GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

# JUNE EXAMINATION
# GRADE 12

# 2024

## PHYSICAL SCIENCES: CHEMISTRY

## (PAPER 2)

**TIME:** 3 hours

**MARKS:** 150

**17 pages + 4 data sheets**

PHYSICAL SCIENCES P2

C2842E

X05

## INSTRUCTIONS AND INFORMATION

1. This question paper consists of EIGHT questions. Answer ALL the questions in the ANSWER BOOK.
2. Start EACH question on a NEW page in the ANSWER BOOK.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Leave ONE line open between two subquestions, e.g., between QUESTION 2.1 and QUESTION 2.2.
5. You may use a non-programmable calculator.
6. You may use appropriate mathematical instruments.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round-off your FINAL numerical answers to a minimum of TWO decimal places.
9. Give brief discussions, et cetera where required.
10. You are advised to use the attached DATA SHEETS.
11. Write neatly and legibly.

## QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

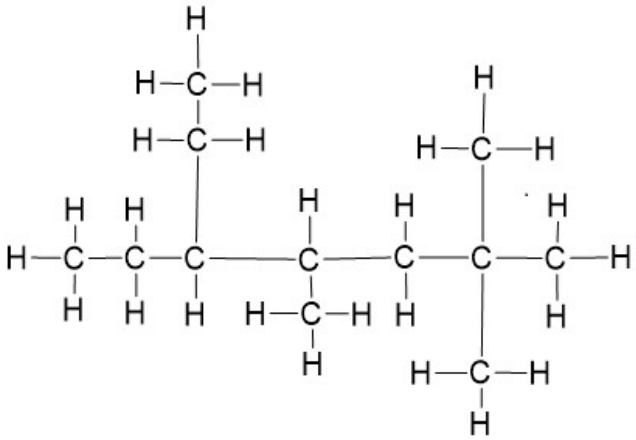
1.1 Consider the condensed structural formula below:

$$CH_3CH_2CH_2OH$$

What is the name of the functional group?

A Hydroxyl group
B Carbonyl group
C Formyl group
D Carboxyl group (2)

1.2 Consider the compound below:



Which of the following is the IUPAC name of this compound?

A 2,2,4-trimethyl-5-ethylheptane
B 4,6,6-trimethyl-3-ethylheptane
C 5-ethyl-2,2,4-trimethylheptane
D 3-ethyl-4,6,6-trimethylheptane (2)

1.3 Ethanal, ethanol, ethanoic acid, and ethane are compounds that are found in a laboratory.

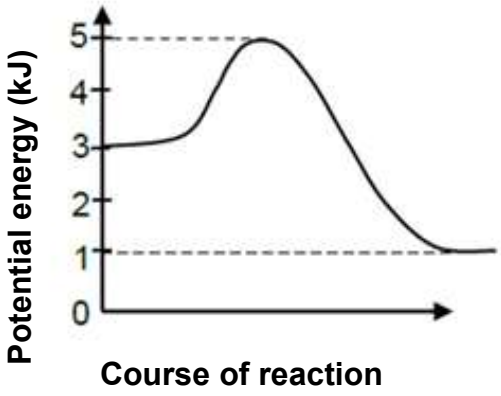
Arrange the compounds mentioned above in decreasing order of vapour pressure.

A Ethanoic acid, ethanol, ethanal, ethane
B Ethane, ethanal, ethanol, ethanoic acid
C Ethanoic acid, ethanal, ethanol, ethane
D Ethane, ethanol, ethanal, ethanoic acid (2)

1.4 Which of the following reaction types will be used to prepare ethene and propane from pentane under high temperatures and pressures?

A Combustion
B Esterification
C Catalytic cracking
D Thermal cracking (2)

1.5 The graph below represents the relationship between potential energy and course of reaction for a certain chemical reaction.




The heat of reaction for the reverse reaction is:

A 2 kJ
B 4 kJ
C -2 kJ
D -5 kJ (2)

1.6 The equation below represents the decomposition of calcium carbonate.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Which of the following factors will NOT affect the initial rate of decomposition of calcium carbonate?

A Increase in temperature
B Using powdered calcium carbonate
C Adding a catalyst
D Increasing the mass of calcium carbonate (2)

1.7 The reaction represented by the equation below reaches equilibrium.

$$\underset{\text{pink}}{Co(H_2O)_6^{+2}}\ (aq) + 4C\ell^-\ (aq) \rightleftharpoons \underset{\text{blue}}{CoC\ell_4^{-2}}\ (aq) + 6H_2O(\ell) \qquad \Delta H > 0$$

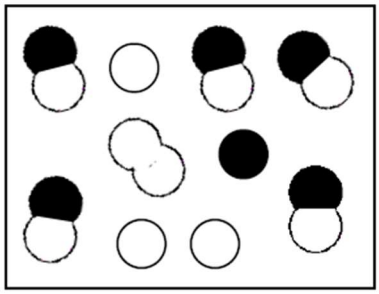
Which of the following changes to the reaction mixture will change its colour from pink to blue?

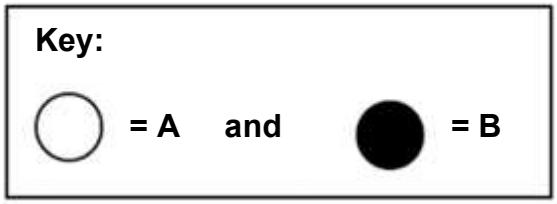
A Add a catalyst.
B Place the reaction mixture in a container with cold water.
C Add a few drops of concentrated hydrochloric acid to the reaction mixture.
D Add water to the reaction mixture. (2)

1.8 The following hypothetical reaction is at equilibrium at 500 K:

$$A_2(g) + B(g) \rightleftharpoons A(g) + AB(g)$$

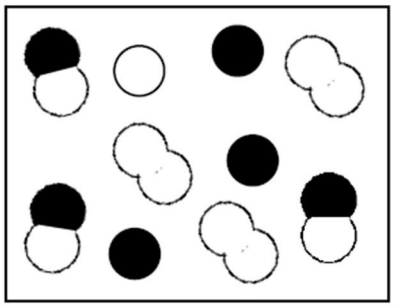
The diagram below shows the molecules involved in this chemical equilibrium at 500 K.






The temperature is decreased to 300 K.

The diagram below represents the same equilibrium mixture at 300 K.



Which of the following statements is CORRECT?

A The forward reaction is exothermic.
B The concentration of **AB** is lower at a lower temperature.
C The forward reaction is endothermic.
D The concentration of **B** is higher at a lower temperature. (2)

1.9 Which of the following is the CORRECT description for a 10 mol·dm$^{-3}$ hydrochloric acid solution?

A Dilute strong acid
B Dilute weak acid
C Concentrated weak acid
D Concentrated strong acid (2)

1.10 Consider the reaction represented by the following equation:

$$2Ag^{+}(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$$

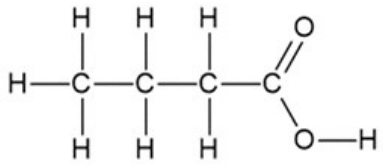
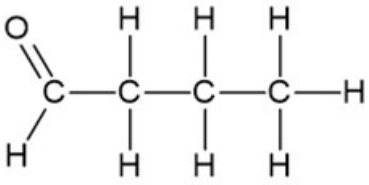
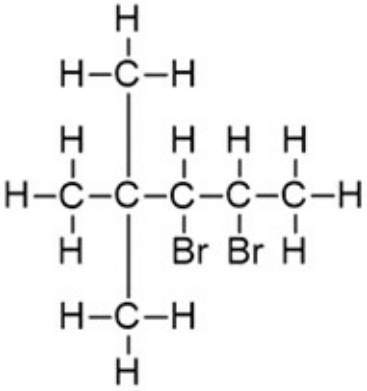
Which of the following represents the oxidising agent in the above reaction?

A $Ag^{+}$
B Cu
C Ag
D $Cu^{2+}$ (2)

**[20]**

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

**A** to **H** in the table below represents eight organic compounds.

| | | | |
|---|---|---|---|
| **A** |  | **B** | 2-methylbutan-2-ol |
| **C** | Pentan-2-one | **D** | $CH_3CH_2COCH_2CH_3$ |
| **E** | Butan-2-ol | **F** | Methyl propanoate |
| **G** |  | **H** |  |

Use the table above to answer the following questions.

2.1 Define the term *homologous series*. (2)

2.2 Consider the organic compound **G**.

2.2.1 Write down the homologous series to which this compound belongs. (1)

2.2.2 Write down the CONDENSED STRUCTURAL FORMULA. (1)

2.2.3 Write down the IUPAC name of the functional isomer of **G**. (2)

2.3 Write down the:

2.3.1 IUPAC name of compound **H** (3)

2.3.2 GENERAL FORMULA of the homologous series to which compound **A** belongs (1)

2.4 Write down the letter(s) of the compound(s) that represent(s):

2.4.1 The positional isomers (2)

2.4.2 An ester (1)

2.5 Consider the organic compound **B.**

2.5.1 Write down the STRUCTURAL FORMULA. (2)

2.5.2 Is compound **B** a PRIMARY, SECONDARY or TERTIARY alcohol? (1)

2.5.3 Explain the answer to QUESTION 2.5.2. (2)

2.6 Hydrocarbons are the principal constituents of petroleum and natural gas. A hydrocarbon consists of 81,82% carbon and 18,18% hydrogen.

Calculate the empirical formula of this hydrocarbon. (4)

**[22]**

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

A group of learners decide to conduct an investigation to compare the boiling points of the first three haloalkanes, namely chloromethane, chloroethane and 1-chloropropane.

The table below shows the results obtained from the investigation.

| COMPOUND | IUPAC NAME | BOILING POINT (°C) |
|---|---|---|
| **A** | chloromethane | -24,2 |
| **B** | chloroethane | 12,3 |
| **C** | 1-chloropropane | 46,6 |

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

3.2 Identify the:

3.2.1 Independent variable (1)

3.2.2 Dependent variable (1)

3.2.3 Controlled variable (1)

3.3 Write down a suitable investigative question. (2)

3.4 Chloromethane is highly flammable.

Write down ONE precaution that should be taken when working with this substance in the laboratory. (1)

3.5 Which ONE of these substances (**A**, **B**, or **C**) has the lowest vapour pressure? Give a reason for the answer. (2)

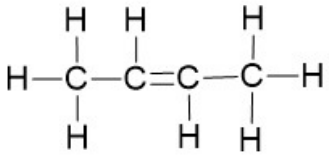
3.6 The learners find 1-chlorobutane in the laboratory.

How would the boiling point of 1-chlorobutane compare to that of 1-chloropropane?

Write only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

3.7 Explain the answer to QUESTION 3.6 by referring to the type of intermolecular forces, strength, and energy. (3)

3.8 The learners decide to do another investigation with compounds **J** and **K**.

| | | | |
|---|---|---|---|
| **J** |  | **K** | Butane |

Bromine water is used to distinguish between compounds **J** and **K** by adding it to each compound in two separate test tubes.

The learners observe that one compound decolourises the bromine water immediately, while the other substance only reacts after placing the test tube in direct sunlight.

Write down:

3.8.1 The letter (**J** or **K**) of the compound that will immediately decolourise the bromine water (1)

3.8.2 The reason that the other substance only reacts when placed in direct sunlight (1)

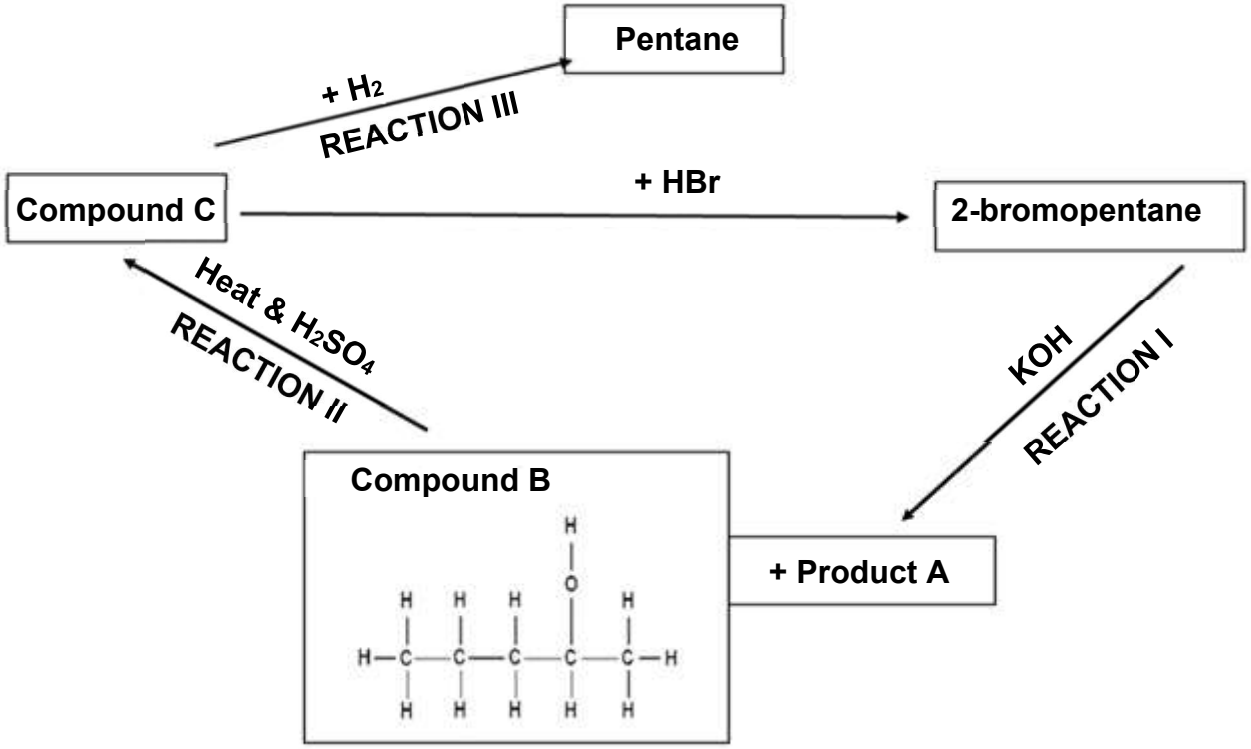
3.8.3 The MOLECULAR FORMULA of the organic product formed in the test tube containing compound **J** (2)

3.8.4 A balanced chemical equation when compound **K** undergoes complete combustion (3)

**[21]**

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

The flow diagram below shows three organic reactions, namely Reactions I, II and III. Various organic and inorganic products are formed as a result of these reactions.




Use the flow diagram above to answer the following questions.

4.1 Define the term *saturated compound*. (2)

4.2 2-bromopentane undergoes hydrolysis.

4.2.1 Name the type of reaction represented in Reaction I. (1)

4.2.2 Name the inorganic product **A** that is formed in the reaction. (1)

4.2.3 Give ONE reaction condition. (1)

4.3 Consider compound **B**.

4.3.1 Write down the IUPAC name. (2)

4.3.2 Name the type of reaction represented in Reaction II. (1)

4.3.3 Write down the STRUCTURAL FORMULA of the major product **C**. (2)

4.3.4 Write down the CHEMICAL FORMULA of the inorganic product formed in Reaction II. (1)

4.4 Consider Reaction III.

4.4.1 Name the type of addition reaction. (1)

4.4.2 Give the CHEMICAL FORMULA of the catalyst needed for this reaction. (1)

4.5 Esterification is one of the most important reactions in both organic synthesis and the chemical industry. When making an ester, 60 g of propan-1-ol reacts with excess ethanoic acid which produces 90,78 g of an ester and water.

The balanced chemical equation below shows the reaction that takes place.

$$C_3H_8OH\ (\ell) + CH_3COOH\ (aq) \rightarrow C_5H_{10}O_2\ (\ell) + H_2O\ (\ell)$$

4.5.1 Write down the STRUCTURAL FORMULA for the ester produced. (3)

4.5.2 Give the IUPAC name for the ester. (2)

4.5.3 Give the chemical name of the catalyst used. (1)

4.5.4 Calculate the percentage purity of propan-1-ol. (5)

**[24]**

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

A group of learners use the reaction between excess hydrochloric acid and magnesium ribbon to investigate one of the factors that influences the rate of a chemical reaction. The reaction that takes place is:

$$Mg(s) + 2HC\ell\ (aq) \rightarrow MgC\ell_2\ (aq) + H_2(g)$$

The learners follow the method shown below to conduct the investigation at room temperature. A diagram of the apparatus is given below.

**Method – Experiment 1:**

Step 1: Place a piece of magnesium ribbon in a conical flask and add 50 $cm^3$ $HC\ell$ (aq) of known concentration.

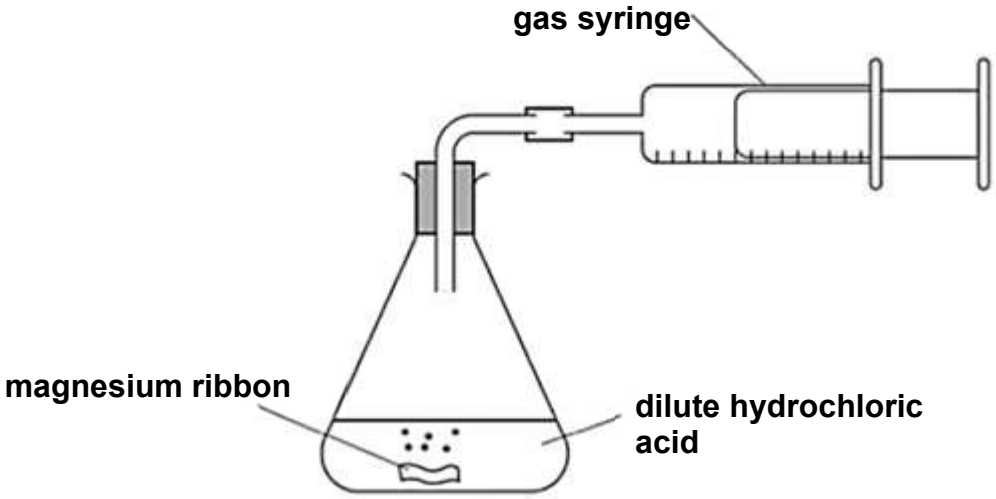
Step 2: Simultaneously start the stopwatch and close the flask with the rubber stopper containing the delivery tube.

Step 3: Measure the volume of the $H_2(g)$ formed in time intervals of 20 seconds.

**Method – Experiment 2:**

Repeat steps 1 to 3 above, but use only 15 $cm^3$ of the same $HC\ell$ (aq) diluted with 50 $cm^3$ distilled water.

**Apparatus:**




5.1 Define the term *reaction rate*. (2)

5.2 Write down a conclusion for this investigation. (2)

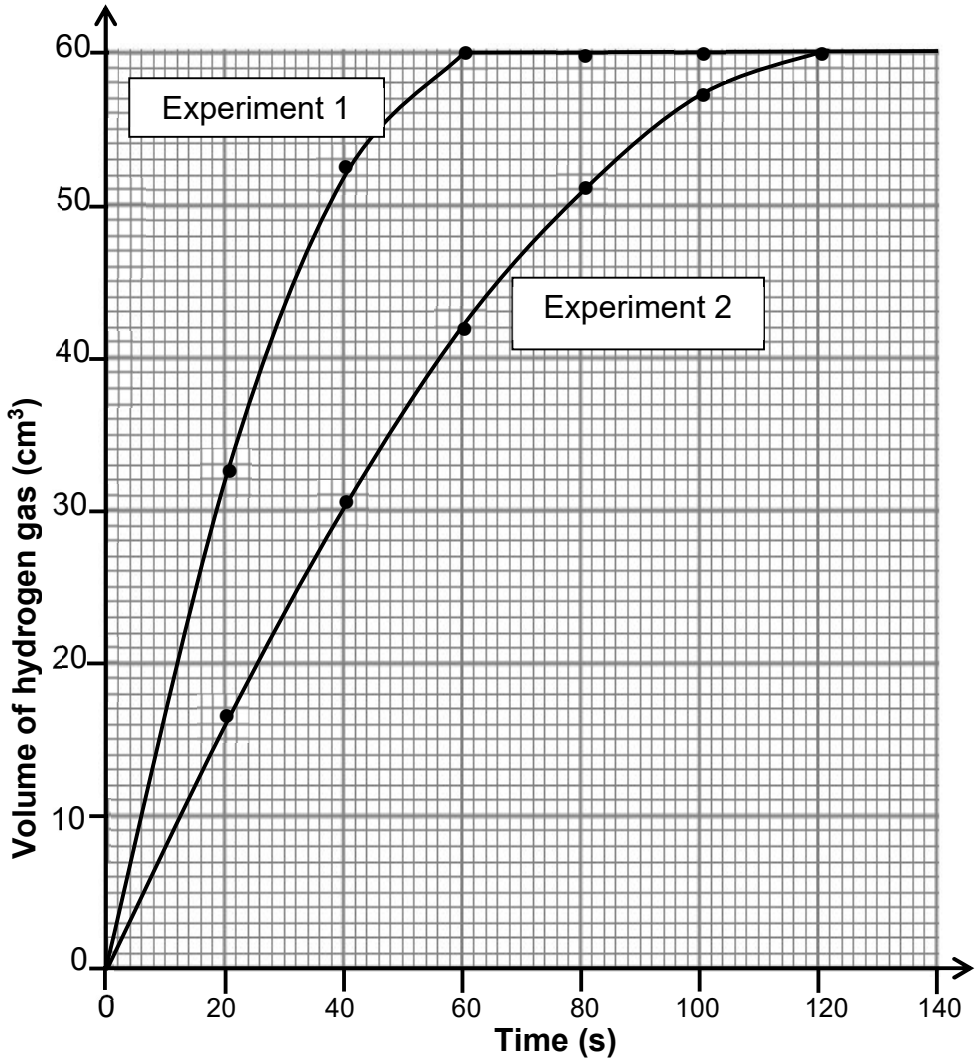
5.3 The concentration of the hydrochloric solution is 2 $mol \cdot dm^{-3}$.

Calculate the concentration used in Experiment **2**. (3)

5.4 Name TWO conditions that learners had to keep the same to ensure that this is a fair test. (2)

After completing the investigation, the learners represented the results obtained during each experiment on the graph below.

**Graph of volume of hydrogen gas versus time**




5.5 Give a reason why the same volume of hydrogen gas is formed in both experiments. (1)

5.6 Write down the volume of hydrogen gas formed during the first minute in:

5.6.1 Experiment **1** (1)

5.6.2 Experiment **2** (1)

5.7 Which ONE of the experiments (Experiment **1** or Experiment **2**) took place at a faster rate? Use the graph to explain the choice. (3)

5.8 Calculate the average reaction rate with respect to the magnesium, in $g \cdot s^{-1}$, in Experiment **1** if the molar volume at room temperature is 24 $dm^3$. (5)

**[20]**

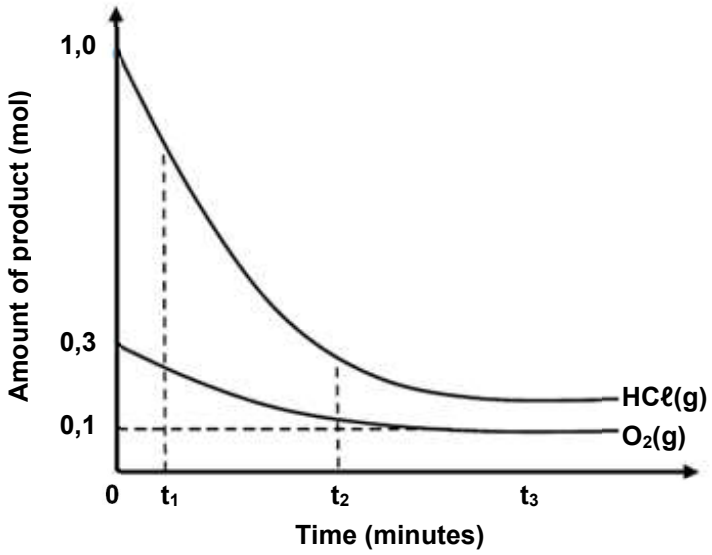
**QUESTION 6 (Start on a new page.)**

The reaction between steam and chlorine gas reaches equilibrium in a closed container according to the following balanced equation:

$$2H_2O(g) + 2C\ell_2(g) \rightleftharpoons 4HC\ell(g) + O_2(g) \qquad \Delta H = +113 \text{ kJ}$$

6.1 Is this reaction EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer. (2)

6.2 The graphs below, not drawn to scale, show how the amount of products present in the container change with time at a specific temperature. The volume of the container is 5 $dm^3$.




6.2.1 Which reaction is favoured? Choose from FORWARD or REVERSE? Give a reason for the answer. (2)

6.2.2 How do the rates of the forward and the reverse reactions compare at time $t_3$?

Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

6.2.3 Calculate the equilibrium constant (Kc) for this reaction at this temperature if there was initially 5 g of water and 5 g of chlorine. (9)

6.3 The pressure is NOW increased. How will this change affect the value of the equilibrium constant?

Write down only INCREASE, DECREASE or REMAINS THE SAME. Give a reason for the answer (2)

6.4 The reaction is repeated with a catalyst. Draw a potential energy diagram of this reaction and indicate the non-catalysed reaction (**B**) and catalysed reaction (**A**) on the same graph. (4)

**[20]**

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

7.1 Sulphuric acid is a diprotic acid.

7.1.1 Define the term *ACID* in terms of the Arrhenius theory. (2)

7.1.2 Give a reason why sulphuric acid is referred to as a diprotic acid. (1)

7.2 The hydrogen carbonate ion can act as both an acid and a base. It reacts with water according to the following balanced equation:

$$HCO_3^-(aq) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$$

7.2.1 Write down ONE word for the underlined phrase above. (1)

7.2.2 Copy the equation above and indicate the conjugate acid-base pairs. (2)

7.3 A laboratory assistant was asked to prepare a 2 500 $cm^3$ solution of $HC\ell$ with a concentration of 0,25 $mol \cdot dm^{-3}$. The laboratory had a bottle of concentrated $HC\ell$ which had the following written on the label:

| | |
|---|---|
| Chemical: | $HC\ell$ |
| Density: | 1,20 $g \cdot cm^{-3}$ |
| % $HC\ell$ by mass in solution: | 36% |

7.3.1 Calculate the mass of $HC\ell$ contained in 2 500 $cm^3$ of a 0,25 $mol \cdot dm^{-3}$ solution. (4)

7.3.2 50 $cm^3$ of the 0,25 $mol \cdot dm^{-3}$ $HC\ell$ solution is used to neutralise 20 $cm^3$ of a sodium carbonate ($Na_2CO_3$) solution.

$$2HC\ell + Na_2CO_3 \rightarrow 2NaC\ell + H_2O + CO_2$$

Calculate the concentration of the carbonate solution. (4)

7.3.3 Name a suitable indicator that can be used for this titration. Give a reason for the answer. (2)

**[16]**

**QUESTION 8 (Start on a new page.)**

8.1 A clean piece of copper (Cu) is placed in a solution of silver nitrate ($AgNO_3$). The balanced net ionic equation is:

$$Cu\ (s) + 2\ Ag^{+}\ (aq) \rightarrow Cu^{2+}\ (aq) + 2\ Ag\ (s)$$

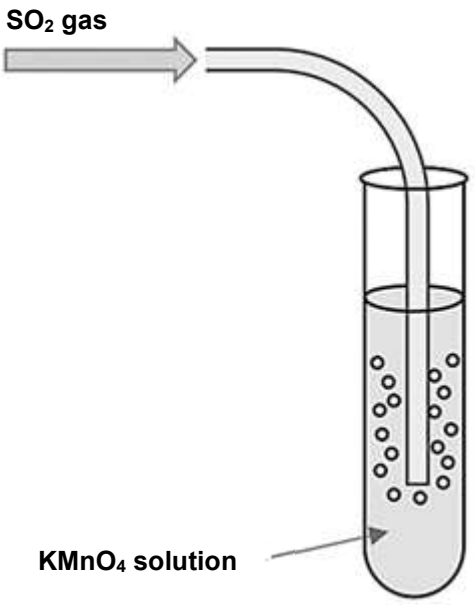
8.1.1 Define *oxidation* in terms of electron transfer. (2)

8.1.2 What type of reaction does copper (Cu) undergo in this equation?

Choose from OXIDATION or REDUCTION.

Explain the answer by referring to oxidation numbers. (3)

8.2 Sulphur dioxide gas ($SO_2$) is bubbled into an acidified solution of potassium permanganate as shown in the diagram below.




It is observed that the solution turns from purple to colourless due to the reduction of $MnO_4^{2-}$ ions to $Mn^{2+}$ ions. During the reaction $SO_2$ is oxidised to sulphate ions, $SO_4^{2-}$.

Determine the oxidation number of manganese, in the permanganate ion ($MnO_4^{2-}$). (2)

**[7]**

**TOTAL: 150**

# DATA FOR PHYSICAL SCIENCES GRADE 12
# PAPER 2 (CHEMISTRY)

## *GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12*
## *VRAESTEL 2 (CHEMIE)*

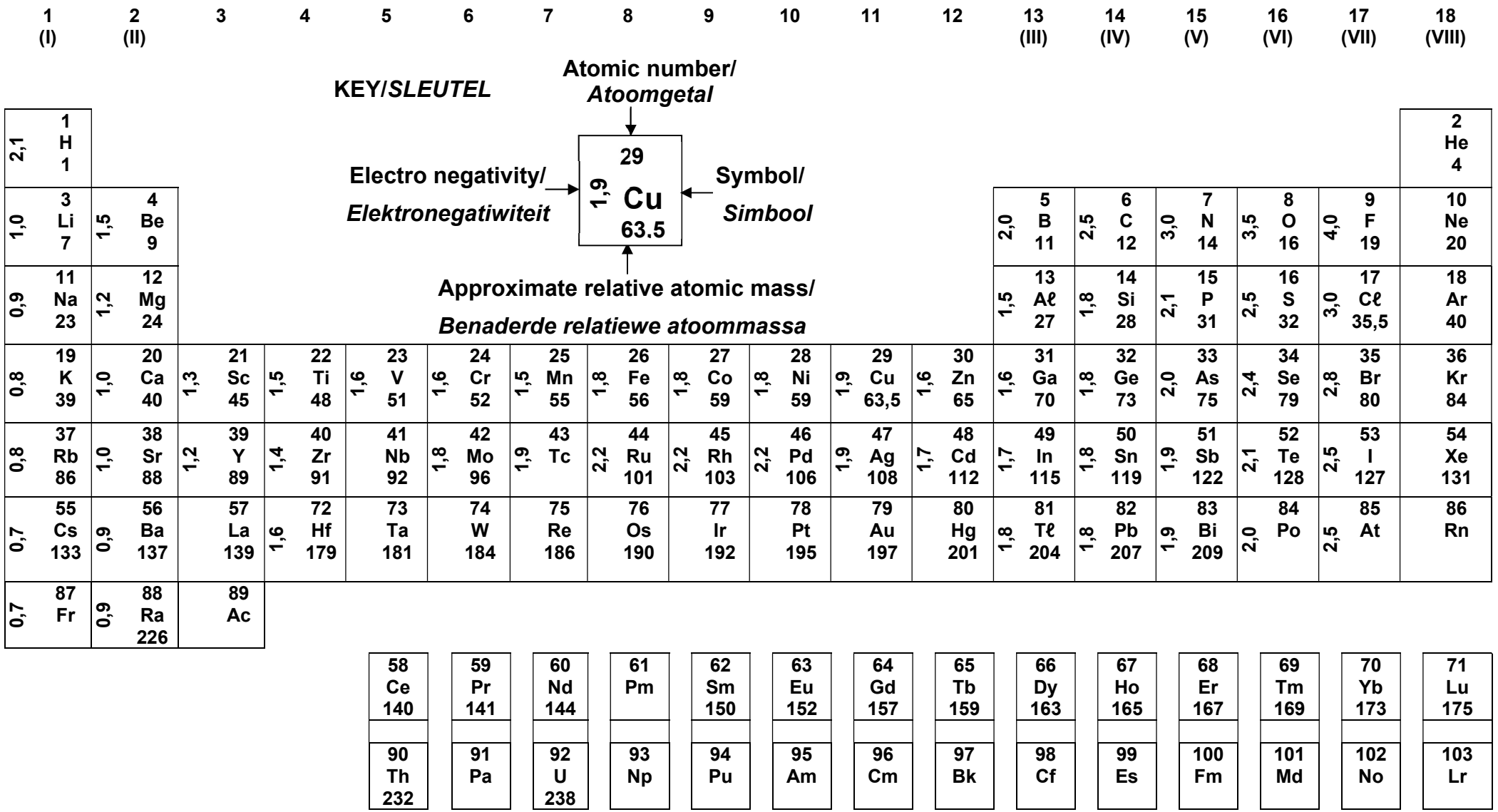
### TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

| NAME/*NAAM* | SYMBOL/*SIMBOOL* | VALUE/*WAARDE* |
|---|---|---|
| Standard pressure<br>*Standaarddruk* | $p^{\theta}$ | $1{,}013 \times 10^5$ Pa |
| Molar gas volume at STP<br>*Molêre gasvolume by STD* | $V_m$ | 22,4 $dm^3 \cdot mol^{-1}$ |
| Standard temperature<br>*Standaardtemperatuur* | $T^{\theta}$ | 273 K |
| Charge on electron<br>*Lading op elektron* | e | $-1{,}6 \times 10^{-19}$ C |
| Avogadro's constant<br>*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 $c = \frac{m}{MV}$ | $n = \frac{V}{V_M}$ |
| $\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$ | pH = - log[$H_3O^+$] |
| $K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/by 298 K | |
| $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$<br>or/of<br>$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$<br>or/of<br>$E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$ | |

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



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

| Half-reactions/*Halfreaksies* | | | $E^{\theta}$ (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/*Toenemende oksiderende vermoë*** ↑

**Increasing reducing ability/*Toenemende reduserende vermoë*** ↓

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

| Half-reactions/*Halfreaksies* | | | $E^{\theta}$ (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 |