Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

JUNE 2023

PHYSICAL SCIENCES: (CHEMISTRY) P2

MARKS: **150**

TIME: **3 hours**

This question paper consists of 21 pages, including 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your name and surname in the appropriate space on the ANSWER BOOK.

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

3. Start EACH question on a NEW page in the ANSWER BOOK.

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

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

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

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

9. Show ALL formulae and substitutions in ALL calculations.

10. Round off your FINAL numerical answers to a minimum of TWO decimal places.

11. Give brief motivations, discussions, et cetera where required.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the correct letter (A–D) next to the question numbers (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 Which ONE of the following homologous series has members that are SATURATED hydrocarbons?

A Alcohols

B Alkenes

C Alkanes

D Alkynes (2)

1.2 When an ALKENE is converted to an ALKANE, the catalyst that is used is …

A Ni or Fe.

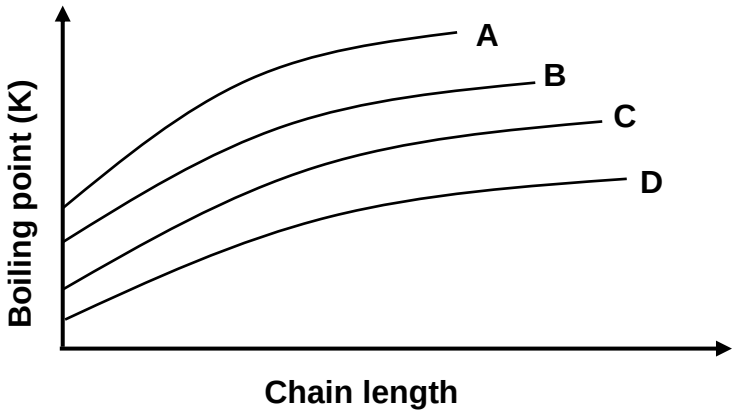
B Pt or Ni.

C H_2SO_4 or Ni.

D H_2SO_4 or Pt. (2)

1.3 The boiling point versus chain length graph below was obtained for straight chain molecules of aldehydes, alkanes, alcohols and carboxylic acids.

The curve for EACH homologous series is labelled as **A**, **B**, **C** or **D**.



Which ONE of the curves above represents alcohols?

A Curve **A**

B Curve **B**

C Curve **C**

D Curve **D** (2)

1.4 Consider the organic reaction below:

$$CH_2CH_2 + \mathbf{X} \longrightarrow \text{Alcohol}$$

Which ONE of the following is CORRECT about reactant **X** and the reaction condition?

	X is …	**Reaction condition**
A	H_2O	Concentrated H_2SO_4 in excess
B	H_2O	Small quantity of concentrated H_2SO_4
C	dilute KOH	Mild heat
D	concentrated KOH	Strong heat

(2)

1.5 Consider the reaction between an EXCESS hydrochloric acid (HCℓ) solution and magnesium powder:

$$Mg\,(s) + 2\,HC\ell\,(aq) \longrightarrow MgCl_2\,(aq) + H_2\,(g)$$

Which ONE of the following factors when INCREASED will cause an increase in both the REACTION RATE and the TOTAL VOLUME of H_2 produced?

A Mass of Mg

B Volume of HCℓ

C Concentration of HCℓ

D Temperature of the reaction mixture (2)

1.6 Which ONE of the following will affect BOTH the equilibrium position of a reversible reaction, and its K_c value?

A Mass

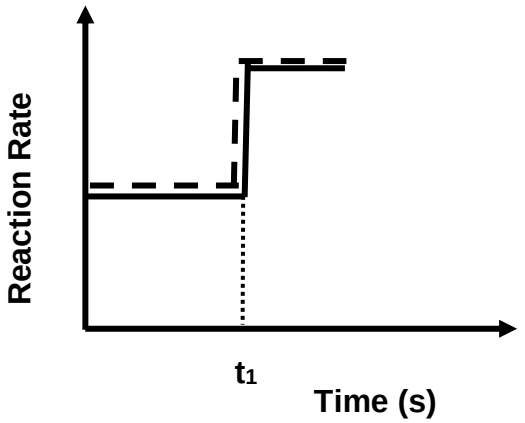
B Pressure

C Temperature

D Concentration (2)

1.7 The graph below shows how the reaction rate changes with time for the reaction represented by the balanced equation below:

$$2\,HI(g) \rightleftharpoons H_2(g) + I_2(g) \quad \Delta H > 0$$



Consider the following changes made to the equilibrium mixture.

I More HI is added

II Temperature is increased

III Pressure is increased by decreasing the volume at constant temperature

Which ONE of the following changes will cause the change at **t_1**?

A **I** only

B **II** only

C **I** and **III**

D **III** only (2)

1.8 A substance that loses protons in some reactions and gains protons in other reactions is called a/an …

A base.

B acid.

C ampholyte.

D acid-base indicator. (2)

1.9 Four titrations are carried out using the pairs of substances shown below.

For which pair of substances when titrated will phenolphthalein be the most suitable indicator?

A HNO_3 and NaOH

B CH_3COOH and NaOH

C Na_2CO_3 and $HC\ell$

D H_2SO_4 and NaOH (2)

1.10 The following equilibrium exists in pure water at 25 °C.

$$2\ H_2O(\ell) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

How will the addition of NaOH to the pure water affect the concentration of the hydronium ion [H_3O^+] and pH of water at constant temperature?

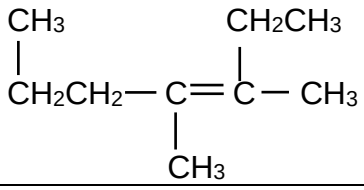
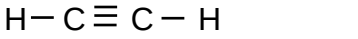
	[H_3O^+]	**pH of water**
A	Increases	Decreases
B	Decreases	Increases
C	Increases	Increases
D	Decreases	Decreases

(2)

[20]

QUESTION 2 (Start on a new page.)

Consider the organic compounds **A** to **F** given in the table below.

A	C_5H_{12}	**B**	
C	Propan-1-ol	**D**	Methanal
E	$CH_3CH(OH)CH_3$	**F**	$CH_3CH_2CH_2COOH$
G	Propanone	**H**	

2.1 Write down the LETTER that represents the following compounds:

2.1.1 An alkyne (1)

2.1.2 An aldehyde (1)

2.1.3 That has the general formula C_nH_{2n+2} (1)

2.1.4 That has a solution with pH < 7 (1)

2.1.5 That has the same general formula as an ester (1)

2.2 Compounds **C** and **E** are structural isomers.

2.2.1 Define the term *structural isomer.* (2)

2.2.2 What TYPE of structural isomers are compounds **C** and **E**?

Choose from CHAIN, POSITIONAL or FUNCTIONAL. (1)

2.2.3 Is compound **E** a PRIMARY, SECONDARY or TERTIARY ALCOHOL?

Give a reason for your answer. (3)

2.3 Write down the:

2.3.1 IUPAC name of compound **B** (3)

2.3.2 CONDENSED STRUCTURAL formula of a FUNCTIONAL isomer of compound **G** (2)

2.4 For compound **F** write down the:

2.4.1 Empirical formula (1)

2.4.2 Name of its functional group (1)

2.5 Compound **F** reacts with methanol in the presence of concentrated sulphuric acid to produce organic product **X**.

For compound **X** write down the:

2.5.1 Name of the homologous series to which it belongs (1)

2.5.2 IUPAC name and STRUCTURAL formula (4)

[23]

QUESTION 3 (Start on a new page.)

The table below shows a number of organic compounds and their respective melting points.

Study the table below and answer the questions that follow.

	Compound	Melting point (°C)
A	Propane	-187
B	Butane	-138
C	Pentane	-129
D	2-methyl butane	**X**
E	Butanal	-96,8
F	Butan-1-ol	-89,8

3.1 Define the term *melting point.* (2)

3.2 Explain the trend in melting points from compound **A** to **C**. (3)

3.3 Which compound (**A**, **B** or **C**) will have the highest vapour pressure at a given temperature?

Give a reason for the answer by referring to the data in the table above. (2)

3.4 Consider compounds **C** and **D**. The melting point of compound **D** is indicated by **X**.

3.4.1 Draw the structural formula of compound **D**. (2)

3.4.2 How does the value of **X** compare to the melting point of compound **C**?

Choose from GREATER THAN -129 °C or LESS THAN -129 °C. (1)

3.4.3 Is the comparison between compounds **C** and **D** a fair comparison?

Write only YES or NO.

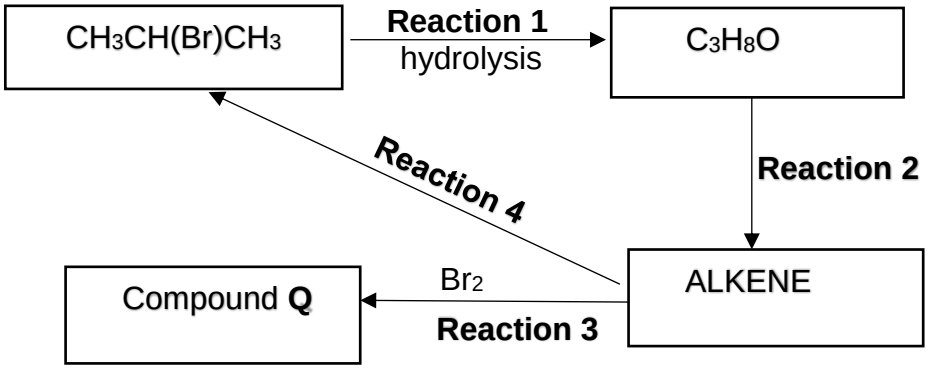
Give a reason for your answer. (2)

3.5 Explain the difference in the melting points of compounds **E** and **F** by referring to intermolecular forces present and energy. (4)

[16]

QUESTION 4 (Start on a new page.)

4.1 Consider the flow diagram showing organic reactions given below.



Consider **REACTION 1**.

Write down:

4.1.1 The name of the homologous series to which the compound C_3H_8O belongs (1)

4.1.2 ONE reaction condition (1)

4.1.3 The formula of the inorganic reactant (1)

Consider **REACTION 2**.

4.1.4 Name the type of elimination reaction taking place. (1)

4.1.5 Using structural formulae for the organic compounds, write down a balanced equation for the reaction. (6)

Consider **REACTIONS 3** and **4**.

Write down the:

4.1.6 Name given to these types of reactions (1)

4.1.7 Formula of the inorganic reactant used in **REACTION 4** (1)

4.1.8 IUPAC name and structural formula of compound **Q** (4)

4.2 Consider the incomplete equations for reactions **I** and **II**.

I	$C_{15}H_{32} \longrightarrow$ ALKANE **P** + 2 **Q** + C_xH_6
II	$CH_3CH_2Br + KOH \longrightarrow$ **Q** + KBr + **Z**

In reaction **I**, the compound $C_{15}H_{32}$ undergoes cracking. **Q** is an organic compound while compound **Z** is an inorganic compound.

The compounds **Q** and C_xH_6 have the same FUNCTIONAL GROUP.

4.2.1 Define *cracking.* (2)

4.2.2 Write down a balanced equation for the complete combustion of ALKANE **P**. (Show ALL workings.) (6)

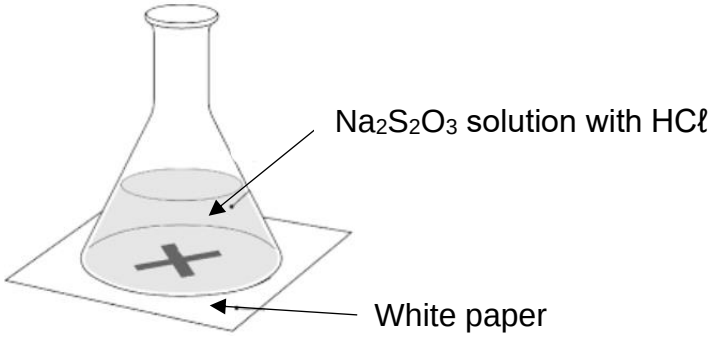
[24]

QUESTION 5 (Start on a new page.)

A group of learners use the reaction between sodium thiosulphate ($Na_2S_2O_3$) and EXCESS hydrochloric acid ($HC\ell$) to investigate one of the factors that affect reaction rate. The balanced equation for the reaction is:

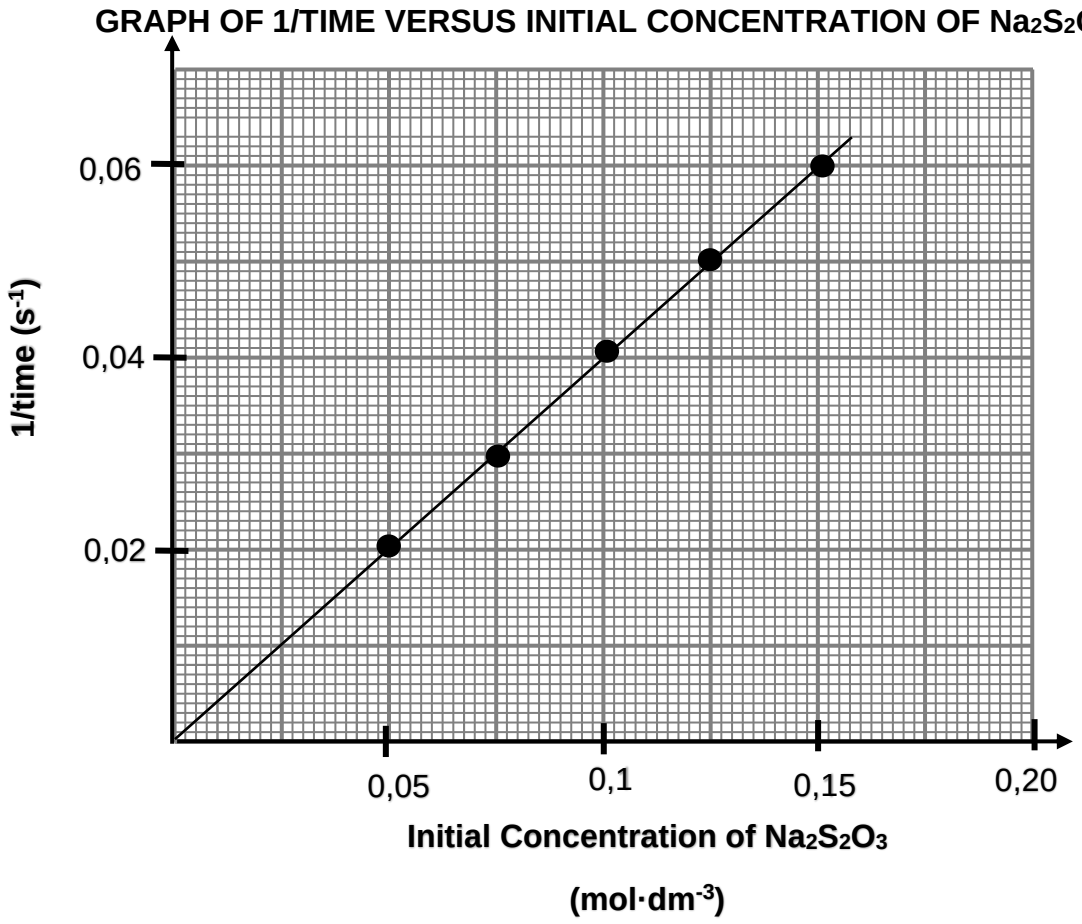
$$Na_2S_2O_3\ (aq) + 2\ HC\ell\ (aq) \longrightarrow 2\ NaC\ell\ (aq) + S\ (s) + H_2O\ (\ell) + SO_2\ (g)$$

The learners carry out five experiments under the same conditions changing only the factor that is investigated in EACH experiment using the experimental set-up shown below.



They recorded the time taken for the cross to become invisible, when viewed from the top.

The learners' results are shown in the graph below.



5.1 Define *reaction rate.* (2)

5.2 Write down an investigative question for the above investigation. (2)

5.3 Name the substance responsible for the disappearance of the cross. (1)

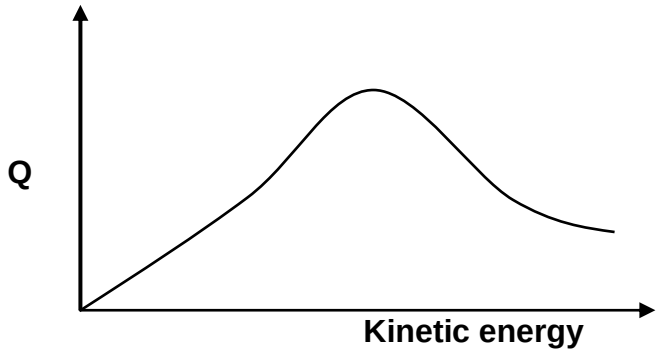
5.4 Give a reason why the same cross must be used in ALL the experiments. (1)

5.5 Use the collision theory to explain the effect of concentration on reaction rate. (3)

5.6 In one of the experiments 50 cm^3 of $Na_2S_2O_3$ is used and it takes 20 seconds for the cross to become invisible.

Calculate the total mass of sulphur, **S**, formed in this experiment. (6)

5.7 The graph below represents Maxwell-Boltzmann distribution curve for $SO_2(g)$ at 30 °C.



Q is a label on the vertical axis.

5.7.1 What does **Q** in the graph represent? (1)

Redraw the graph in the ANSWER BOOK. Clearly label the curve as **A**.

5.7.2 On the same set of axes, sketch the curve that will be obtained for $SO_2(g)$ at 40 °C.

Label this curve as **B**. (2)

[18]

QUESTION 6 (Start on a new page.)

The following reaction reaches equilibrium at a temperature of 200 °C.

$$PC\ell_5(g) \rightleftharpoons PC\ell_3(g) + C\ell_2(g) \quad \Delta H > 0$$

6.1 State Le Chatelier's principle. (2)

6.2 Two conditions must be met for a chemical reaction to establish equilibrium. One of the conditions is represented by the double arrow "⇌".

State the other condition. (1)

6.3 The reaction is initiated by heating 83,4 grams $PC\ell_5(g)$ in a sealed 2 dm^3 container. At equilibrium it is found that the initial concentration of $PC\ell_5$ has changed by **x** $mol \cdot dm^{-3}$.

6.3.1 Show that the equilibrium constant is, $K_c = \mathbf{x}^2 / 0,2 - \mathbf{x}$. (6)

6.3.2 The concentration of $PC\ell_5$ at equilibrium is found to be 0,001 $mol \cdot dm^{-3}$.

Show by calculation that the value of K_c is equal to 39,601 at 200 °C. (2)

6.3.3 Is there a LOW or HIGH YIELD at 200 °C?

Give a reason for your answer. (2)

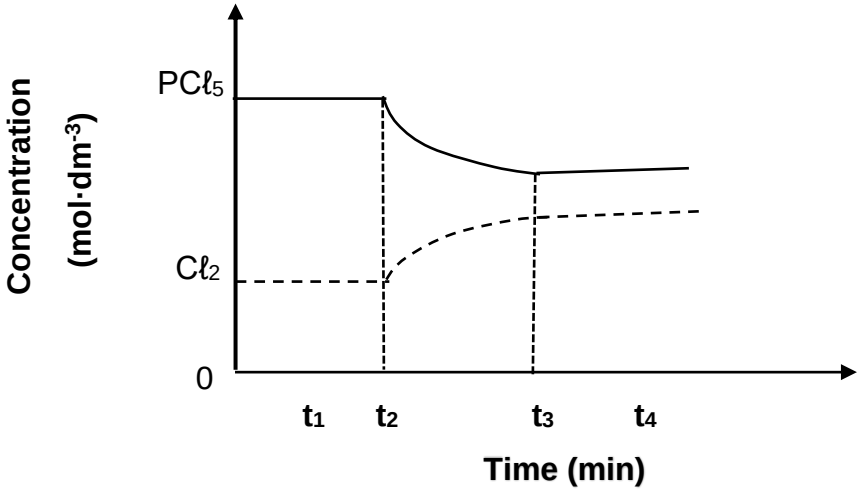
6.4 What effect will the addition of a suitable catalyst have on the following:

Choose from DECREASES, INCREASES or NO EFFECT.

6.4.1 Percentage decomposition of $PC\ell_5(g)$? (1)

6.4.2 Time taken to reach equilibrium? (1)

6.5 The graph below shows changes of concentration of reagents $PC\ell_5$ and $C\ell_2$ against time.



6.5.1 What does the horizontal section of the graph between **0**–t_1 represent? (1)

At time t_2 the temperature of the equilibrium mixture is changed.

6.5.2 Was the container COOLED or HEATED at time t_2? (1)

6.5.3 Use Le Chatelier's principle to fully explain the answer to QUESTION 6.5.2. (3)

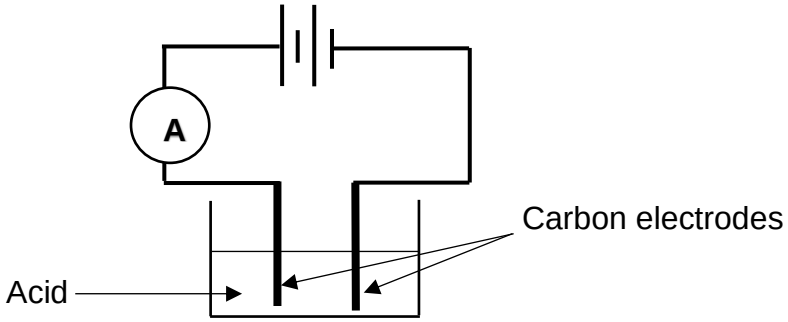
[20]

QUESTION 7 (Start on a new page.)

7.1 An investigation is carried out to compare the strengths of TWO acids $CH_3COOH(aq)$ and $H_2CO_3(aq)$.

To determine the strength of EACH acid electrical conductivity of the acid is measured at 25 ˚C using the experimental set-up shown below.

The concentration of the acids is the same.



7.1.1 Define an acid according to the *Arrhenius theory.* (2)

7.1.2 State ONE property of the carbon electrodes that make them suitable for this investigation. (1)

The ammeter readings taken for each acid are given in the table below.

FORMULA OF ACID	AMMETER READING (mA)
CH_3COOH	500
H_2CO_3	133

7.1.3 Which ACID (CH_3COOH or H_2CO_3) is stronger?

Explain the answer. (3)

H_2CO_3 undergoes ionisation in a TWO step process as shown below:

I $H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+$

II $HCO_3^- + H_2O \rightleftharpoons \mathbf{X} + H_3O^+$

Write down the formula of the substance(s) that:

7.1.4 Are bases in reaction **I** (2)

7.1.5 Is represented by **X** in reaction **II** (1)

7.2 Ammonium chloride ($NH_4C\ell$) undergoes hydrolysis.

7.2.1 Define *hydrolysis.* (2)

7.2.2 Is a solution of ammonium chloride ACIDIC, ALKALINE or NEUTRAL?

Explain the answer with the aid of a balanced equation. (4)

7.3 A school laboratory has a hydrochloric acid ($HC\ell$) solution of concentration 1 $mol \cdot dm^{-3}$.

7.3.1 Calculate the pH of the $HC\ell$ solution. (3)

250 cm^3 of the $HC\ell$ solution is used to dissolve an eggshell.

7.3.2 Calculate the number of moles of $HC\ell$ in 250 cm^3 of solution (3)

The eggshell contains 99,3% calcium carbonate ($CaCO_3$) by mass. The calcium carbonate ($CaCO_3$) in the eggshell reacts with EXCESS $HC\ell$ according to the balanced equation below:

$$CaCO_3\,(s) + 2\,HC\ell\,(aq) \longrightarrow CaC\ell_2\,(aq) + H_2O\,(\ell) + CO_2\,(g)$$

The unreacted $HC\ell$ is neutralised by 103 cm^3 of a solution of sodium hydroxide (NaOH) of concentration 0,5 $mol \cdot dm^{-3}$ according to the balanced equation:

$$NaOH\,(aq) + HC\ell\,(aq) \longrightarrow NaC\ell\,(aq) + H_2O\,(\ell)$$

7.3.3 Calculate the mass of the eggshell. (8)

[29]

TOTAL: 150

NATIONAL SENIOR CERTIFICATE
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DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESE KONSTANTES

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume teen STD*	V_m	$22{,}4\ dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron Lading op elektron	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant Avogadro se konstante	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$ or/*of* $n = \frac{N}{N_A}$ or/*of* $n = \frac{V}{V_o}$	$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$ $\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$ $K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/by 298 K

TABLE 3: THE PERIODIC TABLE OF ELEMENTS/*TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE*

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
2,1 1 H 1																	2 He 4
1,0 3 Li 7	1,5 4 Be 9											2.0 5 B 11	2.5 6 C 12	3.0 7 N 14	3.5 8 O 16	4.0 9 F 19	10 Ne 20
0,9 11 Na 23	1,2 12 Mg 24											1.5 13 Aℓ 27	1.8 14 Si 28	2.1 15 P 31	2.5 16 S 32	3.0 17 Cℓ 35,5	18 Ar 40
0,8 19 K 39	1,0 20 Ca 40	1,3 21 Sc 45	1.5 22 Ti 48	1.6 23 V 51	1,6 24 Cr 52	1.5 25 Mn 55	1.8 26 Fe 56	1.8 27 Co 59	1.8 28 Ni 59	1.9 29 Cu 63,5	1.6 30 Zn 65	1.6 31 Ga 70	1.8 32 Ge 73	2.0 33 As 75	2,4 34 Se 79	2.8 35 Br 80	36 Kr 84
0,8 37 Rb 86	1,0 38 Sr 88	1,2 39 Y 89	1,4 40 Zr 91	41 Nb 92	1,8 42 Mo 96	1.9 43 Tc	2.2 44 Ru 101	2.2 45 Rh 103	2.2 46 Pd 106	1.9 47 Ag 108	1.7 48 Cd 112	1.7 49 In 115	1.8 50 Sn 119	1.9 51 Sb 122	2.1 52 Te 128	2.5 53 I 127	54 Xe 131
0,7 55 Cs 133	0,9 56 Ba 137	57 La 139	1,6 72 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	1.8 81 Tℓ 204	1.8 82 Pb 207	1.9 83 Bi 209	2.0 84 Po	2.5 85 At	86 Rn
0,7 87 Fr	0,9 88 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

KEY/ *SLEUTEL*

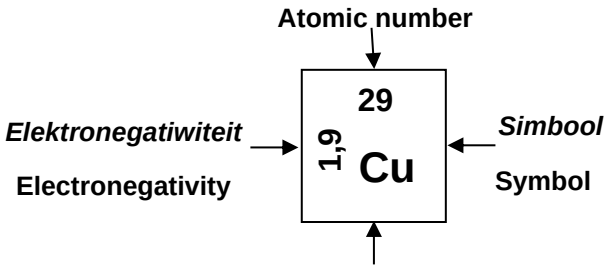

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^{θ} **(V)**
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$Na^+ + e^-$	⇌	Na	– 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	– 2,93
$Li^+ + e^-$	⇌	Li	– 3,05

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TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,05
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,93
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	– 2,92
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	– 2,89
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,36
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,91
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	– 0,74
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	– 0,44
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	– 0,41
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	– 0,40
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	– 0,28
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	– 0,27
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	– 0,06
$2H^+ + 2e^-$	**$\rightleftharpoons$**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

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