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**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

JUNE 2022

PHYSICAL SCIENCES: CHEMISTRY P2

MARKS: 150

TIME: 3 hours

This question paper consists of 20 pages, including 2 data sheets.

INSTRUCTIONS AND INFORMATION

1.   Write your name and surname in the appropriate spaces 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-QUESTIONS

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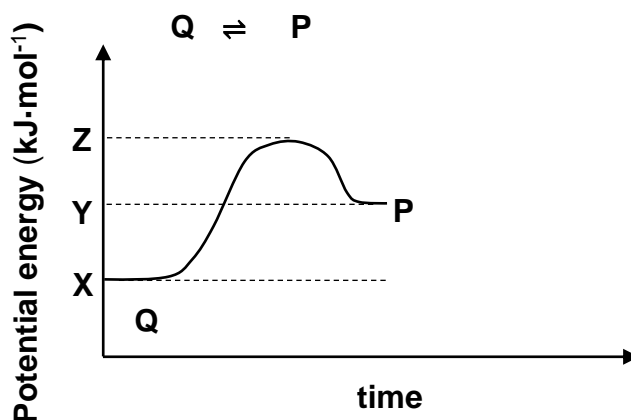
1.1 Which ONE of the following is the general formula of alkenes?

    A C_nH_{2n}

    B C_2H_{2n+2}

    C C_nH_{2n-2}

    D C_nH_{2n+1} (2)

1.2 When the carbonyl group is located at the end of an organic molecule, to which ONE of the given homologous series does the molecule belong?

    A   Alcohol

    B   Aldehyde

    C   Ketone

    D   Haloalkane   (2)

1.3 Which ONE of the following compounds has the HIGHEST boiling point?

    A   Octane

    B   2-methylheptane

    C   2,3-dimethylhexane

    D   2,2,3-trimethylpentane   (2)

1.4 Which ONE of the following changes will INCREASE the average kinetic energy of particles?

    A   Catalyst

    B   Decrease in temperature

    C   Increase in temperature

    D   Increase in surface area   (2)

1.5 Consider the organic reaction below in which compound **P** is the MAJOR organic product.

$$CH_3CH(CH_3)CH_2CH = CH_2 + H_2O \rightarrow \text{compound } \mathbf{P}$$

The correct IUPAC name of the major organic product **P** is …

A   4-methylpentan-1-ol.

B   4-methylpentan-2-ol.

C   2-methylpentan-1-ol.

D   2-methylpentan-2-ol. (2)

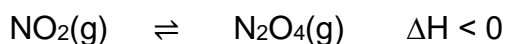1.6 Consider the potential energy diagram for the following hypothetical reversible reaction.

Which ONE of the following is the CORRECT interpretation of the information displayed in the graph?

	ΔH forward reaction	ΔH reverse reaction
A	Y – Z	Z – Y
B	Z – Y	Y – Z
C	X – Y	Y – X
D	Y – X	X – Y

(2)

1.7 Consider the following reaction at equilibrium at temperature **T**.

$$NO_2(g) \quad \rightleftharpoons \quad N_2O_4(g) \quad \quad \Delta H < 0$$

The temperature of the reaction mixture is increased.

Which ONE of the following is CORRECT about the RATE OF THE FORWARD REACTION and the YIELD of N_2O_4 immediately after the temperature is increased?

	Rate of the forward reaction	Yield of N_2O_4
A	Decreases	Increases
B	Increases	Decreases
C	Increases	Increases
D	Decreases	Decreases

(2)

1.8 Which ONE of the following graphs CORRECTLY describe the relationship between the $[H_3O^+]$ and pH?

(2)
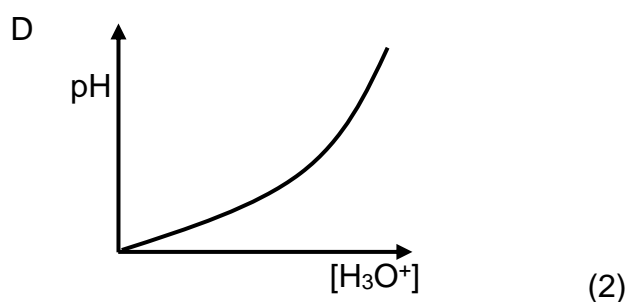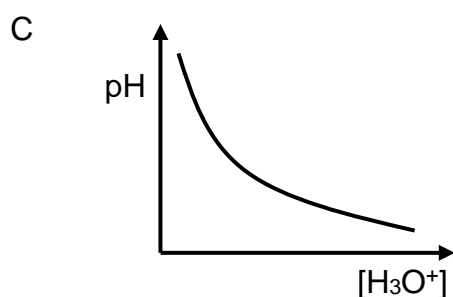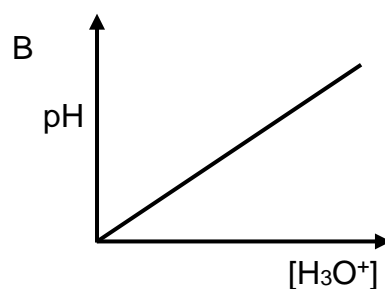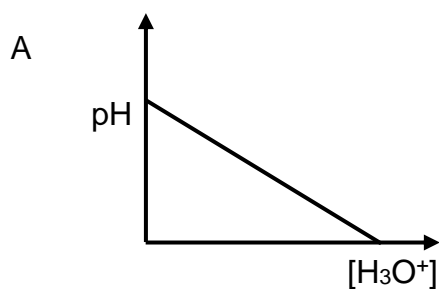
1.9   Consider the acid-base reaction below.

$$H_2PO_4^- \; + \; OH^- \; \rightleftharpoons \; H_2O \; + \; \mathbf{Q}$$
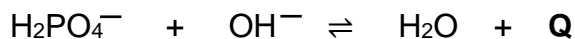
The correct formula for substance **Q** is …

A H_3PO_4.

B HPO_4^{2-}.
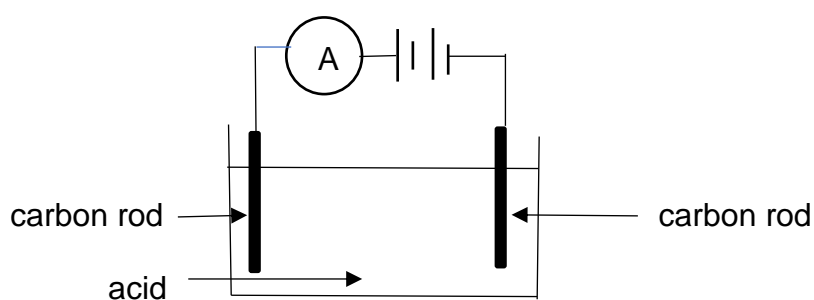
C PO_4^{3-}.

D H_3O^+.   (2)

1.10   The following circuit is used to test the conductivity of acids, HA and HB, at 25 $^\circ$C. Both acids have a concentration of 1 mol·dm^{-3}.

The learners' results are shown in the table below.

ACID	AMMETER READING (A)
HA	0,8
HB	1,5

Learners write the following statements as their conclusions down:

I.   HA is a stronger acid than HB

II.   pH of HB is lower than that of HA

III. K_a value of HB is higher than that of HA

Which ONE of the above statements is/are CORRECT?

A   **I** only

B   **II** only

C   **I** and **II** only

D   **II** and **III** only   (2)
                                                                                          [20]

QUESTION 2 (Start on a new page.)

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

A	$\begin{array}{c} \qquad\qquad\qquad CH_2CH_3 \\ \qquad\qquad\qquad | \\ CH_3CHCH_2 - C \equiv C - CH - CH_2CH_3 \\ \quad | \\ \quad CH_3 \end{array}$	**B**	propan-2-one
C	Bromomethane	**D**	C_4H_8O
E	$C_7H_{15}COOH$	**F**	Hexane

2.1 To which homologous series do the following compounds belong?

    2.1.1 Compound **A** (1)

    2.1.2 Compound **C** (1)

2.2 Write down a LETTER for the compound that meets the following description:

    2.2.1 A carboxylic acid (1)

    2.2.2 A compound whose formula is the same as the empirical formula of compound **E** (1)

2.3 Compound **A** is a hydrocarbon.

    2.3.1 Define the term *hydrocarbon.* (2)

    2.3.2 Is compound **A** SATURATED or UNSATURATED?

        Give a reason for the answer. (2)

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

2.4 Write down the structural formula of compound **B**. (2)

2.5 Compound **D,** a straight chain molecule, has only ONE CHAIN ISOMER.

    For compound **D** write down the:

    2.5.1 IUPAC name (2)

    2.5.2 STRUCTURAL formula of its CHAIN ISOMER (2)

2.6   A group of learners use compound **F** as a fuel by reacting it with excess oxygen.

Write down the:

2.6.1   Name of the reaction between compound **F** and oxygen   (1)

2.6.2   Write down a balanced equation for the reaction of compound **F** with excess oxygen, by using the MOLECULAR FORMULAE   (3)

2.6.3   Give a reason why alkanes are used as fuel   (1)
**[22]**

QUESTION 3 (Start on a new page.)

3.1 A group of learners compare the boiling points of THREE compounds **A**, **B** and **C** during an investigation. The compounds have comparable molecular mass.

The data the learners obtained for the compounds is shown in the table below.

	Compound	Boiling point (°C)
A	Pentane	36,1
B	Butan-2-one	79,64
C	Butan-1-ol	117,7

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

3.1.2 Identify the independent variable for this investigation. (1)

3.1.3 Which intermolecular forces are comparable in this investigation? (1)

3.1.4 Explain why the boiling point of compound **C** is HIGHER than that of compound **B** by referring to TYPE, RELATIVE STRENGTHS of intermolecular forces and ENERGY. (4)

3.2 The graphs below show how the vapour pressure of compounds **A** and **B** (shown in the table above) changes with temperature.

GRAPH OF TEMPERATURE VERSUS VAPOUR PRESSURE
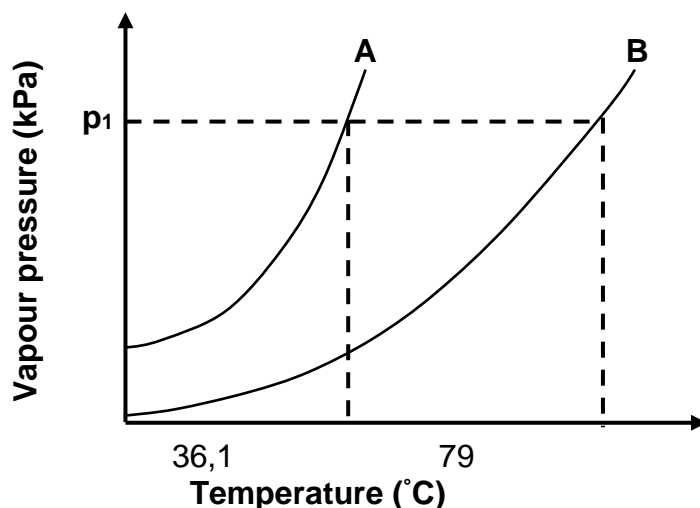
3.2.1 Define the term *vapour pressure.* (2)

3.2.2 Write down the value of p_1 shown in the graph. (1)

3.2.3 In what phase is compound **A** at 50 ˚C?

Explain the answer. (2)

3.2.4 How would the vapour pressure of compound **C** compare, to that of compound **A** at 36,1 ˚C?
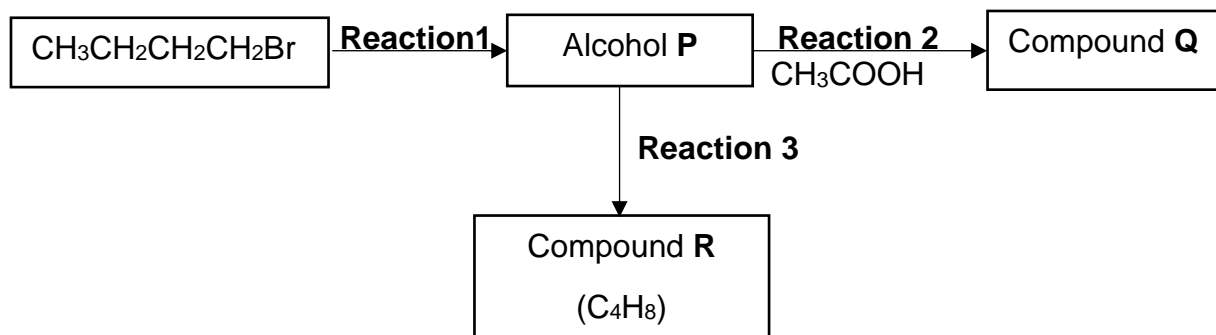
Choose from HIGHER THAN, LOWER THAN or EQUAL TO. (1)

3.2.5 Explain your answer to QUESTION 3.2.4. (2)

[16]

QUESTION 4 (Start on a new page.)

Consider the flow diagram given below. Compounds **P**, **Q** and **R** are organic products of **reactions 1, 2** and **3** respectively.

| $CH_3CH_2CH_2CH_2Br$ | **Reaction1** → | Alcohol **P** | **Reaction 2** → CH_3COOH | Compound **Q** |

Reaction 3 ↓

Compound **R**

(C_4H_8)

For **REACTION 1** write down the:

4.1   Name of the type of reaction taking place   (1)

4.2   Condensed structural formula of compound **P**   (2)

4.3   Is alcohol **P** a primary, secondary, or tertiary alcohol?

      Give a reason for the answer.   (2)

For **REACTION 2** write down the:

4.4   Name of the reaction taking place   (1)

4.5   IUPAC name and structural formula of the organic product **Q**   (4)

4.6   Type of elimination reaction represented by **REACTION 3**   (1)

4.7   ONE reaction condition other than heat for **REACTION 3**   (1)

Compound **R**, C_4H_8, produced in reaction **3** in the flow diagram above is converted to compound **T** in a TWO step process as shown below.

Compounds **R** and **T** are unbranched POSITIONAL isomers.

| R: C_4H_8 | STEP 1
HBr → | Compound **S** | STEP 2 → | Compound **T** |
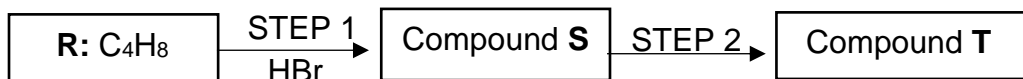
4.8   Define the term *positional isomer.*   (2)
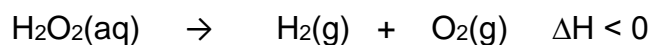
4.9   Write down a balanced equation using structural formulae for the reaction
   taking place in STEP 2.   (6)
                                                                                          [20]

QUESTION 5 (Start on a new page.)

The decomposition of hydrogen peroxide represented by the balanced equation below is used to investigate the factors that influence reaction rate.

$$H_2O_2(aq) \quad \rightarrow \quad H_2(g) \quad + \quad O_2(g) \quad \Delta H < 0$$

5.1 Define *reaction rate.* (2)

5.2 Besides temperature, write down TWO factors that affect the rate of this reaction. (2)

5.3 During an experiment (**experiment 1**),150 cm³ of H_2O_2 decomposes at 30 ˚C in a flask.

The graph below shows the results of **experiment 1**.
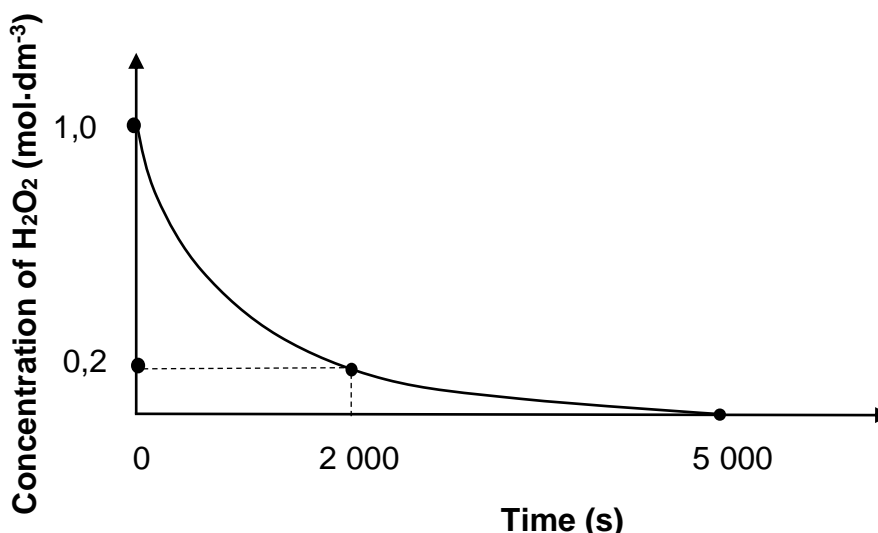
5.3.1 Give a reason why the rate of reaction decreases between
t = 2 000 s and t = 5 000 s. (2)

5.3.2 How long (in seconds) did the reaction take to reach completion? (1)

Calculate the:

5.3.3 Average rate of reaction (3)

5.3.4 Volume of oxygen produced during the interval t = 0 to t = 2 000 s. Assume that the molar gas volume at 30 ˚C is 25 000 cm³·mol⁻¹.

ASSUME THAT THE VOLUME OF THE SOLUTION REMAINS CONSTANT. (5)

5.4 How will the following be affected if the volume of hydrogen peroxide (H_2O_2) used in **experiment 1** is doubled?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

5.4.1 Average rate of reaction (1)

5.4.2 Total volume of oxygen produced (1)

5.5 In **experiment 2** hydrogen peroxide decomposes under the same conditions as in **experiment 1**, but a small amount of manganese dioxide is added.

The Maxwell-Boltzmann distribution curve for the reaction in **experiment 1** and **experiment 2** is shown below.
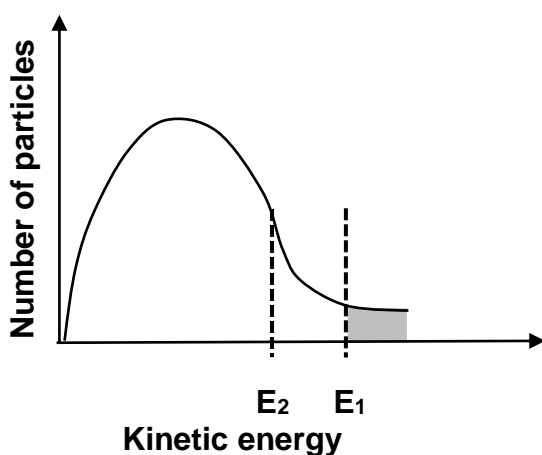
E_1 and E_2 represent activation energies for the reaction in **experiments 1** and **2**.

5.5.1 Define *activation energy.* (2)

5.5.2 Describe what is represented by the shaded area in the graph. (1)

5.5.3 Which ONE of E_1 or E_2 would yield a higher reaction rate? Explain the answer by referring to the collision theory. (4)

[24]

QUESTION 6 (Start on a new page.)

6.1 The following reaction reaches equilibrium at a temperature of 327 °C.

$$N_2(g) + 3 H_2(g) \rightleftharpoons 2 NH_3(g) \qquad \Delta H < 0$$

6.1.1 What is the meaning of the double arrow "$\rightleftharpoons$"? (1)

How does the rate of the forward reaction compare to the rate of the reverse reaction during the following time intervals?

Choose from HIGHER THAN, LOWER THAN or EQUAL TO.

6.1.2 Before equilibrium is reached for the first time (2)

6.1.3 At equilibrium (1)

The reaction is started by placing 4,88 moles of N_2 and 6,18 moles of H_2 in a 2 dm³ sealed container and allowed to react. When equilibrium is established at 327 °C it is found the 41,48 grams of NH_3 is present.

6.2 Calculate the equilibrium constant, Kc, at 327 °C. (8)

6.3 Write down the name of a factor that affects the value of Kc. (1)

6.4 The graph below shows how the percentage yield of NH_3 varies with pressure at different temperature values.
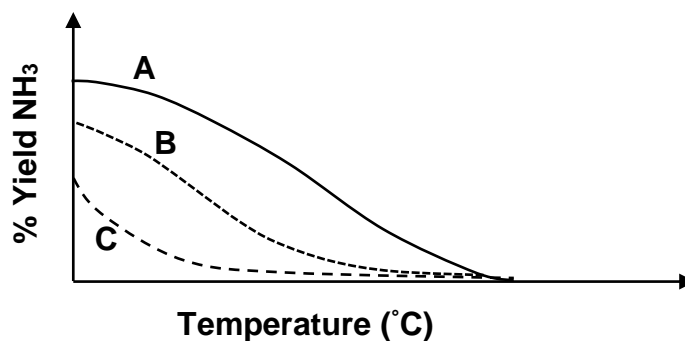
Which graph (**A**, **B** or **C**) represents percentage yield values obtained at the HIGHEST pressure?

Explain the answer by referring to Le Chatelier's principle. (4)

6.5 What effect will the following changes have on the yield of NH_3 at equilibrium?

Choose from INCREASES, DECREASES or NO EFFECT.
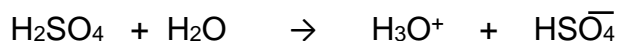
6.5.1 More N_2 is pumped into the container. (1)

6.5.2 A suitable catalyst is added. (1)

6.5.3 The volume of the container is increased at constant temperature. (1)

[20]

QUESTION 7 (Start on a new page.)

7.1 Sulphuric acid, H_2SO_4 ionises according to the balanced equation below:

$$H_2SO_4 + H_2O \rightarrow H_3O^+ + HS\overline{O_4}$$

 7.1.1 Define an *acid* according to the Lowry-Brønsted theory. (2)

 7.1.2 Write down the formulae of the TWO bases in the reaction above. (2)

 7.1.3 Identify a substance in the reaction that can act as an ampholyte in some reactions. (1)

7.2 The table below gives information about solutions of two acids and a salt.

NAME OF SUBSTANCE	FORMULA	Ka value or pH
Ethanoic acid	CH_3COOH	$K_a = 1,8 \times 10^{-4}$ at 25 $^\circ$C
Sulphuric acid	H_2SO_4	pH = 3
Sodium carbonate	Na_2CO_3	pH = 7,8

 7.2.1 Is CH_3COOH a STRONG or a WEAK acid?

 Give a reason for the answer. (2)

 7.2.2 Which acid, CH_3COOH or H_2SO_4, would react faster with Na_2CO_3?

 Assume the acids have the same concentration and are in excess. (1)

 7.2.3 Calculate the concentration of the H_2SO_4 solution. (4)

 7.2.4 Explain by using a relevant equation, why the pH of Na_2CO_3 is greater than 7. (3)

7.3   A standard solution is prepared by dissolving 1,74 g of $Mg(OH)_2$ in water to make 200 cm^3 of the solution.

   7.3.1   Define the term *standard solution.*   (2)

   7.3.2   Show by calculation that the concentration of the $Mg(OH)_2$ solution is 0,15 $mol \cdot dm^{-3}$.   (2)

A group of learners added 50 cm^3 of a **dilute** hydrochloric acid solution to 40 cm^3 of the standard solution of $Mg(OH)_2$.

The balanced equation for the reaction is:

$$Mg(OH)_2 + 2\,HC\ell \rightarrow MgC\ell_2 + 2\,H_2O$$
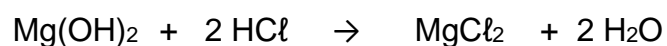
The **diluted** hydrochloric acid solution was obtained by adding 5 cm^3 of 10 $mol \cdot dm^{-3}$ of concentrated hydrochloric acid to water to produce 100 cm^3 of the **diluted** acid solution. ONE of the ions (OH^- or H_3O^+) is found to be in excess at the completion of the reaction.

   7.3.3   Calculate the concentration of the ions in excess.   (9)
                                                                                                      [28]

                                                                      TOTAL: 150

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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 dm³·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

$n = \dfrac{m}{M}$ or/of $n = \dfrac{N}{N_A}$ or/of $n = \dfrac{V}{V_o}$	$c = \dfrac{n}{V}$ or/of $c = \dfrac{m}{MV}$ $\dfrac{c_a V_a}{c_b V_b} = \dfrac{n_a}{n_b}$	pH= -log[H₃O⁺] $K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/by 298 K

$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} \;/\; E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$

$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation} \;/\; E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$

$E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent} \;/\; E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$

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

KEY/ SLEUTEL

Atoomgetal
Atomic number

Elektronegatiwiteit
Electronegativity

29
1,9 **Cu**

Simbool
Symbol

Benaderde relatiewe atoommassa
Approximate relative atomic mass

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