HILLCREST HIGH SCHOOL

Grade 12

PHYSICAL SCIENCE P2

September 2025

MARKS: 150
TIME: 3 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 (20)
   SECTION B (130)
4. Answer SECTIONS A and B in the ANSWER BOOK.
   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 are attached for your use.
8. Give brief motivations, discussions, et cetera where required.
9. Numbers must be rounded off to <u>two decimal</u> places

SECTION A

QUESTION 1: MULTIPLE CHOICE QUESTIONS

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 (1.1-1.10) in the answer book.

1.1 Which one of the following is a SECONDARY alcohol?

A ethanol

B butan-1-ol

C butan-2-ol

D 2-methylbutan-1-ol (2)

1.2 A FUNCTIONAL ISOMER of ethyl propanoate is…

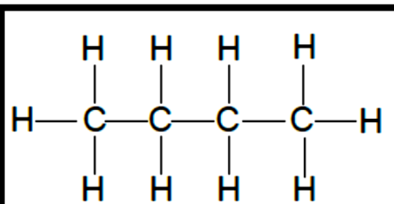
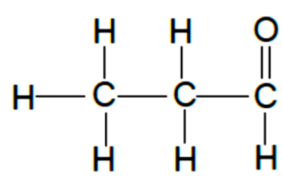
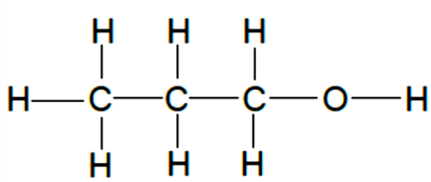
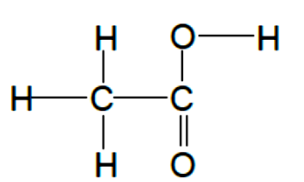
A C_4H_9CHO

B $C_5H_{11}OH$

C C_4H_9COOH

D $CH_3(CH_2)_3CHO$ (2)

1.3 Which one of the following compounds has the HIGHEST melting point under the same conditions?

A		B	
C		D	

(2)

1.4 Consider the balanced equation for a chemical reaction below:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The activation energy of the forward and reverse reactions are 156 kJ.mol^{-1} and 175 kJ.mol^{-1} respectively. The heat of reaction, in kJ.mol^{-1}, for this reaction is…

A +19

B -19

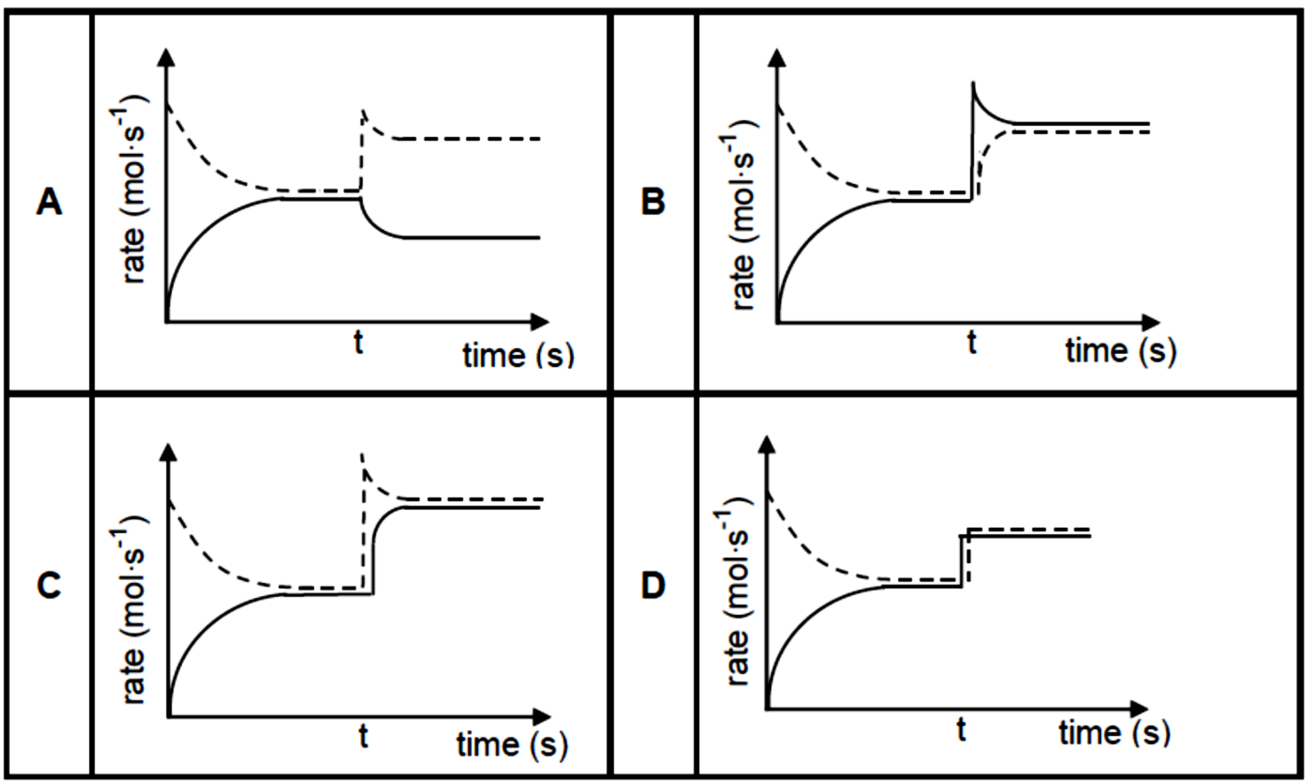
C +331

D -331 (2)

1.5 Initially, a certain amount of P(g) was placed in an empty container. The hypothetical reaction reaches equilibrium in a closed container according to the following balanced equation:

$$P(g) \rightleftharpoons 2Q(g) \qquad \Delta H = +171 \text{ kJ.mol}^{-1}$$

At time t, the temperature is increased. Which graph below best illustrates the resulting changes in the rates of the forward and reverse reactions after the temperature is increased?



(2)

1.6 The reaction given below reaches equilibrium in a closed container. The K_c value is 0,04 at a certain temperature.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$$

Which ONE of the following factors will change the K_c value to 0,4?

A Increase in pressure

B Decrease in pressure

C Increase in temperature

D Decrease in temperature (2)

1.7 Which one of the following shows the PRODUCTS for the reaction of oxalic acid with sodium hydroxide?

A $(COO)_2Na_2(aq) + H_2O(\ell) + CO_2(g)$

B $(COO)_2Na_2(aq) + H_2O(\ell)$

C $CH_3COONa(aq) + H_2O(\ell)$

D $CH_3COONa(aq) + H_2O(\ell) + CO_2(g)$ (2)

1.8 Which one of the following CANNOT act as a reducing agent?

A Mg

B Br^-

C Fe^{2+}

D MnO_4^- (2)

1.9 Which ONE of the following is formed at the cathode in a membrane cell?

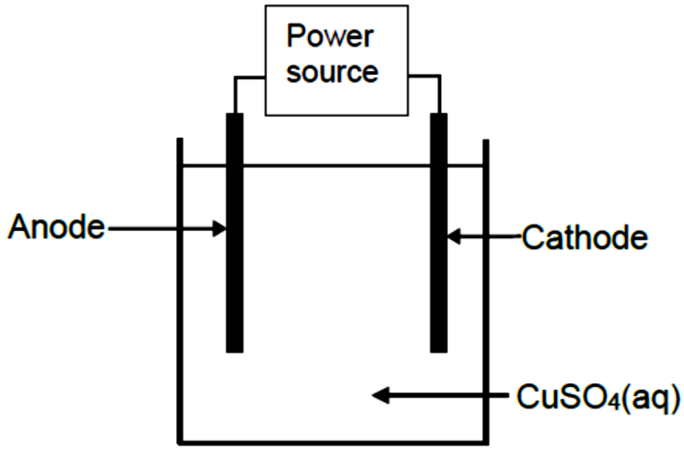
A Chlorine

B Hydrogen

C Sodium chloride

D Oxygen (2)

1.10 Copper is purified by electrolysis. Which ONE of the following combinations is CORRECT for the changes occurring at the anode, cathode and in the electrolyte when the cell is in operation?



	MASS OF THE ANODE	MASS OF THE CATHODE	COLOUR OF THE ELECTROLYTE
A	Increases	Decreases	No change
B	Decreases	Increases	No change
C	Increases	Decreases	Becomes darker
D	Decreases	Increases	Becomes lighter

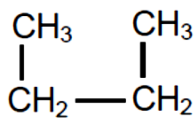
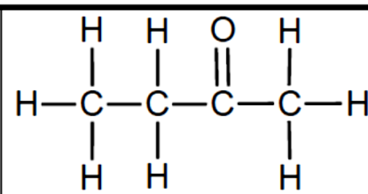
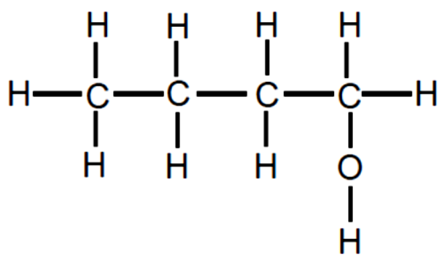
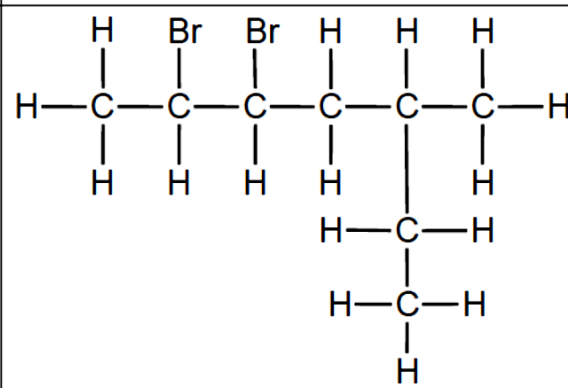
(2)

[2 x 10 = 20]

Section B

Question 2

2.1 The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C	$CH_3CCH_2CH_3$	**D**	Butyl propanoate
E		**F**	

2.1.1 Write down the LETTER that represents each of the following:

a) A ketone. (1)

b) A compound with the general formula C_nH_{2n-2}. (1)

2.1.2 Draw the STRUCTURAL FORMULA of a CHAIN isomer of compound **A**. (2)

2.1.3 Write down the IUPAC name of compound **B**. (2)

2.1.4 Draw the STRUCTURAL FORMULA of compound **D**. (2)

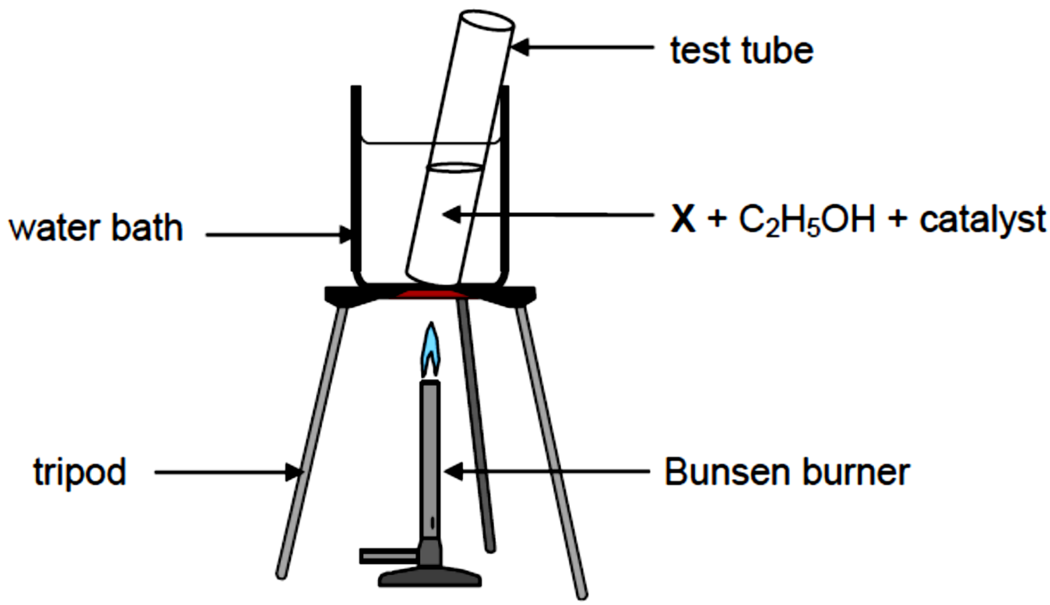
2.1.5 Write down the:

a) Definition of *functional group*. (2)

b) STRUCTURE of the functional group for compound **C**. (1)

c) NAME of the functional group for compound **E**. (1)

2.2 A test tube containing a straight chain organic acid **X**, ethanol and a catalyst is heated in a water bath, as illustrated below.



Organic compound **Y** is produced according to the following equation:

$$\mathbf{X} + C_2H_5OH \rightarrow \mathbf{Y} + H_2O$$

2.2.1 Give a reason why the test tube is heated in a water bath instead of directly over the flame. (1)

2.2.2 Write down the:

a) FORMULA of the catalyst needed (1)

b) Homologous series to which compound **Y** belongs (1)

The molecular mass of compound **Y** is 144 g.mol^{-1} and its empirical formula is C_4H_8O.

2.2.3 Determine the molecular formula of compound **Y**. (2)

2.2.4 Write down the IUPAC name of compound **Y**. (2)

2.2.5 Write down the STRUCTURAL FORMULA of the organic acid **X**. (2)

[21]

Question 3

The boiling points of some organic compounds are shown in the table below. The atmospheric pressure is 101,3kPa.

	ORGANIC COMPOUND	BOILING POINT (°C)
A	$CH_3CH_2CH_2CH_2C\ell$	78
B	$CH_3CH(CH_3)CH_2C\ell$	46
C	$CH_3CH_2CH_2CH_2OH$	118
D	$CH_3CH_2CH_2COOH$	X

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

3.2 Explain the difference in the boiling points of compounds **A** and **B**. (3)

3.3 Consider the boiling points below:

39˚C	**75˚C**	**115˚C**	**164˚C**

3.3.1 Which ONE of these values represents **X**, the boiling point of compound **D**? (1)

3.3.2 Fully explain the answer to QUESTION 3.3.1. (4)

3.4 The atmospheric pressure is now changed to 90 kPa.
How will the boiling points of these organic compounds be affected? Choose from INCREASE, DECREASE or REMAIN THE SAME. (1)

3.5 Name the intermolecular forces present in the organic compound that is a FUNCTIONAL ISOMER of compound **D**. (2)

[13]

Question 4

4.1 Three reactions of organic compounds from the same homologous series are shown below:

I:	Butane + Br_2 $\rightarrow$ 2-bromobutane + **P**
II:	Pentane + excess oxygen $\xrightarrow{\text{heat}}$
III:	Hexane $\rightarrow$ C_2H_4 + **Q**

4.1.1 Define a *homologous series*. (2)

4.1.2 Name the type of reaction represented by **I**. (1)

4.1.3 Write down the formula of the inorganic compound **P**. (1)

4.1.4 State ONE reaction condition necessary for reaction **I** to take place. (1)

4.1.5 Using molecular formulae, write down the balanced equation for reaction **II**. (3)

Reaction **III** is an example of a reaction where long chain hydrocarbons are broken down into shorter, more useful molecules.

4.1.6 Name this type of reaction. (1)

4.1.7 Give the structural formula of compound **Q**. (2)

4.2 Study the flow diagram below:

2-bromobutane $\xrightarrow{\text{Hydrolysis}}$ Compound **R** $\longrightarrow$ Alkene

4.2.1 Write down the IUPAC name of compound **R**. (2)

4.2.2 Compound **R** reacts in the presence of concentrated sulfuric acid to form an alkene.

a) Name this reaction. (1)

b) Write down the structural formula of the MAJOR PRODUCT of this reaction. (2)

[16]

Question 5

The reaction of zinc and EXCESS dilute hydrochloric acid is used to investigate factors that affect reaction rate. The balanced equation for the reaction is:

$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

The reaction conditions used and the results obtained for each experiment are summarised in the table below.

The same mass of zinc is used in all the experiments. The zinc is completely covered in all reactions. The reaction time is the time it takes the reaction to be completed.

EXPERIMENT	CONCENTRATION OF HCℓ ($mol\cdot dm^{-3}$)	VOLUME OF HCℓ (cm^3)	STATE OF DIVISION OF Zn	TEMPERATURE OF HCℓ (°C)	REACTION TIME (min.)
1	2,0	200	powder	25	7
2	1,5	200	granules	25	14
3	5,0	200	powder	25	5
4	1,5	400	granules	25	x
5	2,0	200	powder	35	4

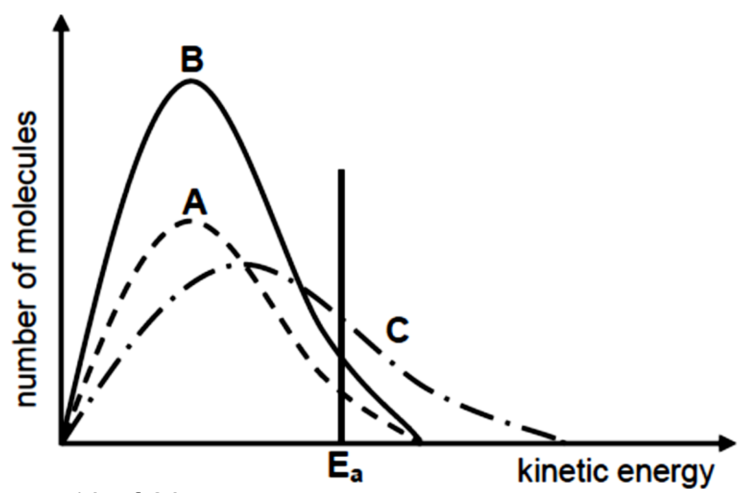
5.1 Experiment **1** and experiment **5** are compared.

5.1.1 Write down the INDEPENDENT variable for this comparison. (1)

5.1.2 Using the Collision Theory, explain the difference in reaction rate that will be observed between these two experiments. (3)

5.2 Write down the value of **x** in experiment **4**. (1)

5.3 The Maxwell-Boltzmann energy distribution curves for particles in each of experiments **1**, **3** and **5** are shown below:



Identify the graph (**A**, **B** or **C**) that represents the following:

5.3.1 Experiment **3**

Give a reason for the answer. (2)

5.3.2 Experiment **5**

Give a reason for the answer. (2)

5.4 Calculate the average rate of the reaction (in $mol.min^{-1}$) with respect to zinc for experiment **2** if **1,5 g of zinc** is used. (4)

[13]

Question 6

Dinitrogen tetroxide, $N_2O_4(g)$, decomposes to nitrogen dioxide, $NO_2(g)$, in a sealed syringe of volume 2 dm^3.

The mixture reaches equilibrium at 325°C according to the following balanced equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

colourless brown

When equilibrium is reached, it is observed that the colour of the gas in the syringe is brown.

6.1 State *Le Chatelier's principle*. (2)

6.2 The syringe is now dipped into a beaker of ice water. After a while the brown colour disappears. Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Explain the answer using Le Chatelier's principle. (3)

6.3 The volume of the syringe is now decreased while the temperature is kept constant. How will EACH of the following be affected?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

6.3.1 The number of moles of $N_2O_4(g)$ (1)

6.3.2 The value of the equilibrium constant, K (1)

6.3.3 The rate of the forward and reverse reactions (1)

6.4 Initially **X** moles of $N_2O_4(g)$ were placed in the syringe of volume 2 dm^3. When equilibrium was reached, it was found that 20% of the $N_2O_4(g)$ had decomposed. If the equilibrium constant, K_c, for the reaction is 0,16 at 325°C, calculate the value of **X**. (8)

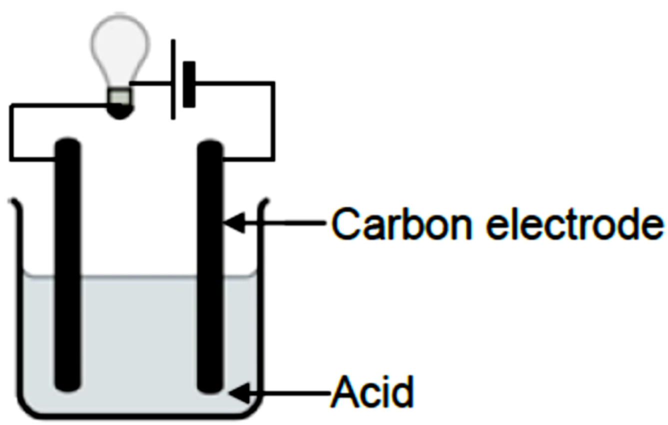
[16]

Question 7

7.1 The conductivity of three acid solutions, **A**, **B** and **C**, as shown below is investigated at the same temperature.

A	**0,1 $mol.dm^{-3}$ $HNO_3(aq)$**
B	**0,1 $mol.dm^{-3}$ $CH_3COOH(aq)$**
C	**0,1 $mol.dm^{-3}$ $H_2SO_4(aq)$**

The brightness of the bulb in the apparatus shown below is used as a measure of the conductivity of the solutions.



The acid solutions are electrolytes. The brightness of the bulb for each of the three solutions, **A**, **B** and **C**, is compared.

7.1.1 Define the term *electrolyte*. (2)

7.1.2 List solutions **A**, **B** and **C**, in order of INCREASING brightness of the bulbs. (2)

7.2 A hydrochloric acid solution, $HC\ell(aq)$, is standardised by titrating it against 25 cm^3 of a 0,04 $mol.dm^{-3}$ sodium carbonate solution, $Na_2CO_3(aq)$. At the end point, it is found that 19,5 cm^3 of $HC\ell(aq)$ has reacted.

$$Na_2CO_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + H_2O(\ell) + CO_2(g)$$

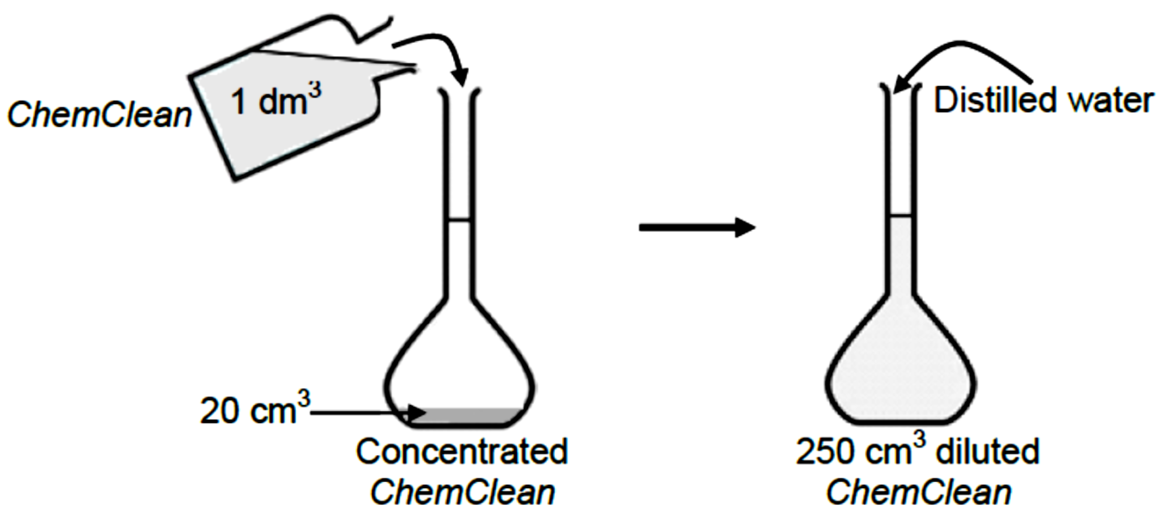
7.2.1 Define the term *end point*. (1)

7.2.2 Suggest a suitable indicator to use in this titration. Explain the reasoning for your choice. (3)

7.2.3 Calculate the concentration of the $HC\ell(aq)$. (3)

A concentrated household product, *ChemClean*, contains ammonia as the main cleaning agent. To determine the amount of ammonia present in 1 dm^3 of *ChemClean*, the following procedure is followed:

20 cm^3 of *ChemClean* is added to a 250 cm^3 flask. The flask is then filled to the 250 cm^3 mark with distilled water.



The diluted solution is titrated against the hydrochloric acid solution of the concentration as calculated in QUESTION 7.2.3. During the titration, 22 cm^3 of the diluted *ChemClean* solution is neutralised by 18,7 cm^3 of the $HC\ell$ solution. The balanced equation for the reaction is:

$$NH_3(aq) + HC\ell(aq) \rightarrow NH_4^+(aq) + C\ell^-(aq)$$

7.2.4 Calculate the mass of ammonia in 1 dm^3 of *ChemClean.* (7)

7.2.5 Will the pH of the solution at the end of the titration be GREATER THAN 7, EQUAL TO 7 or LESS THAN 7?
Write down a relevant equation to motivate your answer. (3)

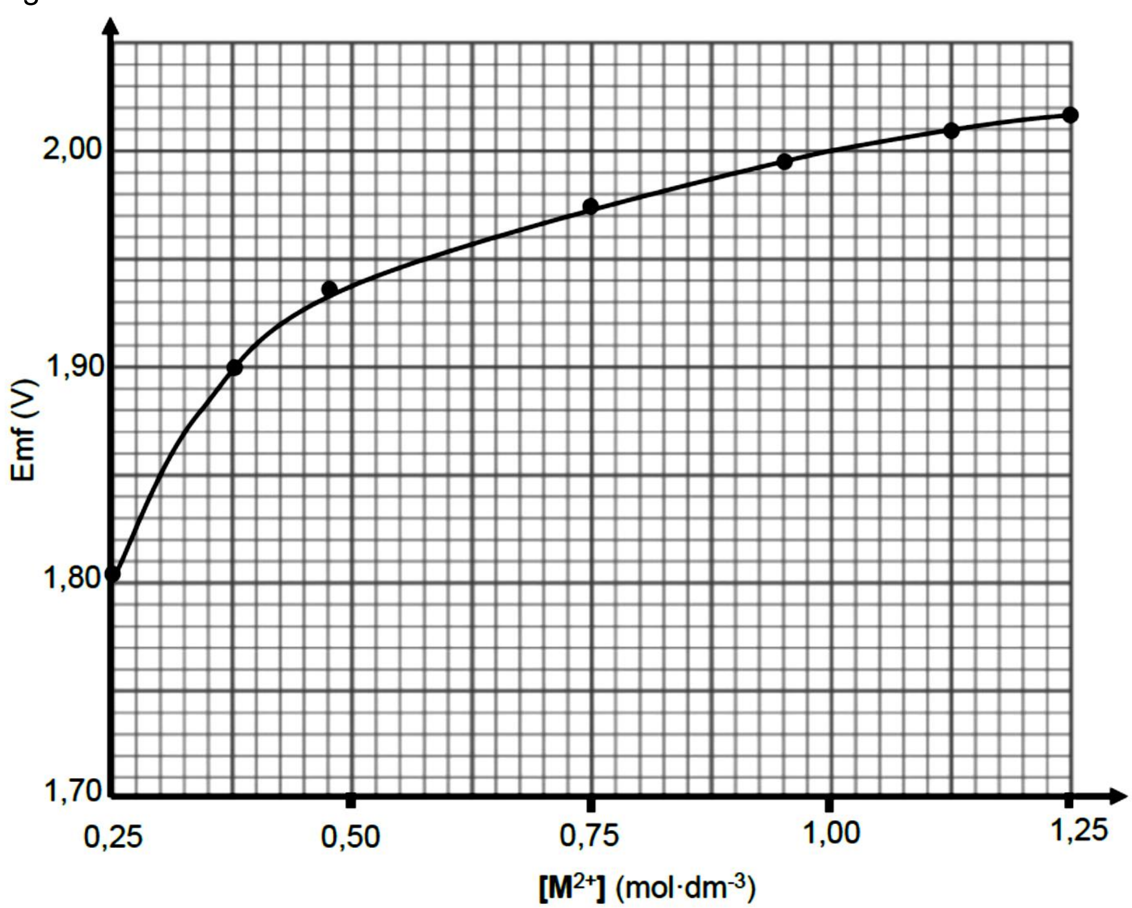
[21]

Question 8

The relationship between the concentration of the electrolyte and the cell potential of a galvanic cell is investigated using the electrochemical cell represented by the cell notation below:

$$A\ell(s) \mid A\ell^{3+}(aq) \parallel M^{2+}(aq) \mid M(s)$$

The concentration of M^{2+}(aq) is changed and the corresponding emf is measured. The concentration of $A\ell^{3+}$(aq) and the temperature are kept at standard conditions. The graph below shows the results of this investigation:



8.1 Define the term *reducing agent* in terms of electron transfer. (1)

8.2 Identify the reducing agent in this cell. (1)

8.3 State:

8.3.1 the energy conversion that takes place in this cell. (1)

8.3.2 the standard conditions for a cell of this type. (2)

8.4 A salt bridge is required to complete the circuit in this cell. State:

8.4.1 a suitable electrolyte for use in the salt bridge. (1)

8.4.2 the electrode (**Aℓ** or **M**) towards which the cations in the salt bridge will move. (1)

8.5 Determine the concentration of $M^{2+}(aq)$ that will produce an emf of 1,96 V. (2)

8.6 How will the concentration of $M^{2+}(aq)$ be affected as the cell operates? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

8.7 Identify metal **M** with the aid of a calculation. (5)

8.8 Metal **M** is now replaced by Calcium, Ca.

8.8.1 Which electrode, **Aℓ** or **Ca**, will be the anode in this new cell? (1)

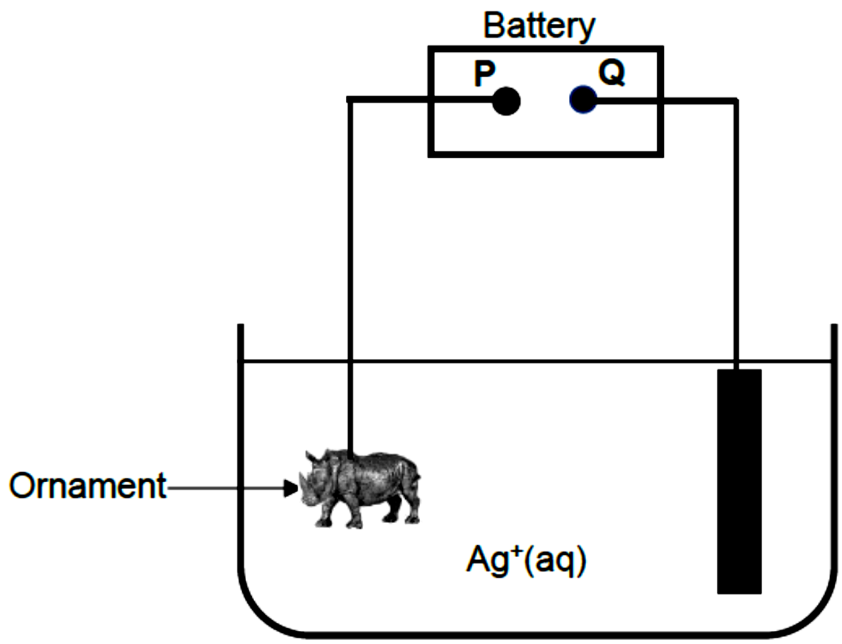
8.8.2 Refer to the relative strengths of the oxidising agents to explain the answer. (2)

[18]

Question 9

The simplified diagram below represents the cell used for electroplating ornaments with silver, Ag.

P and **Q** are the two terminals of the battery.



9.1 Is the reaction of this cell ENDOTHERMIC or EXOTHERMIC? (1)

9.2 Which terminal of the battery (**P** or **Q**) is positive? (1)

9.3 Write down the equation for the half-cell reaction that takes place at the cathode. (2)

9.4 What will happen to the concentration of $Ag^+(aq)$ during the electroplating process? Choose from INCREASE, DECREASE or REMAIN THE SAME.

Give a reason for your answer. (2)

9.5 Calculate the current needed to electroplate the ornament with 5 g of silver in 1 hour. (6)

[12]

Total 150

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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	
$I = \frac{Q}{\Delta t}$	$n = \frac{Q}{q_e}$ where n is the number of electrons/ *waar n die aantal elektrone is*

TABLE 4A: STANDARD REDUCTION POTENTIALS

Half-reactions			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
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 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
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 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
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 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 oxidising ability ↑

Increasing reducing ability/ ↓

TABLE 4B: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability ↓

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

Increasing reducing ability ↑

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

KEY/*SLEUTEL*

Electronegativity / *Elektronegatiwiteit*	Atomic number / *Atoomgetal*	Symbol / *Simbool*	Approximate relative atomic mass / *Benaderde relatiewe atoommassa*
1,9	29	Cu	63,5

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)
1 2,1 **H** 1																	2 **He** 4
3 1,0 **Li** 7	4 1,5 **Be** 9											5 2,0 **B** 11	6 2,5 **C** 12	7 3,0 **N** 14	8 3,5 **O** 16	9 4,0 **F** 19	10 **Ne** 20
11 0,9 **Na** 23	12 1,2 **Mg** 24											13 1,5 **Aℓ** 27	14 1,8 **Si** 28	15 2,1 **P** 31	16 2,5 **S** 32	17 3,0 **Cℓ** 35,5	18 **Ar** 40
19 0,8 **K** 39	20 1,0 **Ca** 40	21 1,3 **Sc** 45	22 1,5 **Ti** 48	23 1,6 **V** 51	24 1,6 **Cr** 52	25 1,5 **Mn** 55	26 1,8 **Fe** 56	27 1,8 **Co** 59	28 1,8 **Ni** 59	29 1,9 **Cu** 63,5	30 1,6 **Zn** 65	31 1,6 **Ga** 70	32 1,8 **Ge** 73	33 2,0 **As** 75	34 2,4 **Se** 79	35 2,8 **Br** 80	36 **Kr** 84
37 0,8 **Rb** 86	38 1,0 **Sr** 88	39 1,2 **Y** 89	40 1,4 **Zr** 91	41 **Nb** 92	42 1,8 **Mo** 96	43 1,9 **Tc**	44 2,2 **Ru** 101	45 2,2 **Rh** 103	46 2,2 **Pd** 106	47 1,9 **Ag** 108	48 1,7 **Cd** 112	49 1,7 **In** 115	50 1,8 **Sn** 119	51 1,9 **Sb** 122	52 2,1 **Te** 128	53 2,5 **I** 127	54 **Xe** 131
55 0,7 **Cs** 133	56 0,9 **Ba** 137	57 **La** 139	72 1,6 **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	81 1,8 **Tℓ** 204	82 1,8 **Pb** 207	83 1,9 **Bi** 209	84 2,0 **Po**	85 2,5 **At**	86 **Rn**
87 0,7 **Fr**	88 0,9 **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**