

# Hillcrest High School

## PHYSICAL SCIENCE P2

JUNE 2023

Grade 12

**MARKS:** 100

**TIME:** 2 Hours

**EXAMINER:** Mrs J. Knox-Whitehead

**MODERATOR:** Ms N. Badenhorst

**Instructions:**

1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (10)  
SECTION B (90)  
  
Answer SECTIONS A and B in the ANSWER BOOK.
4. Non-programmable calculators may be used.
5. Appropriate mathematical instruments may be used.
6. Number the answers correctly according to the numbering system used in this question paper.
7. Data sheets and a periodic table are attached for your use.
8. Give brief motivations, discussions, et cetera where required.
9. Numbers must be rounded off to **two decimal** places

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**SECTION A: QUESTION 1 (Multiple-choice)**

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A- D) next to the question number (1.1 – 1.5) on your ANSWER BOOK.

- 1.1 An alkane burns completely in oxygen. Which ONE of the following represents the CORRECT ratio of the products of combustion, CO<sub>2</sub>: H<sub>2</sub>O?
- A     n: 2n - 1
- B     n: 2n + 1
- C     n: n + 1
- D     n: n - 1

(2)

1.2 Which ONE of the following organic molecules will react rapidly with bromine water?

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

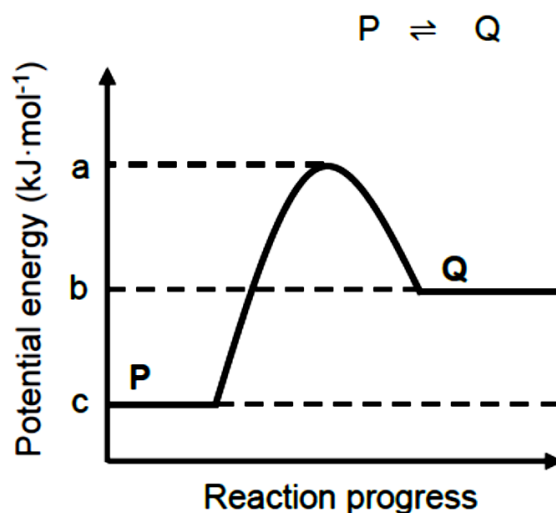
B  $\text{CH}_3\text{CH}_3$

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

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

(2)

1.3 Consider the potential energy profile below for the following hypothetical reaction:

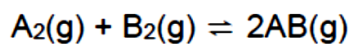


Which ONE of the following combinations correctly indicates both the activation energy and the heat of reaction ( $\Delta H$ ) for the REVERSE REACTION?

	Activation energy ( $\text{kJ}\cdot\text{mol}^{-1}$ )	Heat of reaction ( $\Delta H$ )
A	$a - b$	$b - c$
B	$b - a$	$a - c$
C	$a - b$	$c - b$
D	$a - c$	$a - b$

(2)

- 1.4 Consider the following hypothetical reaction having reached equilibrium at a constant high temperature in a closed container:



The pressure on the system is then INCREASED by decreasing the volume of the container. A new equilibrium is reached at the **same temperature**.

Which ONE of the following is CORRECT regarding the concentration of  $A_2(g)$  and the number of moles of  $AB(g)$ ?

	CONCENTRATION OF $A(g)$	NUMBER OF MOLES OF $AB(g)$
A	Decreases	Increases
B	Increases	Stays constant
C	Increases	Decreases
D	Stays constant	Stays constant

(2)

- 1.5 A  $H_2SO_4$  solution of concentration  $0,001 \text{ mol}\cdot\text{dm}^{-3}$  can BEST be described as a ...

- A concentrated solution of a strong acid.
- B dilute solution of a strong acid.
- C concentrated solution of a weak acid.
- D dilute solution of a weak acid.

(2)  
[10]

**SECTION B: QUESTION 2**

The letters **P** to **W** in the table below represent eight organic compounds.

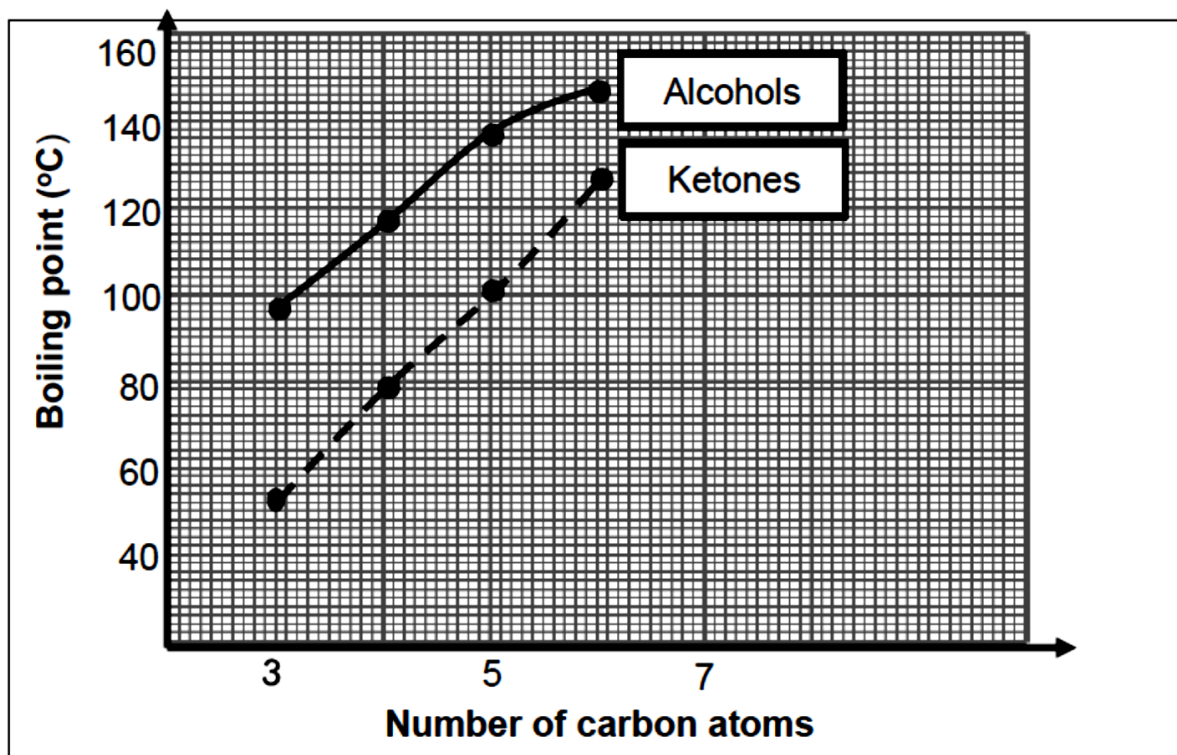
<b>P</b>	$\begin{array}{ccccccc} & \text{Br} & & & \text{CH}_3 & & \\ &   & & &   & & \\ \text{H}_3\text{C} & -\text{CH} & -\text{CH}_2 & -\text{CH}_2 & -\text{C} & -\text{CH}_3 & \\ & & & &   & & \\ & & & & \text{CH}_3 & & \end{array}$	<b>Q</b>	$\text{H}_3\text{C}-\text{CH}=\text{CH}-\text{CH}_3$
<b>R</b>	But-1-ene	<b>S</b>	$\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CHO}$
<b>T</b>	Pentan-3-one	<b>U</b>	4,4-dimethylhex-2-yne
<b>V</b>	Hexane	<b>W</b>	$\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{COOH}$

- 2.1 Define the term *structural isomer*. (2)
- 2.2 Write down the LETTER that represents a compound that:
- 2.2.1 is an aldehyde (1)
- 2.2.2 has the general formula  $\text{C}_n\text{H}_{2n+2}$  (1)
- 2.2.3 is a FUNCTIONAL ISOMER of compound **T** (1)
- 2.2.4 is a POSITIONAL ISOMER of compound **Q** (1)
- 2.2.5 is a CHAIN ISOMER of 2,3-dimethylbutane (1)
- 2.3 Write down the:
- 2.3.1 IUPAC name of compound **P** (2)
- 2.3.2 STRUCTURAL FORMULA of compound **U** (2)
- 2.4 For compound **T**, write down the:
- 2.4.1 *homologous series* to which it belongs (1)
- 2.4.2 *structural formula* for its functional groups (1)
- 2.5 For compound **W**, write down the *homologous series* to which its FUNCTIONAL isomer belongs. (1)

**[14]**

**QUESTION 3**

- 3.1 The graphs below show the boiling points of straight chain primary alcohols and straight chain ketones with different numbers of carbon atoms.



- 3.1.1 Define the term *boiling point*. (2)
- 3.1.2 Explain why the boiling points of alcohols increase as the number of carbon atoms increase by referring to TYPE and STRENGTH of intermolecular forces only. (2)
- 3.1.3 Explain why the curve of the alcohols is higher than that of the ketones. Refer to the TYPE and STRENGTH of intermolecular forces involved. (3)

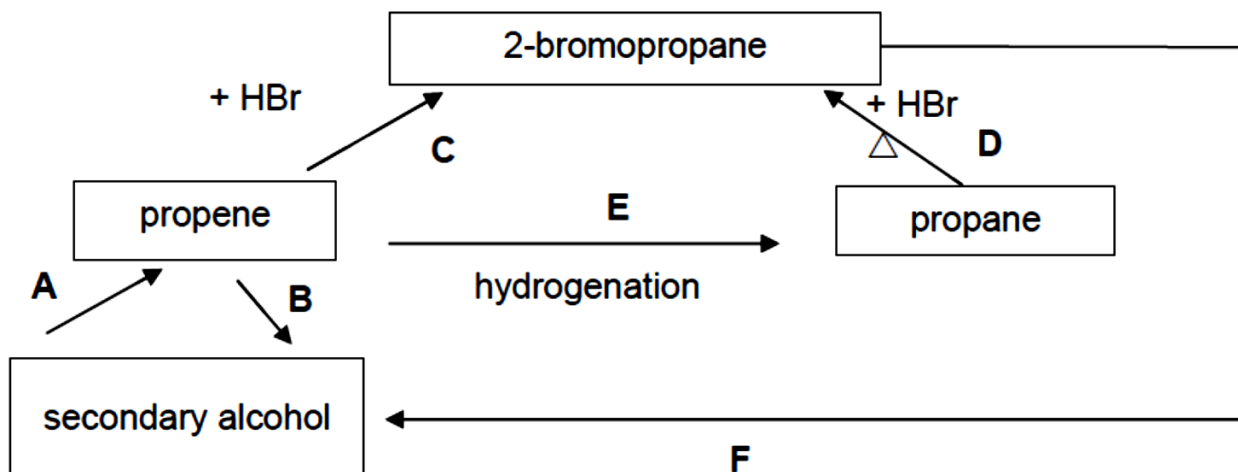
The vapour pressure of the alcohol is compared to that of a ketone at the same temperature.

- 3.1.4 What is the independent variable in this investigation? (1)
- 3.1.5 Which ONE will have a higher vapour pressure? Choose from ALCOHOL or KETONE. Give a reason for the answer by referring to the data in the graph. (2)

**[10]**

**QUESTION 4**

Most organic compounds can undergo different reactions to produce a variety of organic compounds. Some incomplete reactions are represented below.

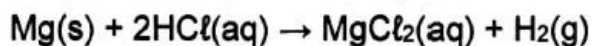


- 4.1 Consider reaction **A**.
- 4.1.1 Write down the type of reaction that takes place. (1)
- 4.1.2 Give the NAME or FORMULA of the inorganic product also formed in this reaction. (1)
- 4.2 Reaction **B** represents a hydration reaction.
- 4.2.1 What catalyst would be appropriate to use for this reaction? (1)
- 4.2.2 Draw the structural formula for the alcohol that forms. (2)
- 4.3 Consider reaction **C**.
- 4.3.1 Write down TWO conditions for this reaction. (2)
- 4.3.2 Use structural formulae to write a balanced equation for this reaction. (3)
- 4.4 Identify the type of reaction taking place at:
- 4.4.1 Reaction **D** (1)
- 4.4.2 Reaction **F** (1)
- 4.5 Reaction **E** is a hydrogenation reaction. Write down ONE reaction condition for this reaction. (1)

**[13]**

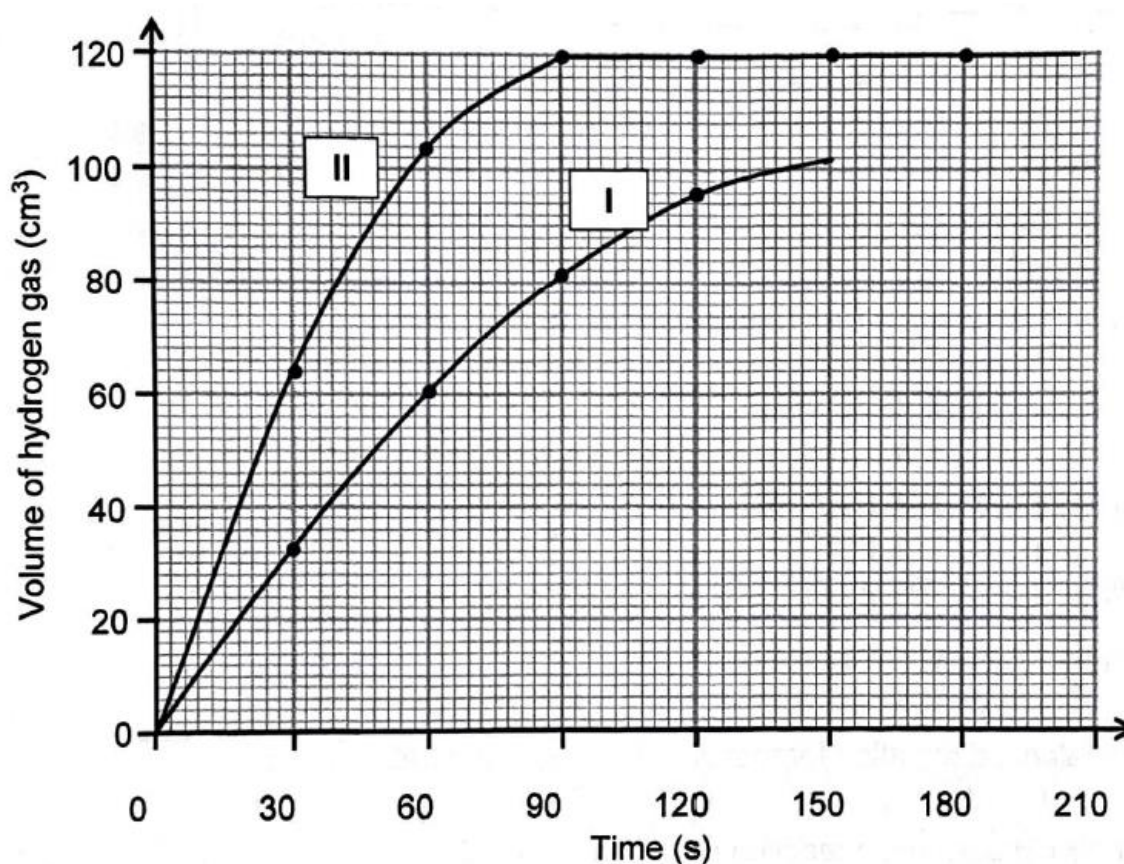
### QUESTION 5

A group of learners use the reaction of **excess** hydrochloric acid with magnesium powder to investigate **ONE** of the factors that influences reaction rate. The balanced equation for the reaction is:



They conduct **TWO** experiments, I and II, using hydrochloric acid of the **SAME CONCENTRATION** and the **SAME MASS** of magnesium powder in **BOTH** experiments. Both experiments are carried out at 20°C.

The graph below shows curves I and II that were obtained for the two experiments I and II respectively. Note that Curve I does not show the completed reaction.



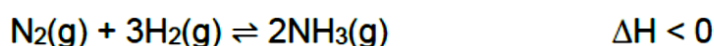
- 5.1 Define *reaction rate* in words. (2)
- 5.2 Calculate the average rate of reaction (in  $\text{cm}^3 \cdot \text{s}^{-1}$ ) for experiment II, for the time interval 30 to 60 s. (3)
- 5.3 Which **ONE** of the experiments, I or II, took place at a slower rate? Give a reason by referring to the graphs. (2)
- 5.4 Write down the factor that is responsible for the difference in the rate of the reactions between experiments I and II. (1)

- 5.5 Using COLLISION THEORY, fully explain how the factor in QUESTION 5.4 affects the reaction rate. (3)
- 5.6 Calculate the mass of magnesium powder remaining in the container at 150 s for experiment I, which has not yet reached completion. (8)  
Take the molar gas volume to be  $24040 \text{ cm}^3 \cdot \text{mol}^{-1}$  at  $20^\circ\text{C}$ .

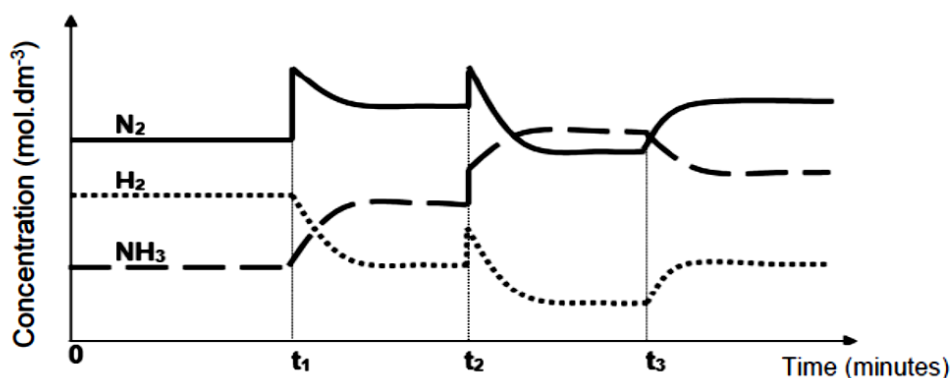
[19]

**QUESTION 6**

- 6.1 The balanced equation below represents the reaction that reaches equilibrium in a sealed container.



To increase the yield of ammonia, adjustments are made to the temperature, pressure and concentration of the equilibrium mixture. The graph below represents the results obtained.



Identify the changes made to the equilibrium mixture at each of the following times:

- 6.1.1  $t_1$  (1)
- 6.1.2  $t_2$  (1)
- 6.1.3  $t_3$  (1)
- 6.2 State *Le Chatelier's principle*. (2)
- 6.3 The pressure of the reaction mixture in QUESTION 6.1 above is disturbed by increasing the volume of the sealed container.
- 6.3.1 How will this change affect the yield of  $\text{NH}_3(\text{g})$ ? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
- 6.3.2 Use *Le Chatelier's principle* to explain the answer to QUESTION 6.3.1. (3)
- 6.4 5 mol  $\text{N}_2$  and 5 mol  $\text{H}_2$  are now sealed into a  $5 \text{ dm}^3$  empty container. Equilibrium is reached at  $450^\circ\text{C}$ . Upon analysis of the equilibrium mixture it is found that the mass of  $\text{NH}_3$  is 20,4 g. Calculate the value of the equilibrium constant,  $K_c$ , at  $450^\circ\text{C}$ . (9)

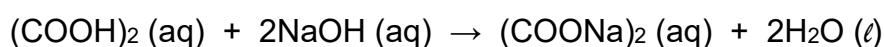
**[18]****QUESTION 7**

As a class project, Grade 12 learners are asked to determine the amount of inert (unreactive) impurities in a contaminated sample of anhydrous oxalic acid,  $(\text{COOH})_2$ .

- 7.1 Define the term *weak acid*. (2)
- 7.2 Is the  $K_a$  value for oxalic acid GREATER THAN or LESS THAN 1? (1)
- 7.3 Explain your answer to QUESTION 7.2. (2)

One group of learners prepares a standard solution of sodium hydroxide (NaOH) by diluting  $50 \text{ cm}^3$  of  $1,63 \text{ mol}\cdot\text{dm}^{-3}$  solution to make up a  $1 \text{ dm}^3$  solution. Another group prepares a solution of contaminated oxalic acid by dissolving  $0,25 \text{ g}$  of the impure oxalic acid in  $75 \text{ cm}^3$  of water. All the learners then titrate the acid solution against the sodium hydroxide solution. The titration requires  $40 \text{ cm}^3$  of the sodium hydroxide solution to reach the endpoint.

The neutralisation reaction that takes place is:



- 7.4 Is the salt produced in this reaction ACIDIC, NEUTRAL or ALKALINE? (1)
- 7.5 What would be an appropriate indicator to use for this titration? (1)
- 7.6 Calculate the percentage purity of the oxalic acid sample. (9)

**[16]****Total 100**

**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 by STD</i>	$V_m$	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	$T^\theta$	273 K
Charge on electron <i>Lading op elektron</i>	$e$	$-1,6 \times 10^{-19} \text{ C}$
Avogadro's constant <i>Avogadro-konstante</i>	$N_A$	$6,02 \times 10^{23} \text{ mol}^{-1}$

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

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ at/by 298 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 $E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta$ / $E_{\text{sel}}^\theta = E_{\text{oksideermiddel}}^\theta - E_{\text{reduseermiddel}}^\theta$	

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 H	4 Be	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
2 He	9 F	39 K	40 Ca	41 Sc	42 Ti	43 V	44 Cr	45 Mn	46 Fe	47 Co	48 Ni	49 Cu	50 Zn	51 Ga	52 Ge	53 As	54 Se	55 Br
3 Li	12 Mg	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I
4 H	19 K	55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
5 Li	20 Ca	87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
6 Li	23 Na	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		
7 Li	24 Mg	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr			
8 Li	25 Mn	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr				
9 Li	26 Fe	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr					
10 Li	27 Co	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr						
11 Li	28 Ni	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr							
12 Li	29 Cu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr								
13 Li	30 Zn	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr									
14 Li	31 Ga	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr										
15 Li	32 Ge	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr											
16 Li	33 As	99 Es	100 Fm	101 Md	102 No	103 Lr												
17 Li	34 Se	100 Fm	101 Md	102 No	103 Lr													
18 Li	35 Br	101 Md	102 No	103 Lr														
19 Li	36 Kr	102 No	103 Lr															
20 Li	37 Rb	103 Lr																
21 Li	38 Sr																	
22 Li	39 Y																	
23 Li	40 Zr																	
24 Li	41 Nb																	
25 Li	42 Mo																	
26 Li	43 Tc																	
27 Li	44 Ru																	
28 Li	45 Rh																	
29 Li	46 Pd																	
30 Li	47 Ag																	
31 Li	48 Cd																	
32 Li	49 In																	
33 Li	50 Sn																	
34 Li	51 Sb																	
35 Li	52 Te																	
36 Li	53 I																	
37 Li	54 Xe																	
38 Li	55 Ba																	
39 Li	56 La																	
40 Li	57 Ce																	
41 Li	58 Pr																	
42 Li	59 Nd																	
43 Li	60 Pm																	
44 Li	61 Sm																	
45 Li	62 Eu																	
46 Li	63 Gd																	
47 Li	64 Tb																	
48 Li	65 Dy																	
49 Li	66 Ho																	
50 Li	67 Er																	
51 Li	68 Tm																	
52 Li	69 Yb																	
53 Li	70 Lu																	
54 Li	71 Lr																	

