education

Department of
Education
FREE STATE PROVINCE

EXAMINATION

GRADE 12

PHYSICAL SCIENCES

PAPER 2

JUNE 2026

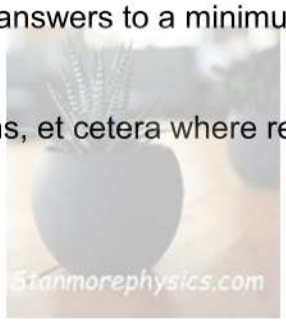
MARKS: 150

TIME: 3 HOURS

This paper consists of 13 pages and four information sheets.

INSTRUCTIONS AND INFORMATION

1. Write your name and other information in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of eight (8) questions. Answer ALL 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 pocket calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your FINAL numerical answers to a minimum of TWO decimal places where applicable.
11. Give brief motivations, discussions, et cetera where required.
12. Write neatly and legibly.



QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write down only the letter A, B, C or D next to the question number (1.1–1.10) in your ANSWER BOOK.

1.1 Which of the following is a molecular formula for an alkyne?

A C_2H_2

B C_2H_4

C C_2H_6

D C_2H_8 (2)

1.2 Which one of the following organic compounds is expected to have the lowest boiling point at room temperature?

A $CH_3CH_2CH_2CH_2CHO$

B $CH_3CH_2CH_2COOCH_3$

C $CH_3(CH_2)_3COOH$

D $CH_3CH_2CH_2CH_3$ (2)

1.3 Identify the product formed and type of reaction when 2-bromopropane reacts with a strong concentrated base KOH.

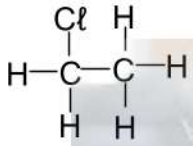
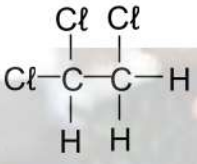
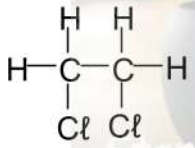
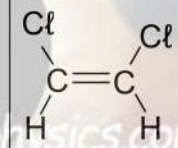
A Propene; Elimination.

B Propene; Substitution.

C Propan-2-ol; Substitution

D Propan-2-ol, Elimination (2)

1.4 Which of the following represents the product that forms for the addition reaction between ethene and chlorine, $C\ell_2$

A		B	
C		D	

(2)

1.5 Which of the following best describes an endothermic reaction?

A ΔH is negative and heat is released.

B ΔH is positive and heat is absorbed.

C No energy is transferred to or from the surroundings.

D The products are at a lower energy level than the reactants. (2)

1.6 Which of the following best defines the rate of a chemical reaction?

A The decrease in mass of reactants per unit time.

B The total time taken for the reaction to complete.

C The number of effective collisions per unit volume.

D The change in concentration of reactants or products per unit time. (2)

1.7 A learner conducts an experiment where 50 cm^3 of 0,1 $mol \cdot dm^{-3}$ hydrochloric acid solution is added to 5 g of zinc granules in a glass beaker at room temperature.

Which of the following changes will NOT increase the initial rate of the reaction between hydrochloric acid and zinc?

A Using a larger beaker for the reaction.

B Increasing the temperature of the solution.

C Using powdered zinc instead of granulated zinc.

D Increasing the concentration of hydrochloric acid. (2)

1.8 Which ONE of the following statements is TRUE for the effect of a catalyst on a reaction at equilibrium?

A The activation energy for the reverse reaction increases.

B The rate of both the forward and reverse reaction increases.

C The enthalpy change, ΔH, for the forward reaction decreases.

D The equilibrium constant decreases. (2)

1.9 Reaction at equilibrium is given below:

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

If the brown colour of NO_2 becomes lighter when the system is COOLED, this means:

A K_c decreases with temperature

B The forward reaction is faster

C The forward reaction is endothermic

D The forward reaction is exothermic (2)

1.10 According to Arrhenius model, a base is …

A a source of H^+ in water.

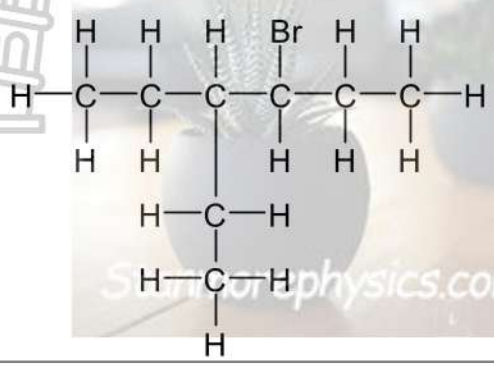
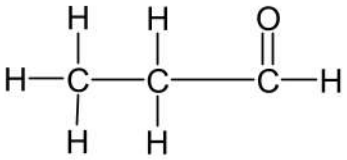
B a source of OH^- in water.

C a proton donor.

D a proton acceptor. (2)
[20]

QUESTION 2

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

A	2,2,4-trimethylhexane	B	$CH_3CH_2COOCH_2CH_3$
C		D	
E	C_3H_6O	F	2-methylpropan-2-ol

2.1 Define the term *molecular formula*. (2)

2.2 Consider compound **C** and write down the:

2.2.1 IUPAC name (3)

2.2.2 condensed structural formula (2)

2.3 Compounds **D** and **E** are isomers.

2.3.1 Write down the IUPAC name of compound **E**. (2)

2.3.2 Name of the functional group of compound **D** (1)

2.3.3 What type of isomers are compounds **D** and **E**? (1)

2.3.4 Explain the answer to QUESTION 2.3.3 (2)

2.4 Compound **F** is a tertiary alcohol.

2.4.1 Explain what is meant by a tertiary alcohol. (2)

2.4.2 Write down the structural formula for the SECONDARY alcohol having the same molecular formula as compound **F**. (2)

2.5 Draw the structural formula of the following compounds

2.5.1 **A** (3)

2.5.2 **B** (2)

[22]

QUESTION 3

The boiling points of some organic molecules determined experimentally are given in the table below.

X is the unknown boiling point for compound **D**.

	Compound	Boiling point (°C)
A	Hexane	68,7
B	Pentane	36,1
C	Butane	- 0,5
D	Propan-1-ol	**X**
E	Propanoic acid	141,15

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

The boiling points of compounds **A**, **B** and **C** are compared.

3.2 Name the intermolecular force responsible for the difference in these boiling points. (1)

3.3 Name the independent variable for the three alkanes. (1)

3.4 Explain the trend in the boiling points in the table. (3)

3.5 Which one of the compounds **A**, **B** or **C** has the highest vapour pressure?

Give a reason for the answer. (2)

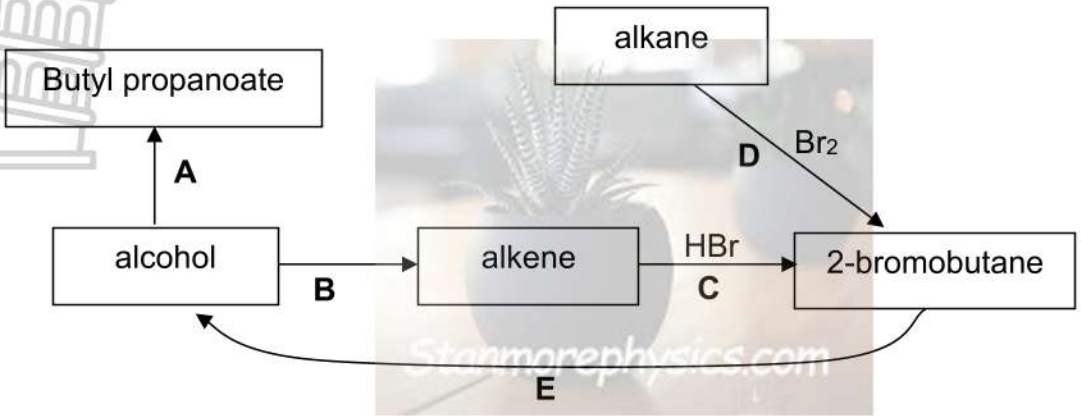
The boiling points of compounds **D** and **E** are compared.

3.6 Will **X**, the boiling point of **D**, be GREATER THAN, LESS THAN or EQUAL TO 141,15 °C?

Fully explain the answer. (4)
[13]

QUESTION 4

In the flow diagram below, an alkane and alcohol are used as starting reactants to form different organic compounds under certain reaction conditions.



4.1 Define the term *halogenation*. (2)

4.2 Write down the type of reaction that occurs at:

4.2.1 Reaction **B** (1)

4.2.2 Reaction **C** (1)

4.3 For reaction **D**:

4.3.1 Write down ONE reaction condition. (1)

4.3.2 Use a condensed structure to write down a balanced chemical equation. (3)

4.4 For reaction **E**, write down the:

4.4.1 type of substitution reaction (1)

4.4.2 TWO reaction conditions. (2)

4.4.3 structural formula of the alcohol formed. (2)

4.5 For reaction **A**, write down the:

4.5.1 the structural formula of the carboxylic acid used in this reaction. (2)

4.5.2 name of an inorganic reactant needed for this reaction. (1)

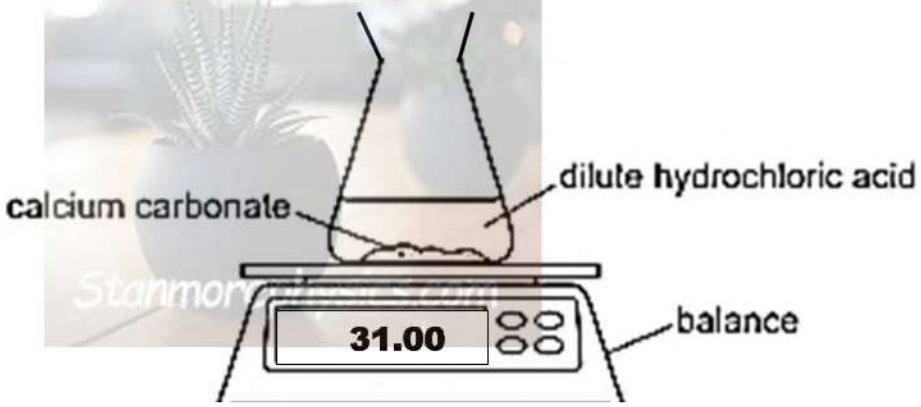
4.5.2 IUPAC name of functional isomer of butyl propanoate. (1)
[17]

QUESTION 5

5.1 The reaction between **X** g of powdered calcium carbonate ($CaCO_3$) and EXCESS dilute hydrochloric acid ($HC\ell$) takes place in a beaker according to the balanced equation below:

$$2HC\ell(aq) + CaCO_3(s) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

The apparatus used are illustrated below.



The results obtained are summarised in the table below:

Mass of beaker, $HC\ell$ and $CaCO_3$ in grams	31,00	30,60	30,30	30,01	30,00	30,00	30,00
Time (s)	0	10	20	30	40	50	60

5.1.1 Define the term *limiting reagent*. (2)

5.1.2 What can be deduced between time interval 40 s to 60 s? (1)

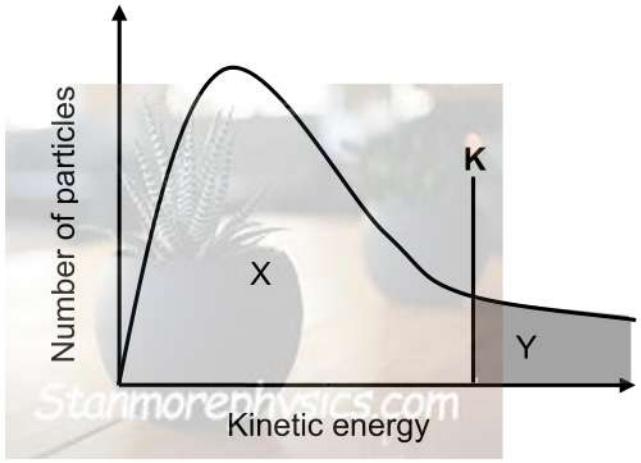
5.1.3 Give a reason for the decrease in the mass of the beaker. (2)

5.1.4 Give TWO reaction conditions for effective collisions to occur according to the collision theory. (2)

5.1.5 Calculate the volume of CO_2 (g) produced in cm^3 at STP. (5)

5.1.6 Calculate the rate of the reaction for the first 10s of the reaction in $mol \cdot s^{-1}$. (6)

5.1.7 The Maxwell-Boltzmann distribution curve for the particles of CO_2 (g) are shown below.



(a) What does the line **K** represent? (1)

(b) What is represented by the UNSHADED area (X) under the curve? (1)

(c) Redraw the above graph in your answer book. Draw on the same set of axes the graph that will be obtained when a suitable catalyst is added to the reaction and name it **M**. (2)

(d) Use the collision theory to fully explain the effect that the addition of a suitable catalyst has on the reaction rate. (4)
[26]

QUESTION 6

During the Haber process, nitrogen gas reacts with hydrogen gas to form ammonia

The reaction is represented by the following chemical equation:

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

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

6.2 Define the term *activated complex* (2)

6.3 Sketch a fully labelled potential energy versus course of reaction diagram for the REVERSE REACTION. Your diagram should show the following:

- Reactants and products
- Activation energy (E_a)
- ΔH

(4)
[8]

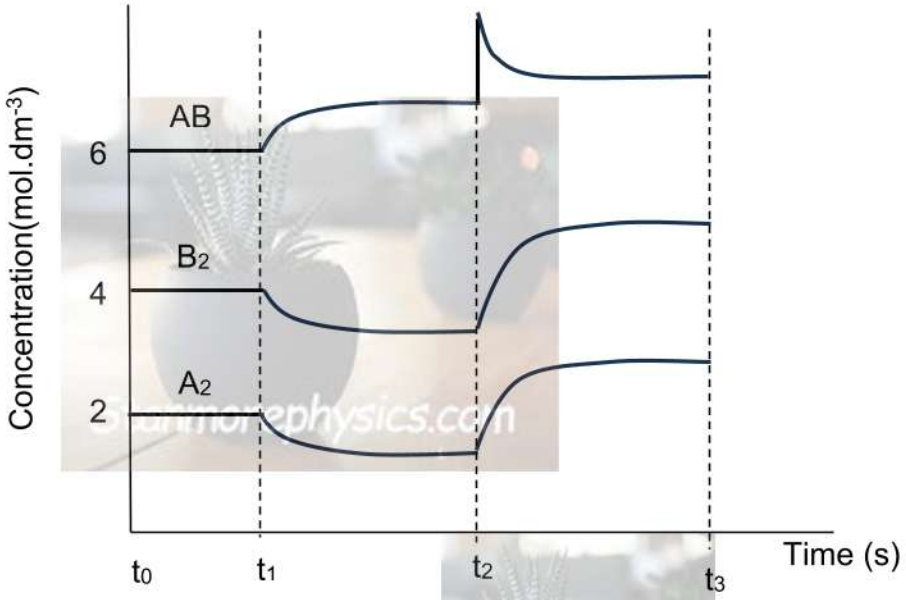
QUESTION 7

7.1 Consider a hypothetical reaction below in which more energy is absorbed than released for the forward reaction.

$$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$$

The equilibrium is reached at temperature of 25 °C.

The concentrations of the reactants and product are represented in the graph below.



7.1.1 What is meant by a reversible reaction? (1)

7.1.2 What can be said about the reaction in the time interval t_0-t_1 of the graph? Explain. (2)

7.1.3 Calculate the K_c value during the time interval t_0 to t_1 at this temperature if the volume of the closed container is 2 dm^3. (4)

Changes were made at certain times.

7.1.4 State Le Chatelier's principle. (2)

Use Le CHATELIER'S PRINCIPLE to fully explain the changes that

7.1.5 occurred at t_1. (4)

7.1.6 was made at t_2. (4)

7.1.7 What effect will the following have on the RATE at t_3:

Fully explain the answer in each.

(a) Addition of a catalyst. (2)

(b) Decrease in pressure. (2)

7.2 A teacher uses the reaction between cobalt chloride ($CoC\ell_2$) and its complex ion, $Co(H_2O)_6^{2+}$, to demonstrate the effect of concentration on the position of the equilibrium.

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

Blue Pink

7.2.1 State two conditions required for the reaction to be at equilibrium. (2)

7.2.2 More chloride ions ($C\ell^-$) are added to the system. How will the concentration of the pink complex ion, $Co(H_2O)_6^{2+}$, be affected? Explain the answer. (3)

7.2.3 By using Le Chatelier's principle, explain how the equilibrium mixture will change when a silver nitrate ($AgNO_3$) solution is added. (4)

[30]

QUESTION 8

8.1 Sulphuric acid, H_2SO_4, ionises into two steps as follows:

I $H_2SO_4(aq) + H_2O(\ell) \rightleftharpoons HSO_4^-(aq) + H_3O^+(aq)$

II $HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$

8.1.1 Define a *base* in terms of the Lowry-Brønsted theory. (2)

8.1.2 Write down the NAME or FORMULA of the substance that acts as an ampholyte in the above equations. Give a reason for the answer. (2)

8.2 The concentration of a nitric acid solution, $HNO_3(aq)$, is 0,096 mol·dm^{-3} at 25 °C.

8.2.1 Calculate the pH of this nitric acid solution. (3)

This HNO_3 solution reacts with sodium carbonate, Na_2CO_3, according to the following balanced equation:

$$2HNO_3(aq) + Na_2CO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(\ell)$$

50 cm^3 of this HNO_3 solution is added to 25 cm^3 of a 0,075 mol·dm^{-3} Na_2CO_3 solution.

8.2.2 Calculate the concentration of the EXCESS HNO_3 in the new solution. (7)
[14]

GRAND TOTAL: 150

Information Sheets – Paper 2 (Chemistry)

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature	T^{θ}	273 K
Charge on electron	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ OR $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ OR $E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent}$	

TABLE 4A: STANDARD REDUCTION POTENTIALS

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

Increasing strength of oxidising agents ↑

Increasing strength of reducing agents ↓

TABLE 4B: STANDARD REDUCTION POTENTIALS

Half-reactions			$E^{\ominus}$ (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
$Al^{3+} + 3e^-$	⇌	Al	− 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
$Cl_2(g) + 2e^-$	⇌	$2Cl^-$	+ 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 strength of oxidising agents ↓

Increasing strength of reducing agents ↑

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
2,1 **H** 1																	2 **He** 4
1,0 **Li** 7	1,5 **Be** 9											2,0 **B** 11	2,5 **C** 12	3,0 **N** 14	3,5 **O** 16	4,0 **F** 19	**Ne** 20
0,9 **Na** 23	1,2 **Mg** 24											1,5 **Aℓ** 27	1,8 **Si** 28	2,1 **P** 31	2,5 **S** 32	3,0 **Cℓ** 35,5	**Ar** 40
0,8 **K** 39	1,0 **Ca** 40	1,3 **Sc** 45	1,5 **Ti** 48	1,6 **V** 51	1,6 **Cr** 52	1,5 **Mn** 55	1,8 **Fe** 56	1,8 **Co** 59	1,8 **Ni** 59	1,9 **Cu** 63,5	1,6 **Zn** 65	1,6 **Ga** 70	1,8 **Ge** 73	2,0 **As** 75	2,4 **Se** 79	2,8 **Br** 80	**Kr** 84
0,8 **Rb** 86	1,0 **Sr** 88	1,2 **Y** 89	1,4 **Zr** 91	**Nb** 92	1,8 **Mo** 96	1,9 **Tc**	2,2 **Ru** 101	2,2 **Rh** 103	2,2 **Pd** 106	1,9 **Ag** 108	1,7 **Cd** 112	1,7 **In** 115	1,8 **Sn** 119	1,9 **Sb** 122	2,1 **Te** 128	2,5 **I** 127	**Xe** 131
0,7 **Cs** 133	0,9 **Ba** 137	**La** 139	1,6 **Hf** 179	**Ta** 181	**W** 184	**Re** 186	**Os** 190	**Ir** 192	**Pt** 195	**Au** 197	**Hg** 201	1,8 **Tℓ** 204	1,8 **Pb** 207	1,9 **Bi** 209	2,0 **Po**	2,5 **At**	**Rn**
0,7 **Fr**	0,9 **Ra** 226	**Ac**															

Ce 140	**Pr** 141	**Nd** 144	**Pm**	**Sm** 150	**Eu** 152	**Gd** 157	**Tb** 159	**Dy** 163	**Ho** 165	**Er** 167	**Tm** 169	**Yb** 173	**Lu** 175
Th 232	**Pa**	**U** 238	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**

KEY

Atomic number → 29 Cu 63,5 ← Symbol

Electronegativity → 1,9

Approximate relative atomic mass ↑