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# **NATIONAL SENIOR CERTIFICATE**

## **GRADE 12**

## **JUNE 2025**

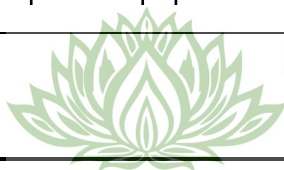
### **PHYSICAL SCIENCES: (CHEMISTRY) P2**

**MARKS:** 150

**TIME:** 3 hours



This question paper consists of 18 pages, including 2 data sheets.



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**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. 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, et cetera where required.
11. You are advised to use the attached DATA SHEETS.
12. Write neatly and legibly.

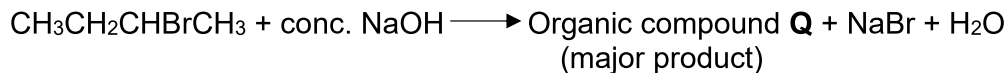


**QUESTION 1: MULTIPLE-CHOICE QUESTIONS**

Various options are provided as possible answers to the following questions. 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 compounds is an alkene?
- A  $\text{C}_3\text{H}_8$
- B  $\text{C}_3\text{H}_6$
- C  $\text{C}_3\text{H}_4$
- D  $\text{C}_3\text{H}_6\text{O}$  (2)
- 1.2 Which ONE of the following is NOT correct about compounds that belong to the same homologous series?
- A Similar chemical properties
- B They have the same general formula
- C They have the same functional group
- D Similar physical properties (2)
- 1.3 Which ONE of the following can form a TERTIARY ALCOHOL?
- A  $\text{CH}_3\text{OH}$
- B  $\text{C}_2\text{H}_5\text{OH}$
- C  $\text{C}_3\text{H}_7\text{OH}$
- D  $\text{C}_4\text{H}_9\text{OH}$  (2)

- 1.4 Consider the reaction below:



Which ONE of the following CORRECTLY gives the type of reaction and the name of organic compound Q?

	TYPE OF REACTION	ORGANIC COMPOUND Q
A	Elimination	But-1-ene
B	Elimination	But-2-ene
C	Addition	But-1-ene
D	Addition	But-2-ene

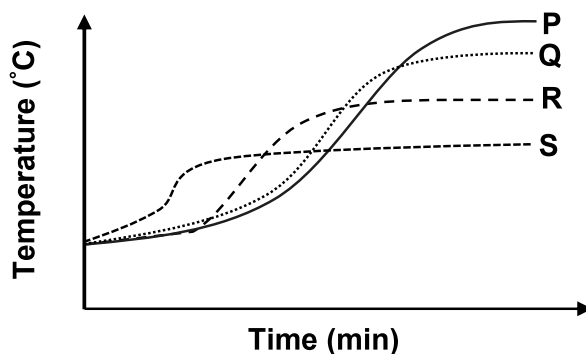
(2)



1.5 Consider the four organic compounds below:

butan-1-ol, propanoic acid, 2-methylpropanal and butanal

The heating curves for the four organic compounds were obtained.



Which curve represents the heating curve of butanal?

A Curve **P**

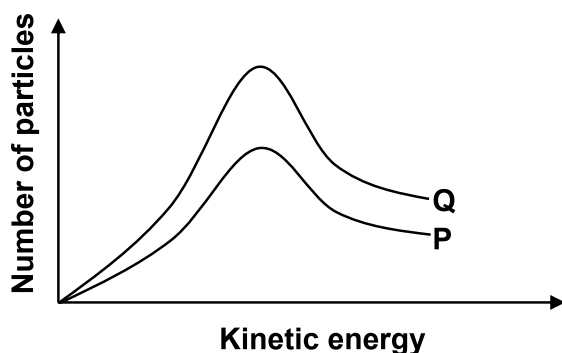
B Curve **Q**

C Curve **R**

D Curve **D**

(2)

1.6 The Maxwell-Boltzmann energy distribution curve **P** for  $\text{CO}_2$  gas under certain conditions. Curve **Q** was obtained after a change was made.



Which ONE of the following represents the change made to obtain curve **Q**?

A Increase in temperature

B Addition of a catalyst

C Increase in concentration

D Increase in surface area of  $\text{CO}_2$

(2)



- 1.7 Consider the following reversible hypothetical reaction:



The heat of reactants ( $H_r$ ) for the forward reaction is  $25 \text{ kJ}\cdot\text{mol}^{-1}$  and activation energies ( $E_a$ ) for the forward reaction and reverse reaction is  $35 \text{ kJ}\cdot\text{mol}^{-1}$  and  $45 \text{ kJ}\cdot\text{mol}^{-1}$  respectively.

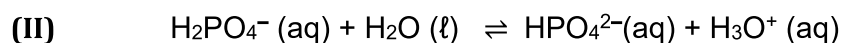
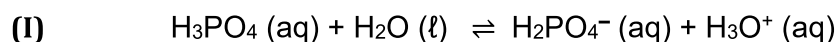
The heat of the products ( $H_p$ ) for the forward reaction is ...

- A  $10 \text{ kJ}\cdot\text{mol}^{-1}$ .
- B  $15 \text{ kJ}\cdot\text{mol}^{-1}$ .
- C  $20 \text{ kJ}\cdot\text{mol}^{-1}$ .
- D  $35 \text{ kJ}\cdot\text{mol}^{-1}$ . (2)

- 1.8 Which ONE of the following acids, with the same concentration, will have the highest conductivity at a given temperature?

- A  $\text{H}_2\text{CO}_3$
- B  $\text{CH}_3\text{COOH}$
- C  $\text{HCl}$
- D  $\text{H}_2\text{SO}_4$  (2)

- 1.9 Consider the two-step ionisation of phosphoric acid:



Consider the following statements regarding the two-step ionisation of  $\text{H}_3\text{PO}_4$ .

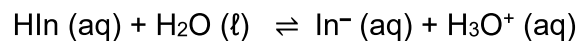
- I**  $\text{H}_2\text{PO}_4^-$  act as an ampholyte
- II**  $\text{HPO}_4^{2-}$  is the conjugate acid of  $\text{H}_2\text{PO}_4^-$
- III**  $\text{H}_2\text{PO}_4^-$  can be considered as a diprotic acid

Which ONE of the above statement(s) is/are TRUE?

- A **I** only
- B **I** and **II** only
- C **I** and **III** only
- D **II** and **III** only (2)



- 1.10 A specific indicator is colourless in an acidic solution and pink in an alkaline solution. The general equation for the indicator is:



The indicator is added to a sodium hydroxide (NaOH) solution.

Which ONE of the following combinations are CORRECT regarding the colour of HIn and In<sup>-</sup> and the shift in the equilibrium position?

	HIn	In <sup>-</sup>	SHIFT IN EQUILIBRIUM POSITION
A	Pink	Colourless	Right
B	Colourless	Pink	Right
C	Pink	Colourless	Left
D	Colourless	Pink	Left

(2)  
[20]



**QUESTION 2 (Start on a new page.)**

The table below shows organic molecules (**A** to **E**) from different homologous series.

<b>A</b>	2-methylpentan-3-one	<b>B</b>	$  \begin{array}{c}  \text{O} \\  \parallel \\  \text{CH}_3\text{CH}-\text{CH}-\text{C}-\text{H} \\    \\  \text{CH}_3  \end{array}  $
<b>C</b>	$\text{CH}_3\text{C}\equiv\text{CCH}(\text{CH}_3)\text{CH}_3$	<b>D</b>	$  \begin{array}{c}  \text{Br} \quad \text{CH}_2\text{CH}_3 \\    \quad   \\  \text{CH}_3\text{CH}-\text{C}-\text{C}-\text{H} \\    \quad   \quad   \\  \text{Br} \quad \text{H} \quad \text{CH}_2\text{CH}_3  \end{array}  $
<b>E</b>	Ethyl butanoate		

- 2.1 Define *functional group*. (2)
- 2.2 Write down the LETTER of the organic compound that represents the following:
- 2.2.1 Carbonyl group bonded to two carbon atoms (1)
- 2.2.2 Has the general formula  $\text{C}_n\text{H}_{2n-2}$  (1)
- 2.2.3 Is an aldehyde (1)
- 2.3 Write down the IUPAC name of:
- 2.3.1 Compound **B** (2)
- 2.3.2 Compound **C** (2)
- 2.3.3 Compound **D** (3)
- 2.4 Write down the:
- 2.4.1 STRUCTURAL FORMULA of compound **A** (2)
- 2.4.2 Name of the reaction that occurred to produce compound **E** (1)
- 2.4.3 STRUCTURAL FORMULA of the carboxylic acid needed to produce compound **E** (2)





- 2.5 An unknown organic compound ( $C_xH_yO_z$ ) with a molar mass of  $74 \text{ g}\cdot\text{mol}^{-1}$  consists of 43,24% oxygen by mass.
- 2.5.1 Determine the MOLECULAR FORMULA of the organic compound. (3)
- 2.5.2 Draw TWO STRUCTURAL FORMULAE for the functional isomers that are represented by the molecular formula in QUESTION 2.5.1. (4)

**[24]**

**QUESTION 3 (Start on a new page.)**

Learners investigate the effect of structural differences on the boiling points of straight-chain PRIMARY ALCOHOLS. The data from the investigation are shown in the table below.

NUMBER OF CARBON ATOMS	BOILING POINTS OF THE ALCOHOLS (20 °C)
1	64
2	78
3	98
4	118

- 3.1 Define *boiling point*. (2)
- 3.2 Write down the controlled variable for this investigation. (1)
- 3.3 Explain the trend observed in the boiling points of the alcohols. (4)
- 3.4 Will the vapour pressure of the alcohols INCREASE, DECREASE or REMAIN THE SAME with an increase in the number of carbon atoms?  
Give a reason for the answer. (2)

A PRIMARY ALCOHOL has a boiling point of 108 °C.

- 3.5 Give the IUPAC name of the primary alcohol with a boiling point of 108 °C. (2)
- 3.6 Fully explain the answer to QUESTION 3.5. (4)

**[15]**

**QUESTION 4 (Start on a new page.)**

- 4.1 Heptane undergoes cracking to produce a FIVE CARBON alkane **P** and organic compound **Q**, as shown below.



4.1.1 Define *cracking*. (2)

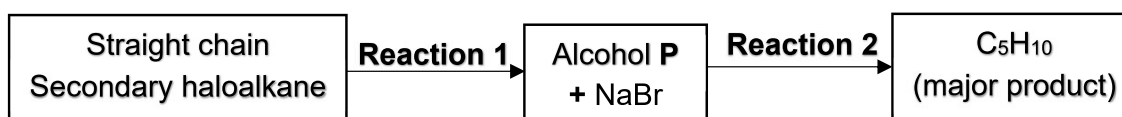
4.1.2 Write down the MOLECULAR FORMULA for compound **Q**. (2)

Compound **P** undergoes complete combustion.

4.1.3 Write down the most important use of alkanes. (1)

4.1.4 Using MOLECULAR FORMULAE, write down balanced equation for the complete combustion for COMPOUND **P**. (3)

- 4.2 Consider the flow diagram showing organic reactions given below.



Consider **REACTION 1**.

Write down:

4.2.1 The IUPAC name of the SECONDARY HALOALKANE (2)

4.2.2 The name of the reaction (1)

4.2.3 One reaction condition besides heat (1)

4.2.4 The STRUCTURAL FORMULA of alcohol **P** (2)

Consider **REACTION 2**.

Write down the:

4.2.5 Name of the type of elimination reaction (1)

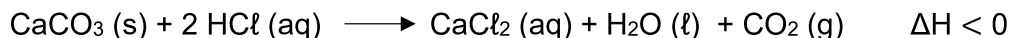
4.2.6 STRUCTURAL FORMULA for the product that was produced (2)

**[17]**

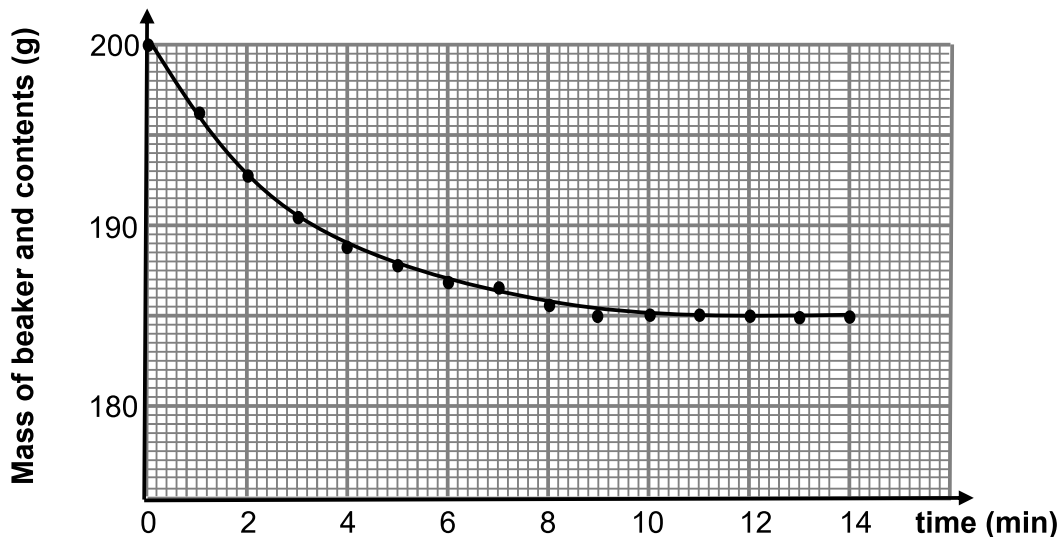


**QUESTION 5 (Start on a new page.)**

Calcium carbonate ( $\text{CaCO}_3$ ) chunks are added to EXCESS dilute hydrochloric acid ( $\text{HCl}$ ) solution in an Erlenmeyer flask that is placed on an electronic scale, as shown below. The balanced equation for the reaction that takes place is:

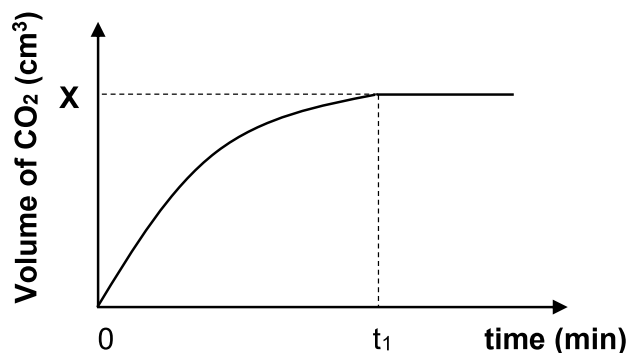


The change in mass of the flask and its contents are recorded in 1-minute intervals. The results obtained are shown in the graph below.



- 5.1 Is the reaction EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer. (2)
- 5.2 Give a reason why the mass of the flask and its contents does not remain constant. (2)
- 5.3 Write down the reading on the scale balance on 4 minutes. (1)

- 5.4 The sketch graph below shows the change in volume of  $\text{CO}_2$  gas produced for this experiment.



- 5.4.1 Write down the value of  $t_1$ . (1)

- 5.4.2 How does the rate at which the amount  $\text{CO}_2$  is produced compared to the rate at which the amount  $\text{CaCO}_3$  is consumed?

Choose from HIGHER THAN, SMALLER THAN or EQUAL TO.

Give a reason for the answer. (3)

Calculate the:

- 5.4.3 Value of **X**  
Take the molar volume as  $24\,000\text{ cm}^3\cdot\text{mol}^{-1}$  (5)

- 5.4.4 Average rate in  $\text{g}\cdot\text{min}^{-1}$  at which calcium carbonate was consumed after 11 minutes (4)

- 5.5 The experiment is repeated by increasing the temperature of the reaction mixture. The results of the two experiments are compared.

- 5.5.1 Write down a hypothesis for this comparison. (2)

- 5.5.2 How would reaction rate be affected by this change?

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

- 5.5.3 Explain the answer to QUESTION 5.5.2 by referring to the collision theory. (3)

**[24]**



**QUESTION 6 (Start on a new page.)**

- 6.1 Dinitrogen tetraoxide ( $\text{N}_2\text{O}_4$ ) decomposes to nitrogen dioxide ( $\text{NO}_2$ ) according to the balanced equation:



The reaction is allowed to reach chemical equilibrium.

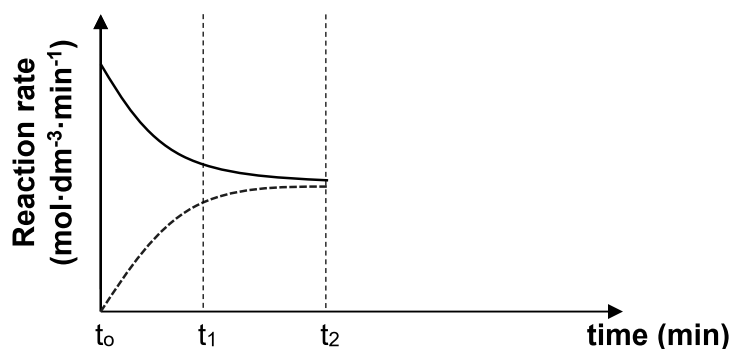
- 6.1.1 State Le Chatelier's principle in words. (2)

- 6.1.2 How would EACH of the following changes effect the concentration of  $\text{NO}_2$  at equilibrium.

Choose from INCREASES, DECREASES or NO EFFECT.

- (a) Addition of a suitable indicator (1)
- (b) Increase in temperature (1)
- (c) Increase in pressure by decreasing the volume. (4)  
Explain the answer by referring to Le Chatelier's principle.

- 6.2 The reaction rate-time graph below shows the reaction until equilibrium.



- 6.2.1 Write down the reaction represented by the dashed line. (2)

- 6.2.2 The concentration of  $\text{NO}_2$  was increased at  $t_2$ .

Redraw the graph above in the ANSWER BOOK on the same set of axes, sketch the complete graph showing the effect of the increase in the concentration of  $\text{NO}_2$  after  $t_2$ . (2)



- 6.3 The table below shows the experimental data for the  $\text{NO}_2\text{--N}_2\text{O}_4$  system at  $25^\circ\text{C}$ .

INITIAL CONCENTRATIONS ( $\text{mol}\cdot\text{dm}^{-3}$ )		EQUILIBRIUM CONCENTRATIONS ( $\text{mol}\cdot\text{dm}^{-3}$ )	
$[\text{NO}_2]$	$[\text{N}_2\text{O}_4]$	$[\text{NO}_2]$	$[\text{N}_2\text{O}_4]$
0,05	0,446	0,0457	0,448

- 6.3.1 Calculate the equilibrium constant at  $25^\circ\text{C}$ . (3)

- 6.3.2 Is there a HIGH YIELD or LOW YIELD of  $\text{NO}_2$  at  $25^\circ\text{C}$ .

Give a reason for the answer. (2)

When the initial concentration of  $\text{NO}_2$  was changed to  $0,03\text{ mol}\cdot\text{dm}^{-3}$ , it is found that the equilibrium concentration of  $\text{N}_2\text{O}_4$  is now  $0,491\text{ mol}\cdot\text{dm}^{-3}$  at  $25^\circ\text{C}$ .

- 6.3.3 Calculate the percentage decomposition of  $\text{N}_2\text{O}_4$  when the concentration of  $\text{NO}_2$  was changed to  $0,03\text{ mol}\cdot\text{dm}^{-3}$  at  $25^\circ\text{C}$ . (6)  
[23]



**QUESTION 7 (Start on a new page.)**

7.1 The table below shows the ionisation constants,  $K_a$  values, for three acids at 25 °C.

NAME	FORMULA	$K_a$ value
Methanoic acid	HCOOH	$1,8 \times 10^{-4}$
Ethanoic acid	CH <sub>3</sub> COOH	$1,8 \times 10^{-5}$
Propanoic acid	CH <sub>3</sub> CH <sub>2</sub> COOH	$1,3 \times 10^{-5}$

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

7.1.2 Write down the ionisation reaction for CH<sub>3</sub>COOH. (2)

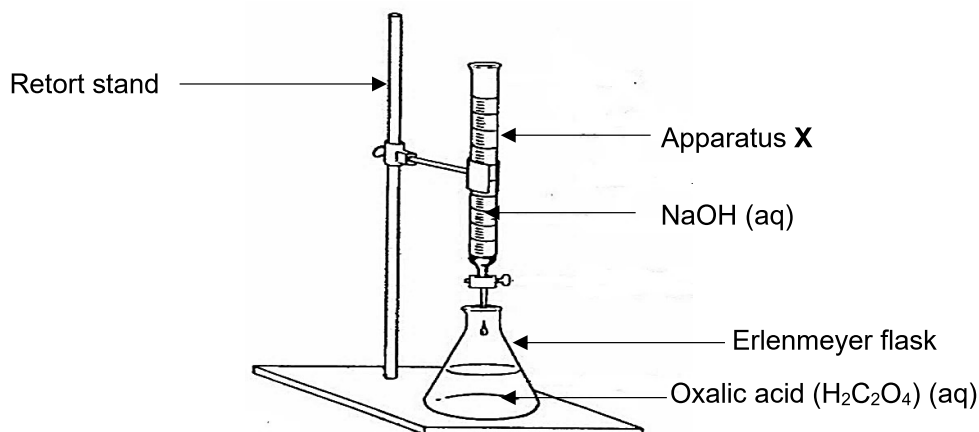
7.1.3 Are the above WEAK ACIDS or STRONG ACIDS?

Give a reason for the answer. (2)

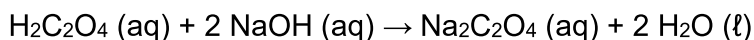
7.1.4 Which ONE of the three acids, with equal concentrations, will have the lowest pH value?

Explain the answer. (3)

7.2 A group of learners used the set-up below to titrate sodium hydroxide (NaOH) against oxalic acid (H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>).



The balanced equation is:



7.2.1 Write down the name of apparatus X. (1)

7.2.2 Give a reason why the titration is carried out at least three times. (1)





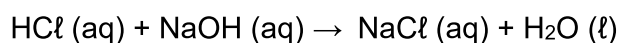
7.2.3 At what pH range will a suitable indicator changes colour for this titration?

Choose from:

3,1– 4,4	6,0–7,6	8,3–10	(1)
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7.2.4 Explain the answer to QUESTION 7.2.3 by referring to the relevant equation. (3)

7.3 The learners carried out another titration between hydrochloric acid (HCl) and sodium hydroxide (NaOH) with EQUAL concentration. They placed 25 cm<sup>3</sup> of hydrochloric acid with a concentration of 0,1 mol·dm<sup>-3</sup> in the Erlenmeyer flask. The balanced equation is:



They over titrated the sodium hydroxide solution. The pH value at the end is 12,52.

Calculate the:

7.3.1 Initial number of moles of hydrochloric acid (3)

7.3.2 Concentration of the excess hydroxide ions (4)

7.3.3 Volume of sodium hydroxide titrated in cm<sup>3</sup> (5)  
[27]

**TOTAL: 150**



**NATIONAL SENIOR CERTIFICATE  
NASIONALE SENIOR SERTIFIKAAT**

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

**TABLE 2: FORMULAE/TABEL 2: FORMULES**

$n = \frac{m}{M}$ or/of $n = \frac{N}{N_A}$ or/of $n = \frac{V}{V_m}$	$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$ $\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$ $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ at/by 298 K
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TABLE 3: THE PERIODIC TABLE OF ELEMENTS/TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/ SLEUTEL																																																																																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																																								
(I)	(II)							Atomgetal Atomic number				(III)	(IV)	(V)	(VI)	(VII)	(VIII)																																																																								
1 H 1	3 Li 7	4 Be 9	11 Na 23	12 Mg 24	19 K 39	20 Ca 40	21 Sc 45	22 Ti 48	23 V 51	24 Cr 52	25 Mn 55	26 Fe 56	27 Co 59	28 Ni 59	29 Cu 63,5	30 Zn 65	31 Ga 70	32 Ge 73	33 As 75	34 Se 79	35 Br 80	36 Kr 84	37 Rb 86	38 Sr 88	39 Y 89	40 Zr 91	41 Nb 92	42 Mo 96	43 Tc 98	44 Ru 101	45 Rh 103	46 Pd 106	47 Ag 108	48 Cd 112	49 In 115	50 Sn 119	51 Sb 122	52 Te 128	53 I 127	54 Xe 131	55 Cs 133	56 Ba 137	57 La 139	58 Ce 140	59 Pr 141	60 Nd 144	61 Pm 146	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	72 Hf 178	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 Tl 204	82 Pb 207	83 Bi 209	84 Po 210	85 At 210	86 Rn 222	87 Fr 223	88 Ra 226	89 Ac 227	90 Th 232	91 Pa 231	92 U 238	93 Np 237	94 Pu 244	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 251	99 Es 252	100 Fm 257	101 Md 258	102 No 259	103 Lr 262

2	He	4
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10	Ne	20
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18	Ar	40
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36	Kr	84
----	----	----

54	Xe	131
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86	Rn	
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9	F	19
---	---	----

17	Cl	35,5
----	----	------

8	O	16
---	---	----

16	S	32
----	---	----

7	N	14
---	---	----

15	P	31
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6	C	12
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14	Si	28
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5	B	11
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13	Al	27
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31	Ga	70
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49	In	115
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81	Tl	204
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129	Te	128
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84	Po	210
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209	Bi	209
-----	----	-----

53	I	127
----	---	-----

85	At	
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52	Te	128
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84	Po	210
----	----	-----

209	Bi	209
-----	----	-----

33	As	75
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51	Sb	122
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83	Bi	209
----	----	-----

32	Ge	73
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50	Sn	119
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82	Pb	207
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48	Cd	112
----	----	-----

80	Hg	201
----	----	-----

47	Ag	108
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79	Au	197
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46	Pd	106
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78	Pt	195
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45	Rh	103
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77	Ir	192
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44	Ru	101
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76	Os	190
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43	Tc	98
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75	Re	186
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42	Mo	96
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74	W	184
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41	Nb	92
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73	Ta	181
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40	Zr	91
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72	Hf	179
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39	Y	89
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57	La	139
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89	Ac	
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38	Sr	88
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56	Ba	137
----	----	-----

88	Ra	226
----	----	-----

37	Rb	86
----	----	----

55	Cs	133
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87	Fr	223
----	----	-----

29	Cu	
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Electronegatiwiteit Electronegativity	→	
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Simbools Symbol	←	
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Benaderde relatiewe atoommassa Approximate relative atomic mass		
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2 He 4	10 Ne 20	18 Ar 40	36 Kr 84	54 Xe 131	86 Rn 222
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5 B 11	13 Al 27	31 Ga 70	49 In 115	81 Tl 204	127 Nh 289
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6 C 12	14 Si 28	32 Ge 73	50 Sn 119	82 Pb 207	128 Lv 293
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7 N 14	15 P 31	33 As 75	51 Sb 122	83 Bi 209	129 Ts 295
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8 O 16	16 S 32	34 Se 79	52 Te 128	84 Po 210	130 Og 294
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9 F 19	17 Cl 35,5	35 Br 80	53 I 127	85 At 210	131 Nh 293
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16 O 16	34 Se 79	52 Te 128	84 Po 210	130 Og 294
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17 Cl 35,5	35 Br 80	53 I 127	85 At 210	131 Nh 293
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18 Ar 40	36 Kr 84	54 Xe 131	86 Rn 222	132 Fl 297
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19 K 39	37 Rb 86	55 Cs 133	87 Fr 223	133 Nh 293
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20 Ca 40	38 Sr 88	56 Ba 137	88 Ra 226	134 Fl 297
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21 Sc 45	39 Y 89	57 La 139	89 Ac 227	135 Nh 293
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22 Ti 48	40 Zr 91	72 Hf 179	104 Rf 261	136 Nh 293
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23 V 51	41 Nb 92	73 Ta 181	105 Db 262	137 Nh 293
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24 Cr 52	42 Mo 96	74 W 184	106 Sg 266	138 Nh 293
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25 Mn 55	43 Tc 98	75 Re 186	107 Bh 264	139 Nh 293
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26 Fe 56	44 Ru 101	76 Os 190	108 Hs 265	140 Nh 293
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27 Co 59	45 Rh 103	77 Ir 192	109 Mt 268	141 Nh 293
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28 Ni 59	46 Pd 106	78 Pt 195	110 Ds 271	142 Nh 293
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29 Cu 63,5	47 Ag 108	79 Au 197	111 Rg 272	143 Nh 293
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30 Zn 65	48 Cd 112	80 Hg 201	112 Cn 285	144 Nh 293
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31 Ga 70	49 In 115	81 Tl 204	113 Nh 288	145 Nh 293
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32 Ge 73	50 Sn 119	82 Pb 207	114 Fl 289	146 Nh 293
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33 As 75	51 Sb 122	83 Bi 209	115 Nh 290	147 Nh 293
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34 Se 79	52 Te 128	84 Po 210	116 Lv 293	148 Nh 293
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35 Br 80	53 I 127	85 At 210	117 Ts 294	149 Nh 293
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36 Kr 84	54 Xe 131	86 Rn 222	118 Og 294	150 Nh 293
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37 Rb 86	55 Cs 133	87 Fr 223	119 Nh 295	151 Nh 293
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38 Sr 88	56 Ba 137	88 Ra 226	120 Nh 296	152 Nh 293
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39 Y 89	57 La 139	89 Ac 227	121 Nh 297	153 Nh 293
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40 Zr 91	72 Hf 179	104 Rf 261	122 Nh 298	154 Nh 293
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41 Nb 92	73 Ta 181	105 Db 262	123 Nh 299	155 Nh 293
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42 Mo 96	74 W 184	106 Sg 266	124 Nh 300	156 Nh 293
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43 Tc 98	75 Re 186	107 Bh 264	125 Nh 301	157 Nh 293
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44 Ru 101	76 Os 190	108 Hs 265	126 Nh 302	158 Nh 293
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45 Rh 103	77 Ir 192	109 Mt 268	127 Nh 303	159 Nh 293
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46 Pd 106	78 Pt 195	110 Ds 271	128 Nh 304	160 Nh 293
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47 Ag 108	79 Au 197	111 Rg 272	129 Nh 305	161 Nh 293
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48 Cd 112	80 Hg 201	112 Cn 285	130 Nh 306	162 Nh 293
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49 In 115	81 Tl 204	113 Nh 288	131 Nh 307	163 Nh 293
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50 Sn 119	82 Pb 207	114 Fl 289	132 Nh 308	164 Nh 293
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51 Sb 122	83 Bi 209	115 Nh 290	133 Nh 309	165 Nh 293
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52 Te 128	84 Po 210	116 Lv 293	134 Nh 310	166 Nh 293
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53 I 127	85 At 210	117 Ts 294	135 Nh 311	167 Nh 293
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54 Xe 131	86 Rn 222	118 Og 294	136 Nh 312	168 Nh 293
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55 Cs 133	87 Fr 223	119 Nh 295	137 Nh 313	169 Nh 293
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56 Ba 137	88 Ra 226	120 Nh 296	138 Nh 314	170 Nh 293
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57 La 139	89 Ac 227	121 Nh 297	139 Nh 315	171 Nh 293
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58 Ce 140	90 Th 232	91 Pa 231	140 Nh 316	172 Nh 293
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59 Pr 141	91 Pa 231	92 U 238	141 Nh 317	173 Nh 293
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60 Nd 144	92 U 238	93 Np 237	142 Nh 318	174 Nh 293
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61 Pm 146	93 Np 237	94 Pu 244	143 Nh 319	175 Nh 293
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62 Sm 150	94 Pu 244	95 Am 243	144 Nh 320	176 Nh 293
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63 Eu 152	95 Am 243	96 Cm 247	145 Nh 321	177 Nh 293
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64 Gd 157	96 Cm 247	97 Bk 247	146 Nh 322	178 Nh 293
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65 Tb 159	97 Bk 247	98 Cf 251	147 Nh 323	179 Nh 293
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66 Dy 163	98 Cf 251	99 Es 252	148 Nh 324	180 Nh 293
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67 Ho 165	99 Es 252	100 Fm 257	149 Nh 325	181 Nh 293
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68 Er 167	100 Fm 257	101 Md 258	150 Nh 326	182 Nh 293
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69 Tm 169	101 Md 258	102 No 259	151 Nh 327	183 Nh 293
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70 Yb 173	102 No 259	103 Lr 262	152 Nh 328	184 Nh 293
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71 Lu 175	103 Lr 262		153 Nh 329	185 Nh 293
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			154 Nh 330	186 Nh 293
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			155 Nh 331	187 Nh 293
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			156 Nh 332	188 Nh 293
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			157 Nh 333	189 Nh 293
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			158 Nh 334	190 Nh 293
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			159 Nh 335	191 Nh 293
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			160 Nh 336	192 Nh 293
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			161 Nh 337	193 Nh 293
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			162 Nh 338	194 Nh 293
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			163 Nh 339	195 Nh 293
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			164 Nh 340	196 Nh 293
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			165 Nh 341	197 Nh 293
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			166 Nh 342	198 Nh 293
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			167 Nh 343	199 Nh 293
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			168 Nh 344	200 Nh 293
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			169 Nh 345	201 Nh 293
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			170 Nh 346	202 Nh 293
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			171 Nh 347	203 Nh 293
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			172 Nh 348	204 Nh 293
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			173 Nh 349	205 Nh 293
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			174 Nh 350	206 Nh 293
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			175 Nh 351	207 Nh 293
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			176 Nh 352	208 Nh 293
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			177 Nh 353	209 Nh 293
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			178 Nh 354	210 Nh 293
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			179 Nh 355	211 Nh 293
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			180 Nh 356	212 Nh 293
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			181 Nh 357	213 Nh 293
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			182 Nh 358	214 Nh 293
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			183 Nh 359	215 Nh 293
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