



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA



SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2022

MARKS: 150
TIME: 3 hours



This question paper consists of 16 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of NINE 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 subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your FINAL numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, etc. where required.
11. You are advised to use the attached DATA SHEETS.
12. Write neatly and legibly.



QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

1.1 Which ONE of the following compounds has the LOWEST melting point?

A Hexane

B Ethane

C Butane

D Octane

(2)

1.2 When $\text{CH}_2 = \text{CH}_2$ is converted to CH_3CH_3 , the type of reaction is ...

A hydration.

B hydrolysis.

C halogenation.

D hydrogenation.

(2)

1.3 Which ONE of the following compounds in solution will change the colour of bromothymol blue?

A $\text{CH}_3\text{CH}_2\text{CHO}$

B $\text{CH}_3\text{CH}_2\text{COOH}$

C $\text{CH}_3\text{CH}_2\text{COCH}_3$

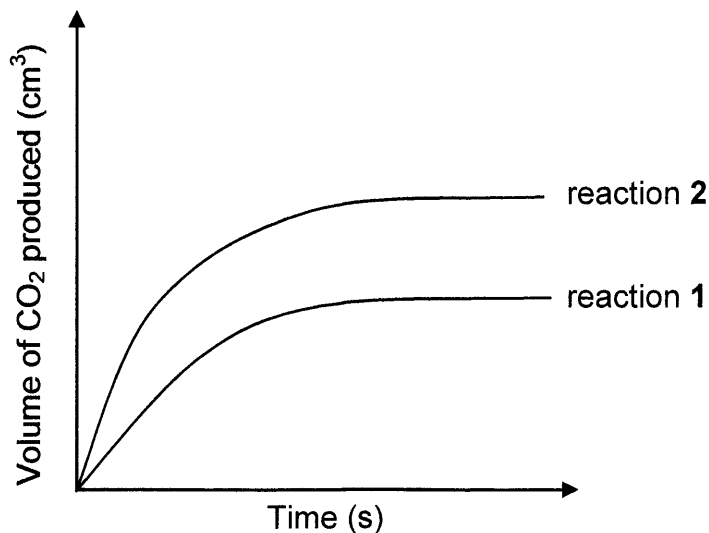
D $\text{CH}_3\text{CH}_2\text{COOCH}_3$

(2)



- 1.4 Two DIFFERENT samples of IMPURE CaCO_3 of EQUAL masses react with $0,1 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_2\text{SO}_4$. Assume that the impurities do not react.

The graph below shows the volume of $\text{CO}_2(\text{g})$ produced for each reaction.



When compared to reaction 2, which ONE of the following statements BEST explains the curve obtained for reaction 1?

- A The temperature is higher in reaction 1.
- B The surface area is greater in reaction 2.
- C The amount of impurities is greater in reaction 2.
- D The amount of impurities is greater in reaction 1. (2)

- 1.5 The equation below represents a hypothetical reaction.



The activation energy for the REVERSE reaction is $110 \text{ kJ} \cdot \text{mol}^{-1}$.

Which ONE of the following is the activation energy (in $\text{kJ} \cdot \text{mol}^{-1}$) for the FORWARD reaction?

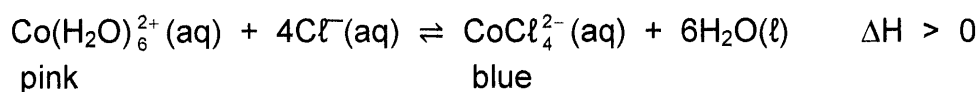
- A 50
- B 60
- C 110
- D 160



(2)



- 1.6 A reaction reaches equilibrium at 25 °C in a flask according to the following balanced equation:



Which ONE of the following will change the colour of the mixture from pink to blue?

- A Adding water
- B Cooling the flask
- C Adding NaOH(aq)
- D Adding $\text{NH}_4\text{Cl}(\text{aq})$ (2)

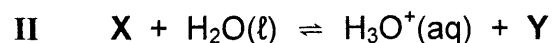
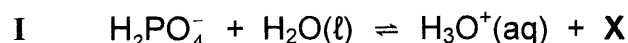
- 1.7 Dilute nitric acid is added to distilled water at 25 °C.

How will this affect the hydronium ion concentration $[\text{H}_3\text{O}^+]$ and the ionisation constant (K_w) of water at 25 °C?

	$[\text{H}_3\text{O}^+]$	K_w
A	Increases	Increases
B	Increases	Decreases
C	Increases	Remains the same
D	Remains the same	Remains the same

(2)

- 1.8 Consider the ionisation reactions I and II.



Which ONE of the following combinations represents the formulae of X and Y respectively?

	X	Y
A	HPO_4^{2-}	PO_4^{3-}
B	HPO_4^{2-}	H_3PO_4
C	H_3PO_4	PO_4^{3-}
D	HPO_4^{2-}	H_2PO_4^-

(2)



- 1.9 An electrochemical cell was set up using a $\text{Hg}(\ell)|\text{Hg}^{2+}(\text{aq})$ half-cell and another half-cell under standard conditions.

Which ONE of the following half-cells, when connected to the $\text{Hg}(\ell)|\text{Hg}^{2+}(\text{aq})$ half-cell, will result in the HIGHEST cell potential?

- A $\text{Al}(\text{s})|\text{Al}^{3+}(\text{aq})$
- B $\text{Zn}(\text{s})|\text{Zn}^{2+}(\text{aq})$
- C $\text{Co}(\text{s})|\text{Co}^{2+}(\text{aq})$
- D $\text{Pt}(\text{s})|\text{H}_2(\text{g})|\text{H}^+(\text{aq})$ (2)

- 1.10 The following reaction takes place in an electrochemical cell:



Which ONE of the following is CORRECT for this cell?

- A It is a galvanic cell.
- B A power source is needed.
- C The reaction is spontaneous.
- D Copper acts as the oxidising agent. (2)

[20]



QUESTION 2 (Start on a new page.)

The letters **A** to **H** in the table below represent eight organic compounds.

A	$\begin{array}{ccccccc} & \text{Br} & & \text{CH}_3 & & & \\ & & & & & & \\ \text{CH}_3 & - \text{C} & - \text{CH}_2 & - \text{CH} & - \text{CH} & - \text{CH}_3 \\ & & & & & & \\ & \text{CH}_3 & & \text{CH}_3 & & & \end{array}$	B	$\begin{array}{ccccccc} & \text{H} & & & & \text{H} & \\ & & & & & & \\ \text{H} & - \text{C} & - & \text{C} = & \text{C} & - \text{C} & - \text{H} \\ & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & \end{array}$
C	Pent-2-ene	D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
E	Butan-2-one	F	4,4-dimethylpent-2-yne
G	Butane	H	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$

- 2.1 Write down the LETTER that represents a compound that:
- Is a ketone (1)
 - Has the general formula $\text{C}_n\text{H}_{2n-2}$ (1)
 - Is an isomer of 2-methylbut-2-ene (1)
 - Has the same molecular formula as ethyl ethanoate (1)
- 2.2 Write down the:
- IUPAC name of compound **A** (3)
 - STRUCTURAL FORMULA of compound **F** (3)
- 2.3 For compound **D**, write down the:
- Homologous series to which it belongs (1)
 - NAME of its functional group (1)
 - STRUCTURAL FORMULA of its functional isomer (2)
- 2.4 For compound **G**, write down:
- The IUPAC name of a chain isomer (2)
 - A balanced equation, using molecular formulae, for its complete combustion (3)

[19]

QUESTION 3 (Start on a new page.)

Learners investigate factors that influence the boiling points of organic compounds. The boiling points of some organic compounds obtained are shown in the table below.

COMPOUND		MOLECULAR MASS (g·mol ⁻¹)	BOILING POINT (°C)
A	Propane	44	- 42
B	Butane	58	- 0,5
C	Pentane	72	36
D	Methylbutane	72	28
E	Ethanol	46	78
F	Ethanal	44	20

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

3.2 The boiling points of compounds **A**, **B** and **C** are compared.

3.2.1 How do the boiling points vary from compound **A** to compound **C**?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

3.2.2 Explain the answer to QUESTION 3.2.1. (3)

3.3 The boiling points of compounds **B**, **C** and **D** are compared.

Is this a fair comparison?

Choose from YES or NO. Give a reason for the answer. (2)

3.4 The boiling points of compounds **E** and **F** are compared.

3.4.1 State the independent variable for this comparison. (1)

3.4.2 Write down the name of the strongest Van der Waals force present in compound **F**. (1)

3.5 Which compound, **D** or **E**, has a higher vapour pressure? Give a reason for the answer. (2)

[12]



QUESTION 4 (Start on a new page.)

4.1 Study the following incomplete equations for organic reactions **I** and **II**.

Compounds **P** and **Q** are ORGANIC compounds and **T** is an INORGANIC compound.

I	$ \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{CHCHCH}_3 \\ \\ \text{Br} \end{array} + \text{NaOH (conc.)} \longrightarrow \text{P} + \text{NaBr} + \text{T} $ <p style="text-align: center;">(major product)</p>
II	$\text{CH}_3\text{COOH} + \text{compound Q} \rightarrow \text{butyl ethanoate} + \text{H}_2\text{O}$

For reaction **I**, write down the:

4.1.1 Type of reaction that takes place (1)

4.1.2 IUPAC name of compound **P** (2)

4.1.3 NAME or FORMULA of compound **T** (1)

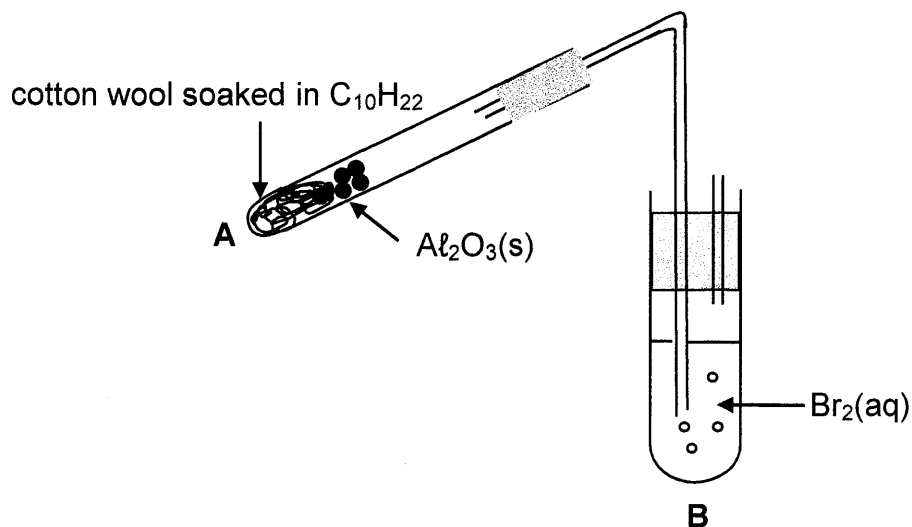
For reaction **II**, write down:

4.1.4 TWO reaction conditions needed (2)

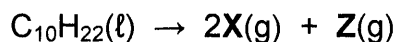
4.1.5 The STRUCTURAL FORMULA of compound **Q** (2)



- 4.2 The cracking of a long chain hydrocarbon, $C_{10}H_{22}$, takes place in test tube **A**, as shown below.



Two STRAIGHT CHAIN organic compounds, **X** and **Z**, are produced in test tube **A** according to the following balanced equation:



- 4.2.1 State the function of the $Al_2O_3(s)$ in test tube **A**. (1)

The organic compounds, **X** and **Z**, are now passed through bromine water, $Br_2(aq)$, at room temperature in test tube **B**. Only compound **X** reacts with the bromine water.

- 4.2.2 Apart from gas bubbles being formed, state another observable change in test tube **B**. (1)

- 4.2.3 Write down the TYPE of reaction that takes place in test tube **B**. (1)

- 4.2.4 Write down the molecular formula of compound **Z**. (3)

- 4.2.5 Write down the STRUCTURAL FORMULA of compound **X**. (3)

[17]



QUESTION 5 (Start on a new page.)

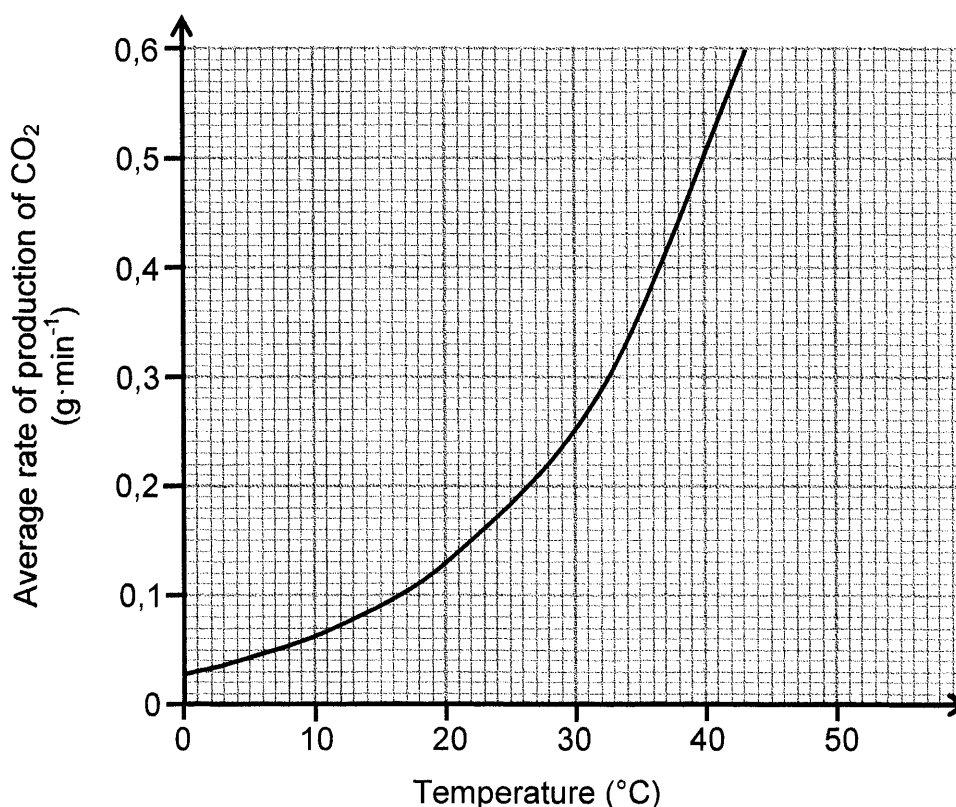
Learners use the reaction of $\text{MgCO}_3(\text{s})$ with EXCESS dilute $\text{HCl}(\text{aq})$ to investigate the relationship between temperature and the rate of a chemical reaction.

The balanced equation for the reaction is:



The results obtained are represented in the graph below.

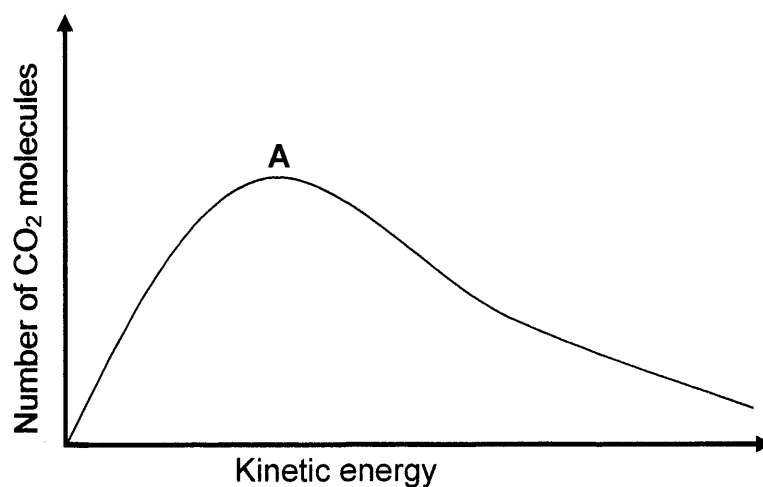
Graph of average rate of production of CO_2 (in $\text{g} \cdot \text{min}^{-1}$) versus temperature



- 5.1 Define the term *rate of reaction*. (2)
- 5.2 State TWO conditions that must be kept constant during this investigation. (2)
- 5.3 Use the collision theory to explain the relationship shown in the graph. (4)
- 5.4 The learners obtained the graph above using 5 g $\text{MgCO}_3(\text{s})$ with EXCESS HCl at 40°C .
Calculate the:
- 5.4.1 Time taken for the reaction to run to completion (6)
- 5.4.2 Molar gas volume at 40°C if $1,5 \text{ dm}^3 \text{ CO}_2$ is collected in a syringe (2)



- 5.5 The graph below represents the Maxwell-Boltzmann distribution curve for $\text{CO}_2(\text{g})$ at 40°C .



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

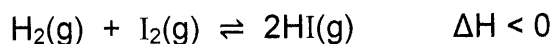
On the same set of axes, sketch the curve that will be obtained for the $\text{CO}_2(\text{g})$ at 20°C . Label this curve as **B**.

(2)
[18]

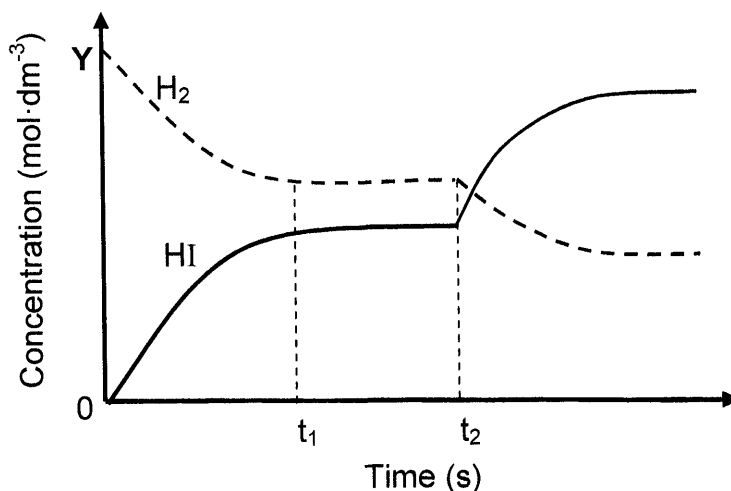


QUESTION 6 (Start on a new page.)

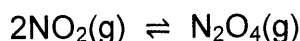
- 6.1 Initially, 4 moles $\text{H}_2(\text{g})$ and 4 moles $\text{I}_2(\text{g})$ are allowed to react in a sealed 2 dm^3 flask according to the following balanced equation:



The graph below shows the concentrations of $\text{H}_2(\text{g})$ and $\text{HI}(\text{g})$ versus time during the reaction.



- 6.1.1 Write down the value of Y. (1)
- 6.1.2 State Le Chatelier's principle. (2)
- 6.1.3 Changes were made to the temperature of the flask at time t_2 .
Was the flask HEATED or COOLED? (1)
- 6.1.4 Fully explain the answer to QUESTION 6.1.3. (3)
- 6.2 The equation below represents the reversible reaction that takes place when $\text{NO}_2(\text{g})$ is converted to $\text{N}_2\text{O}_4(\text{g})$.



Initially, x mol of $\text{NO}_2(\text{g})$ is sealed in a 1 dm^3 container at 350 K. When equilibrium is established at this temperature, 0,81 mol $\text{N}_2\text{O}_4(\text{g})$ is present in the container.

- 6.2.1 Write down the meaning of the term *reversible reaction*. (1)
- 6.2.2 Show that the equilibrium constant for this reaction is given by

$$\frac{0,81}{(x - 1,62)^2}$$
 (5)
- 0,79 moles of $\text{N}_2\text{O}_4(\text{g})$ is now added to the equilibrium mixture above. When the NEW equilibrium is established at 350 K, it is found that the amount of $\text{NO}_2(\text{g})$ increased by 1,2 moles.
- 6.2.3 Calculate the value of x . (6)

[19]

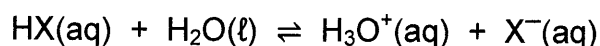
QUESTION 7 (Start on a new page.)

- 7.1 Two acids, HX and HY, of EQUAL CONCENTRATIONS are compared. The pH of HX is 2,7 and the pH of HY is 0,7.

7.1.1 Define an *acid* in terms of the Lowry-Brønsted theory. (2)

7.1.2 Which acid, HX or HY, is STRONGER? Give a reason for the answer. (2)

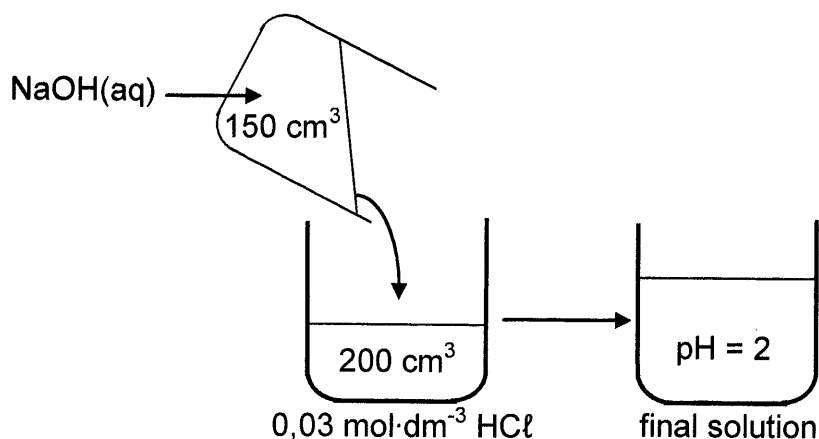
7.1.3 Acid HX ionises in water according to the following equation:



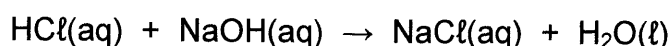
The K_a value for the reaction is $1,8 \times 10^{-5}$ at 25 °C.

Is the concentration of the hydronium ions HIGHER THAN, LOWER THAN or EQUAL TO the concentration of HX? Give a reason for the answer. (2)

- 7.2 Learners add 150 cm³ of a sodium hydroxide solution, NaOH, of unknown concentration to 200 cm³ of a 0,03 mol·dm⁻³ hydrochloric acid solution, HCl, as illustrated below. They find that the pH of the final solution is 2. Assume that the volumes are additive.



The balanced equation for the reaction is:



Calculate the:

7.2.1 Concentration of the H₃O⁺ ions in the final solution (3)

7.2.2 Initial concentration of the NaOH(aq) (7)

[16]



QUESTION 8 (Start on a new page.)

8.1 An electrochemical cell is set up using an aluminium rod, Al, and a gas X.

The initial emf measured under standard conditions is 2,89 V.

8.1.1 State the standard conditions under which this cell operates. (3)

8.1.2 Use a calculation to identify gas X. (5)

8.1.3 Write down the FORMULA of the reducing agent in this cell. (1)

8.1.4 Write down the half-reaction that takes place at the cathode. (2)

8.1.5 Write down the cell notation for this cell. (3)

8.2 Which container, ZINC or COPPER, will be more suitable to store an aqueous solution of nickel ions, Ni^{2+} ?

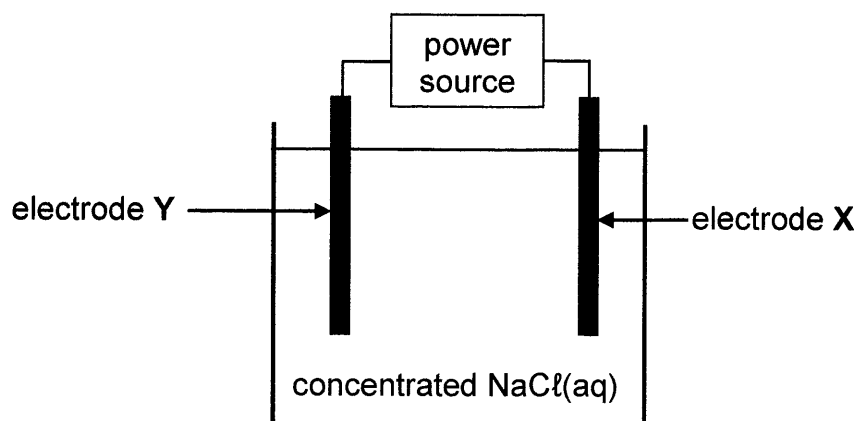
Refer to the Table of Standard Reduction Potentials to fully explain the answer in terms of the relative strengths of reducing agents.

(4)
[18]



QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrochemical cell used for the electrolysis of a concentrated sodium chloride solution, NaCl(aq) . **X** and **Y** are carbon electrodes.



9.1 Define the term *electrolysis*. (2)

9.2 Chlorine gas, $\text{Cl}_2(\text{g})$, is released at electrode **X**.

Write down the:

9.2.1 Letter (**X** or **Y**) of the electrode where oxidation takes place (1)

9.2.2 Half-reaction that takes place at electrode **Y** (2)

9.2.3 Direction in which electrons flow in the external circuit

Choose from **X** to **Y** OR **Y** to **X**. (1)

9.2.4 Balanced equation for the net (overall) cell reaction that takes place in the cell (3)

9.3 How will the pH of the electrolyte change during the reaction?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

9.4 Give a reason for the answer to QUESTION 9.3. (1)

[11]

TOTAL: 150



DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESTE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESTE KONSTANTES

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

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ at/by } 298 \text{ K}$	
$E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta} / E_{\text{sel}}^{\theta} = E_{\text{katode}}^{\theta} - E_{\text{anode}}^{\theta}$ or/of $E_{\text{cell}}^{\theta} = E_{\text{reduction}}^{\theta} - E_{\text{oxidation}}^{\theta} / E_{\text{sel}}^{\theta} = E_{\text{reduksie}}^{\theta} - E_{\text{oksidasie}}^{\theta}$ or/of $E_{\text{cell}}^{\theta} = E_{\text{oxidising agent}}^{\theta} - E_{\text{reducing agent}}^{\theta} / E_{\text{sel}}^{\theta} = E_{\text{oksideermiddel}}^{\theta} - E_{\text{reduseermiddel}}^{\theta}$	
$n = \frac{Q}{e}$ or/of $n = \frac{Q}{q_e}$	



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

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
(I)	(II)											(III)	(IV)	(V)	(VI)	(VII)	(VIII)
1 1 H																	2 He
3 7 Li	4 9 Be															9 19 F	10 20 Ne
11 23 Na	12 24 Mg															17 35,5 Cl	18 40 Ar
19 39 K	20 40 Ca	21 45 Sc	22 48 Ti	23 51 V	24 52 Cr	25 55 Mn	26 56 Fe	27 59 Co	28 59 Ni	29 63,5 Cu	30 65 Zn	31 70 Ga	32 73 Ge	33 75 As	34 79 Se	35 80 Br	36 84 Kr
37 86 Rb	38 88 Sr	39 89 Y	40 91 Zr	41 92 Nb	42 96 Mo	43 96 Tc	44 101 Ru	45 103 Rh	46 106 Pd	47 108 Ag	48 112 Cd	49 115 In	50 119 Sn	51 122 Sb	52 128 Te	53 127 I	54 131 Xe
55 133 Cs	56 137 Ba	57 139 La	72 179 Hf	73 181 Ta	74 184 W	75 186 Re	76 190 Os	77 192 Ir	78 195 Pt	79 197 Au	80 201 Hg	81 204 Tl	82 207 Pb	83 209 Bi	84 209 Po	85 209 At	86 210 Rn
87 226 Fr	88 226 Ra	89 226 Ac															
				58 140 Ce	59 141 Pr	60 144 Nd	61 144 Pm	62 150 Sm	63 152 Eu	64 157 Gd	65 159 Tb	66 163 Dy	67 165 Ho	68 167 Er	69 169 Tm	70 173 Yb	71 175 Lu
				90 232 Th	91 232 Pa	92 238 U	93 238 Np	94 238 Pu	95 238 Am	96 238 Cm	97 238 Bk	98 238 Cf	99 238 Es	100 238 Fm	101 238 Md	102 238 No	103 238 Lr

KEYISLEUTEL

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

Symbol
Simbool

29
Cu
63,5

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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

Half-reactions/Halfreaksies	E^{θ} (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 2,87
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+ 1,81
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+ 1,20
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(l)$	+ 0,85
$Ag^+ + e^- \rightleftharpoons Ag$	+ 0,80
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+ 0,77
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+ 0,68
$I_2 + 2e^- \rightleftharpoons 2I^-$	+ 0,54
$Cu^+ + e^- \rightleftharpoons Cu$	+ 0,52
$SO_2 + 4H^+ + 4e^- \rightleftharpoons S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^-$	+ 0,40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+ 0,16
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+ 0,15
$S + 2H^+ + 2e^- \rightleftharpoons H_2S(g)$	+ 0,14
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	0,00
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	- 0,06
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	- 0,13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	- 0,14
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	- 0,27
$Co^{2+} + 2e^- \rightleftharpoons Co$	- 0,28
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	- 0,40
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	- 0,41
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	- 0,44
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	- 0,74
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	- 0,76
$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$	- 0,83
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	- 0,91
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	- 1,18
$Al^{3+} + 3e^- \rightleftharpoons Al$	- 1,66
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	- 2,36
$Na^+ + e^- \rightleftharpoons Na$	- 2,71
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	- 2,87
$Sr^{2+} + 2e^- \rightleftharpoons Sr$	- 2,89
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	- 2,90
$Cs^+ + e^- \rightleftharpoons Cs$	- 2,92
$K^+ + e^- \rightleftharpoons K$	- 2,93
$Li^+ + e^- \rightleftharpoons Li$	- 3,05

Increasing strength of oxidising agents/Toenemende sterkte van oksideermiddels

Increasing strength of reducing agents/Toenemende sterkte van reduseermiddels

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

Increasing strength of oxidising agents/Toenemende sterkte van oksideermiddels

Half-reactions/Halfreaksies	E^{θ} (V)
$\text{Li}^{+} + \text{e}^{-} \rightleftharpoons \text{Li}$	- 3,05
$\text{K}^{+} + \text{e}^{-} \rightleftharpoons \text{K}$	- 2,93
$\text{Cs}^{+} + \text{e}^{-} \rightleftharpoons \text{Cs}$	- 2,92
$\text{Ba}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ba}$	- 2,90
$\text{Sr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Sr}$	- 2,89
$\text{Ca}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ca}$	- 2,87
$\text{Na}^{+} + \text{e}^{-} \rightleftharpoons \text{Na}$	- 2,71
$\text{Mg}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Mg}$	- 2,36
$\text{Al}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Al}$	- 1,66
$\text{Mn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Mn}$	- 1,18
$\text{Cr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cr}$	- 0,91
$2\text{H}_2\text{O} + 2\text{e}^{-} \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^{-}$	- 0,83
$\text{Zn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Zn}$	- 0,76
$\text{Cr}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Cr}$	- 0,74
$\text{Fe}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Fe}$	- 0,44
$\text{Cr}^{3+} + \text{e}^{-} \rightleftharpoons \text{Cr}^{2+}$	- 0,41
$\text{Cd}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cd}$	- 0,40
$\text{Co}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Co}$	- 0,28
$\text{Ni}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ni}$	- 0,27
$\text{Sn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Sn}$	- 0,14
$\text{Pb}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Pb}$	- 0,13
$\text{Fe}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Fe}$	- 0,06
$2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2\text{S}(\text{g})$	+ 0,14
$\text{Sn}^{4+} + 2\text{e}^{-} \rightleftharpoons \text{Sn}^{2+}$	+ 0,15
$\text{Cu}^{2+} + \text{e}^{-} \rightleftharpoons \text{Cu}^{+}$	+ 0,16
$\text{SO}_4^{2-} + 4\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+ 0,17
$\text{Cu}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cu}$	+ 0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^{-} \rightleftharpoons 4\text{OH}^{-}$	+ 0,40
$\text{SO}_2 + 4\text{H}^{+} + 4\text{e}^{-} \rightleftharpoons \text{S} + 2\text{H}_2\text{O}$	+ 0,45
$\text{Cu}^{+} + \text{e}^{-} \rightleftharpoons \text{Cu}$	+ 0,52
$\text{I}_2 + 2\text{e}^{-} \rightleftharpoons 2\text{I}^{-}$	+ 0,54
$\text{O}_2(\text{g}) + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2\text{O}_2$	+ 0,68
$\text{Fe}^{3+} + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}$	+ 0,77
$\text{NO}_3^{-} + 2\text{H}^{+} + \text{e}^{-} \rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+ 0,80
$\text{Ag}^{+} + \text{e}^{-} \rightleftharpoons \text{Ag}$	+ 0,80
$\text{Hg}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Hg}(\ell)$	+ 0,85
$\text{NO}_3^{-} + 4\text{H}^{+} + 3\text{e}^{-} \rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+ 0,96
$\text{Br}_2(\ell) + 2\text{e}^{-} \rightleftharpoons 2\text{Br}^{-}$	+ 1,07
$\text{Pt}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Pt}$	+ 1,20
$\text{MnO}_2 + 4\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+ 1,23
$\text{O}_2(\text{g}) + 4\text{H}^{+} + 4\text{e}^{-} \rightleftharpoons 2\text{H}_2\text{O}$	+ 1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^{+} + 6\text{e}^{-} \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+ 1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^{-} \rightleftharpoons 2\text{Cl}^{-}$	+ 1,36
$\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{e}^{-} \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+ 1,51
$\text{H}_2\text{O}_2 + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons 2\text{H}_2\text{O}$	+ 1,77
$\text{Co}^{3+} + \text{e}^{-} \rightleftharpoons \text{Co}^{2+}$	+ 1,81
$\text{F}_2(\text{g}) + 2\text{e}^{-} \rightleftharpoons 2\text{F}^{-}$	+ 2,87

Increasing strength of reducing agents/Toenemende sterkte van reduceermiddels