text{O} \rightleftharpoons 2\text{H}_3\text{O}^+ + \text{CO}_3^{2-}$ form a weak acid, undergo hydrolysis,

reducing H^+ ions**QUESTION 6 ELECTROLYSIS**

- 6.1 In an investigation to determine the relationship between the current supplied and the mass of aluminium deposited, Clint and Kabo manipulated the current and recorded the mass of aluminium collected after 30 minutes. The following results were recorded.

Current (A)	Mass (g)
5	0,8
7,2	1,2
10	1,6
15	2,5
20	3,6

- 6.1.1 At which electrode would the aluminium be deposited? State only ANODE or CATHODE. (1)

Cathode✓

- 6.1.2 Provide the half reaction that takes place at this electrode. (2)



- 6.1.3 Identify the independent variable. (1)

Current✓

- 6.1.4 Give the controlled variable. (1)

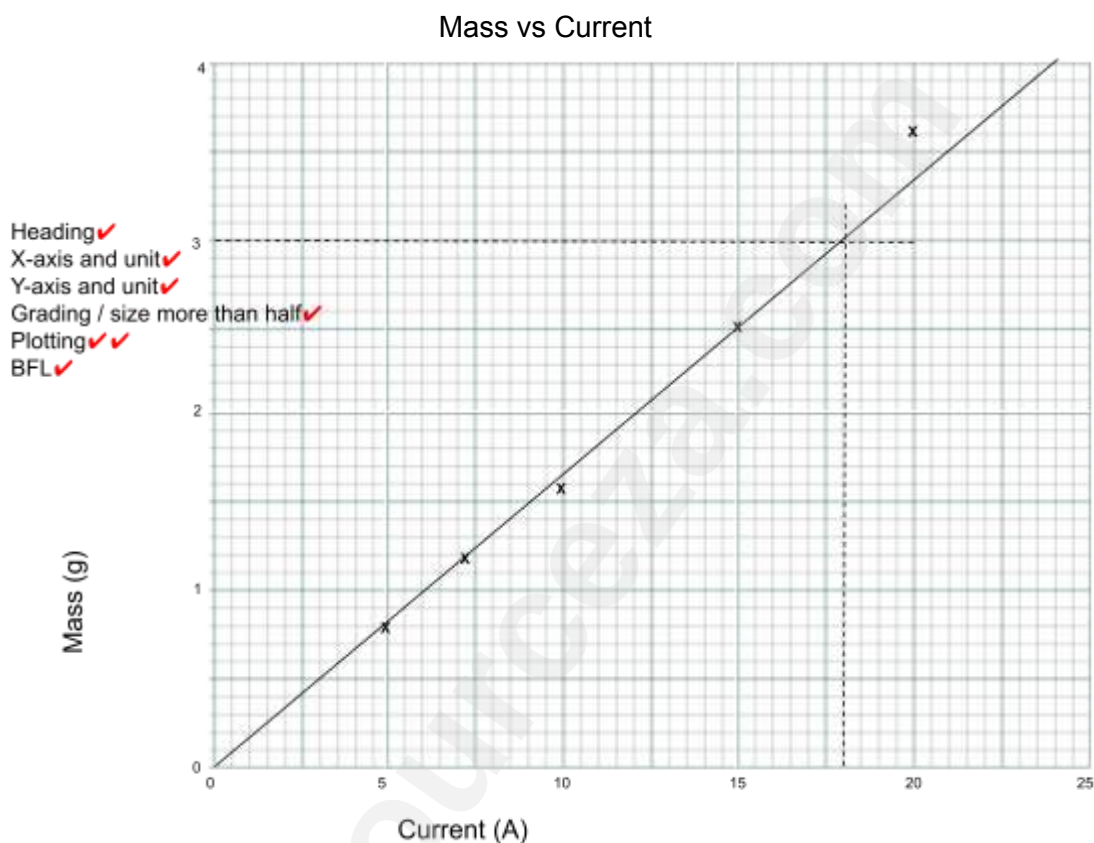
Time of 30 minutes✓

- 6.1.5 Explain why it is necessary to control this variable. (1)

It allows only the current to be manipulated and cause the mass of Al to be

measured, making it a fair test.✓

- 6.1.6 On the graph paper following, draw a graph depicting the results of this investigation. (7)



- 6.1.7 Using your graph determine the mass of Aluminium produced when a current of 18 A is supplied for 30 minutes. Indicate your answer on your graph.✓ (2)

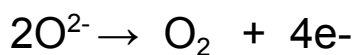
3,0 g (Accept 2,9 - 3,3)✓

- 6.2 In a separate reaction, in order to extract aluminium, alumina Al_2O_3 is melted in cryolite so that electrolysis can take place.

- 6.2.1 Explain why cryolite is necessary. (2)

It dissolves the alumina and reduces the melting point, allowing the ions to move freely and conduct current.✓✓

The following half reaction takes place during this electrolysis.



19,2 g of oxygen gas is produced by this reaction at STP, when a current of 12 A is supplied.

- 6.2.2 Determine the number of moles of electrons that would be produced by this reaction. (4)

$$n(\text{O}_2) = \frac{m}{M_r}$$

$$= \frac{19,2}{32} \checkmark \checkmark$$

$$= 0,6 \text{ mol}$$



- 6.2.3 Calculate the time needed for the cell to produce 19,2 g of oxygen. (3)

$$Q = I \cdot t = n_e F \checkmark$$

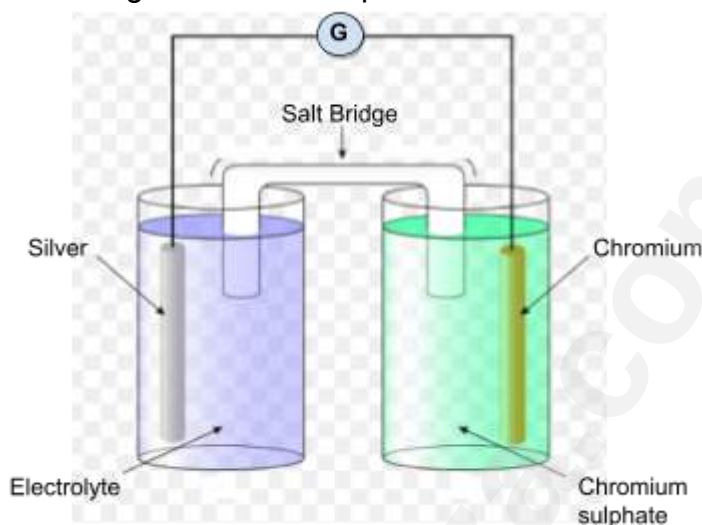
$$(12) t = 2,4(96500) \checkmark$$

$$t = 19300 \text{ s} \checkmark$$

[24]

QUESTION 7 ELECTROCHEMISTRY

7.1 Consider the following Galvanic cell operated under standard conditions.



7.1.1 Define *reduction*. (1)

The gain of electrons ✓✓

7.1.2 State the energy conversion taking place in this cell. (1)

Chemical potential to electrical energy ✓✓

7.1.3 Give the formula of a suitable electrolyte that can be used in the silver half cell. (2)

AgNO_3 ✓✓

7.1.4 Identify the anode half cell. State either Silver or Chromium. (1)

Chromium ✓

7.1.5 Provide the half reaction that verifies that your answer to Qu 7.1.4 is the anode. (2)

$\text{Cr} \rightarrow \text{Cr}^{3+} + 3\text{e}^-$ ✓✓

7.1.6 Write down the balanced net ionic cell reaction for this cell. (2)



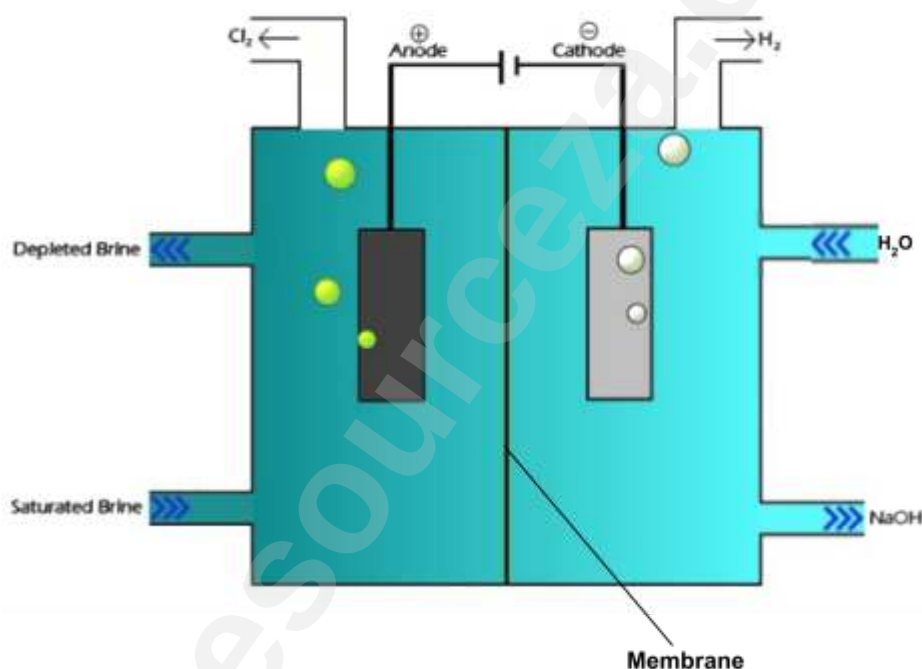
7.1.7 Determine the initial emf for this cell under standard conditions. (3)

$$E_{\text{cell}}^{\ominus} = E_{\text{cathode}} - E_{\text{anode}} \checkmark$$

$$= +0,80 - (-0,74) \checkmark$$

$$= +1,54 \text{ V} \checkmark$$

7.2 The diagram below depicts the electrolysis of brine that forms the foundation of the chlor-alkali industry.



The overall balanced equation for this reaction is :



7.2.1 Give the function of the membrane. (2)

To separate the two half cells. $\checkmark$

To allow only cations (Na^+) to pass through. $\checkmark$

7.2.2 Explain why Na^+ ions are not reduced at the cathode. (2)

H_2O is a stronger oxidising agent than Na^+ $\checkmark$ and will be readily reduced instead of sodium ions. $\checkmark$

- 7.2.3 5 kg of NaCl is processed during the functioning of this cell. 850 dm³ of hydrogen gas is collected at STP. Calculate the percentage purity of the salt used. (5)

$$n(\text{H}_2) = \frac{V}{V_m}$$

$$= \frac{850}{22,4} \checkmark$$

$$= 37,946.. \text{ mol}$$



$$2(37,946..) : 37,946..$$

$$75,89.. \text{ mol}$$

$$m(\text{NaCl}) = nM_r$$

$$= 75,89..(58,5) \checkmark$$

$$= 4439,73.. \text{ g}$$

$$\% \text{Purity} = \frac{4439,73..}{5000} \checkmark$$

Various alternatives acceptable

$$= 88,79\% \checkmark$$

- 7.2.4 Provide one use of sodium hydroxide in industry. (1)

Used to purify bauxite in the manufacture of aluminium.

Making soaps and detergents

Making paper (or other suitable use) $\checkmark$

[22]

QUESTION 8 ORGANICS

The letters A to F in the table below represent organic compounds and some reactions.

A	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$	B	<i>2,2-dimethylpentan-1-ol</i>
C	$CH_3CH_2CH_2COOCH_2CH_3$	D	$CH_3CHCHCH_2CH_3 + HF \rightarrow$
E	$CH_3CH_2CH_2CH_3$	F	$CH_3CH_2COOH + CH_3OH \rightarrow$

Refer to the table above and then answer the following questions.

8.1 Write down the:

8.1.1 Name of the functional group of compound **B**. (1)

Hydroxyl group ✓

8.1.2 IUPAC name of compound **E**. (1)

Butane ✓

8.1.3 General and specific type of reaction in **A**. (2)

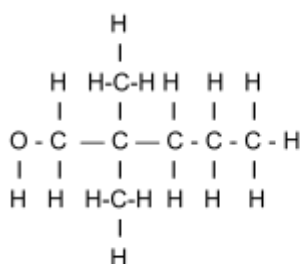
Substitution ✓ halogenation reaction ✓

8.1.4 IUPAC name of the organic product in reaction **F**. (2)

Methyl propanoate ✓✓

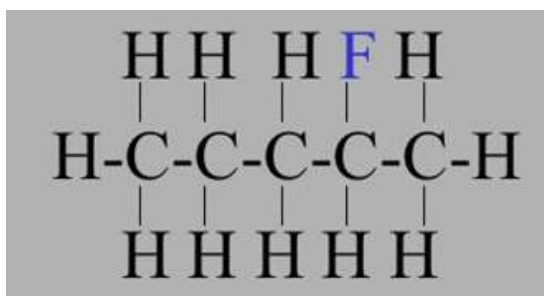
8.2 Draw:

8.2.1 the structural formula for compound **B**. (2)



✓✓

8.2.2 The structural formula for the organic product in reaction D. (2)



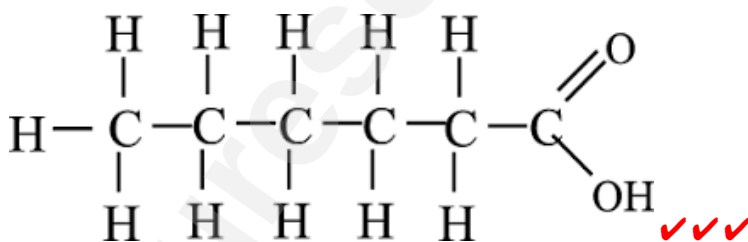
✓✓

(Or F on 3rd C)

8.3.1 Give the definition of *an isomer*. (2)

A compound that has the same molecular formula, but a different structural formula. ✓✓

8.3.2 Draw the structural formula for the functional isomer of molecule C. (3)



✓✓✓

8.3.3 Give the IUPAC name for the isomer drawn in 8.3.2 (1)

Hexanoic acid ✓

[16]

QUESTION 9 ORGANICS AND IMF

Learners use compounds A,B and C, shown in the table below, to investigate a factor which influences the boiling point of organic compounds.

A	$CH_3CH_2CH_2CH_3$
B	$CH_3CH_2CH_2CH_2OH$
C	$CH_3CH_2CH_2COOH$

9.1 For this investigation, write down the following:

9.1.1 Controlled variable. (1)

Chain length ✓ (number of carbons)

9.1.2 Independent variable. (1)

Homologous series ✓

9.2 Which one of the compounds(**A**, **B** or **C**) has the highest boiling point? Explain your answer in terms of intermolecular forces, relative strength of the forces and energy for each compound. (5)

A has weak London/dispersion forces ✓

B has London/dispersion forces, dipole dipole forces and one hydrogen bond. ✓

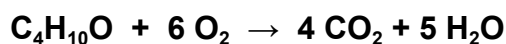
C has London forces, dipole dipole forces and two hydrogen bonds. ✓

C has the strongest net IMF forces, then B, then A. ✓

Molecules of C need more energy than A and B to overcome the forces. ✓

Therefore, C has the HIGHEST boiling point.

- 9.3 Molecule **B** burns in oxygen at STP, according to the following balanced chemical equation.



49,95 **kg** of butanol is reacted with 120 **kg** of oxygen.

- 9.3.1 Determine the limiting reagent. (6)

$$\begin{aligned} n(\text{C}_4\text{H}_{10}\text{O}) &= \frac{m}{Mr} & n(\text{O}_2) &= \frac{m}{Mr} \\ &= \frac{49950}{74} \checkmark\checkmark & &= \frac{120000}{32} \checkmark\checkmark \text{ (-2 if left in kg)} \\ &= 675 \text{ mol} & &= 3750 \text{ mol} \\ & & & \frac{(\text{C}_4\text{H}_{10}\text{O}) : (\text{O}_2)}{675 : 3750 \checkmark} \\ & & & \frac{1 : 6}{= 625 \text{ mol O}_2 \text{ limits} \checkmark} \end{aligned}$$

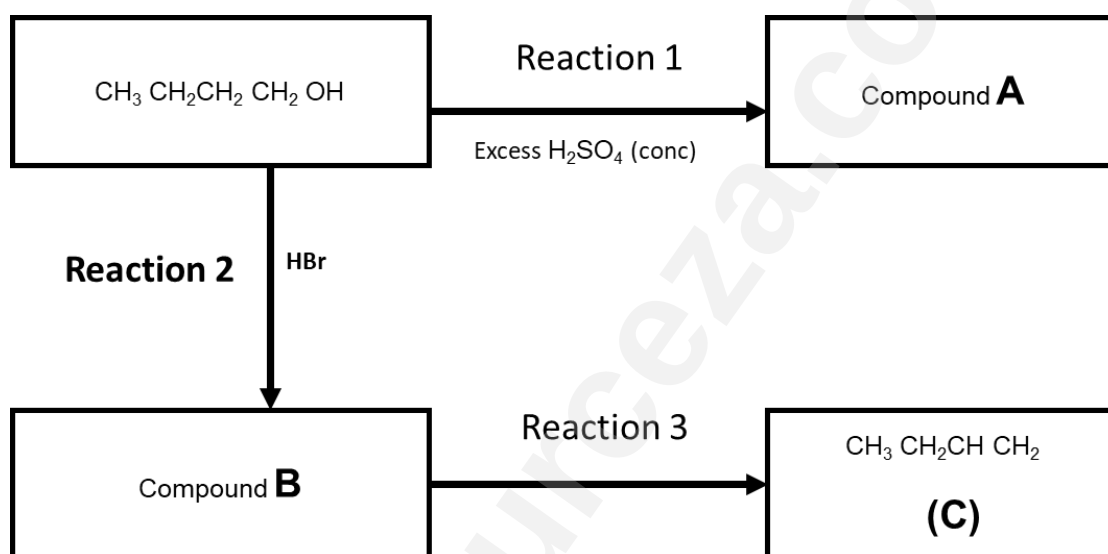
- 9.3.2 Calculate the mass of carbon dioxide produced in kilograms. (4)

$$\begin{aligned} \text{O}_2 &: \text{CO}_2 \\ 6 &: 4 \checkmark \\ 3750 &: \frac{4}{6} (3750) = 2500 \text{ mol} \\ m(\text{CO}_2) &= nMr \\ &= (2500)(44) \checkmark\checkmark \\ &= 110000 \text{ g} \\ &= 110 \text{ kg} \checkmark \end{aligned}$$

[17]

QUESTION 10 ORGANIC REACTIONS

In the flow diagram below, butan-1-ol is used as a starting reactant in the preparation of compound A and B.



10.1 Compound **A** is the organic product formed in Reaction 1.
Write down the following:

10.1.1 the condensed structural formula for compound **A**. (2)

CH₃CH₂CHCH₂ ✓✓

10.1.2 the GENERAL type of reaction that takes place in Reaction 1. (1)

Elimination ✓

10.1.3 the IUPAC name of compound **A**. (1)

But-1-ene ✓

10.1.4 state whether compound **A** is saturated or unsaturated. (1)

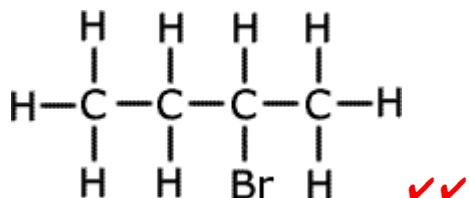
Unsaturated ✓

10.2 For compound **B**, write down the following:

10.2.1 the SPECIFIC reaction type for Reaction 2. (1)

Hydrohalogenation ✓

10.2.2 the structural formula for a positional isomer of compound **B**. (2)



(4 Carbons, Br on 2nd carbon)

10.3 For Reaction 3, write down the following:

10.3.1 TWO reaction conditions necessary for this reaction. (2)

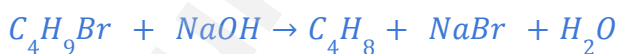
Pure ethanol as solvent for the base. ✓

Concentrated NaOH or KOH/heat ✓

10.3.2 the type of reaction that occurs. (1)

Elimination/Dehydrohalogenation ✓

10.3.3 a balanced equation, using molecular formulae. (4)



(reactants ✓, products ✓✓, balanced ✓)

[15]