higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PHYSICAL SCIENCE
(Second Paper)
NQF LEVEL 4

(10021004)

15 March 2018 (Y-Paper)
13:00–16:00

This question paper consists of 14 pages, 4 information sheets and 1 periodic table.

TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. ALL final answers must be approximated to TWO decimals.
5. Cross out ALL work that you do not want to be marked.
6. Write with blue or black ink only.
7. Write neatly and legibly.

SECTION A

QUESTION 1

Give ONE word or term for each of the following descriptions. Write only the word or term next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 Chemical substance which produces hydronium ions in water.

1.2 Organic compound which has single bonds between the carbon atoms.

1.3 Type of substance which accepts electrons during a chemical reaction.

1.4 Mass per volume unit of a substance.

1.5 Spontaneous disintegration of the nuclei of an atom with the emission of α, β or γ rays.

(5 × 1) **[5]**

QUESTION 2

Choose a description from COLUMN B that matches a word in COLUMN A. Write only the letter (A–I) next to the question number (2.1–2.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
2.1	Graphite	A	produces “acid-rain”
2.2	Sulphur	B	encourages the production of roots and stem
2.3	Sulphur dioxide	C	an allotrope of sulphur
2.4	Cryolite	D	encourages the production of flowers and seeds
2.5	Ammonia	E	energy required to break chemical bonds
		F	element used industrially to manufacture sulphuric acid
		G	reduces the melting point of Al_2O_3
		H	used to manufacture nitric acid
		I	used as an electrode in electrolysis of aluminium

(5 × 1) **[5]**

QUESTION 3

Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1–3.5) in the ANSWER BOOK.

3.1 The sun's energy is produced by fusion reactions.

3.2 The functional group of ethanol is the carboxyl group.

3.3 The removal of water from a compound during a reaction is known as HYDRATION.

3.4 The rate of a reaction can be measured in $mol \cdot dm^{-3} \cdot s^{-1}$.

3.5 Hydrostatics is the study of liquids at rest.

(5 × 2) **[10]**

QUESTION 4

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 The nucleus of the radioactive atom $^{238}_{92}U$ has …

A 238 protons and 92 neutrons.

B 238 neutrons and 92 protons.

C 92 protons and 146 neutrons.

D 92 neutrons and 146 protons.

4.2 In a reversible chemical reaction, the activation energy for the forward reaction is 80 kJ. If the activation energy for the reverse reaction is 60 kJ, then ΔH for the forward reaction is …

A + 20 kJ

B - 20 kJ

C +140 kJ

D - 140 kJ

4.3 When a 0,1 mol.dm^{-3} HCl solution is added to a litre of water the …

A pH of the water decreases.

B pH of the water does not change.

C electrical conductivity of the water decreases.

D pH and electrical conductivity of the water decreases.

4.4 The following reaction has reached chemical equilibrium:

$$2\,NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H < 0$$

Which ONE of the changes below will shift the equilibrium to the RIGHT?

A Adding a catalyst

B Adding more $O_2(g)$

C Decreasing the pressure

D Increasing the temperature

4.5 The use of nuclear energy to produce electricity is opposed mainly because ...

A there is a limited supply of fuel available.

B the spent fuel is a radioactive hazard to life.

C it is a very expensive way to generate electricity.

D it produces gases which contribute to global warming.

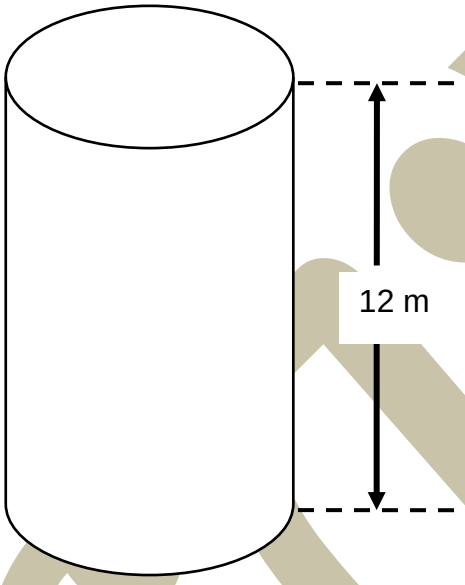
(5 × 3) **[15]**

TOTAL SECTION A: 35

SECTION B

QUESTION 5 (Start on a new page.)

5.1 A circular tank with a radius of 5 m and a height of 12 m is filled to the top with a liquid of density 1,2 kg·m^{-3}.



Calculate the net pressure at the bottom of the tank. Assume that atmospheric pressure is 100 kPa. (4)

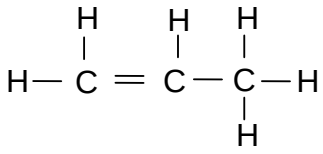
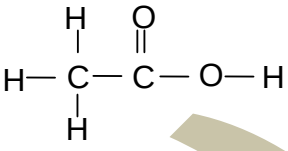
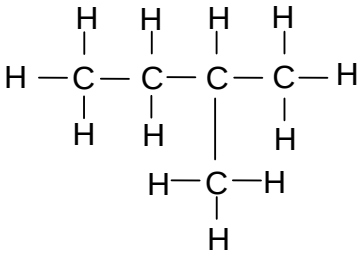
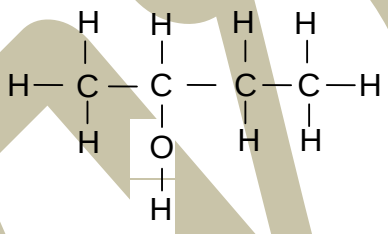
5.2 Define hydrostatic pressure. (2)

5.3 What is the relationship between hydrostatic pressure and density? (2)

5.4 Name the principle on which a hydraulic press functions. (1)
[9]

QUESTION 6 (Start on a new page.)

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

A		**D**	
B	chloroethene	**E**	ethane
C		**F**	

6.1 Write a balanced equation for the combustion of compound **A** in excess oxygen. (3)

6.2 Identify the compound used to manufacture PVC. (1)

6.3 NAME the functional group of compound **D**. (2)

6.4 Write down the structural formula and NAME of an isomer of **F**. (4)

6.5 Select a compound from the table above, that is…:

6.5.1 derived from the general formula C_nH_{2n}.

6.5.2 an alcohol.

(2 × 2) (4)

6.6 Write down the IUPAC NAME for the following:

6.6.1 Compound **C**

6.6.2 Compound **F**

(2 × 2) (4)

[18]

QUESTION 7 (Start on a new page.)

The relationship between the boiling point and the functional group of a number of organic compounds was investigated and recorded as follows:

	COMPOUND	MOLAR MASS in $g \cdot mol^{-1}$	BOILING POINT in ^0C
A	$CH_3CH_2CH_2CH_3$	58	-1
B	$CH_3CH_2CH_2CH_2OH$	74	117
C	$CH_3CH_2CH_2COOH$	88	163

7.1 Explain why compound C has such a high boiling point. (3)

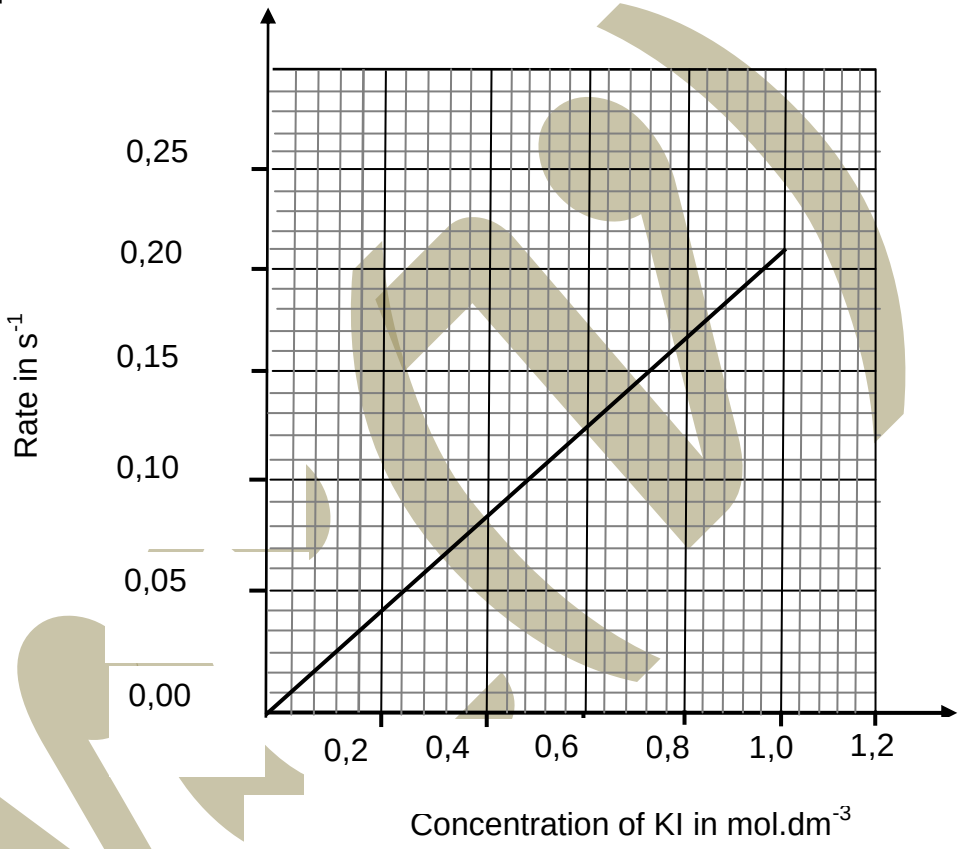
7.2 Which compound (A, B or C) has the highest vapour pressure at room temperature? Write only the letter (A–C) next to the question number (7.1) in your answer book. (2)

[5]

QUESTION 8

8.1 The 'elephant toothpaste' reaction is the common name for the catalytic decomposition of hydrogen peroxide by potassium iodide.

A student carried out an experiment to investigate the effect of changing the concentration of potassium iodide on the reaction rate. The results are shown on the graph below.



8.1.1 What is the independent variable? (1)

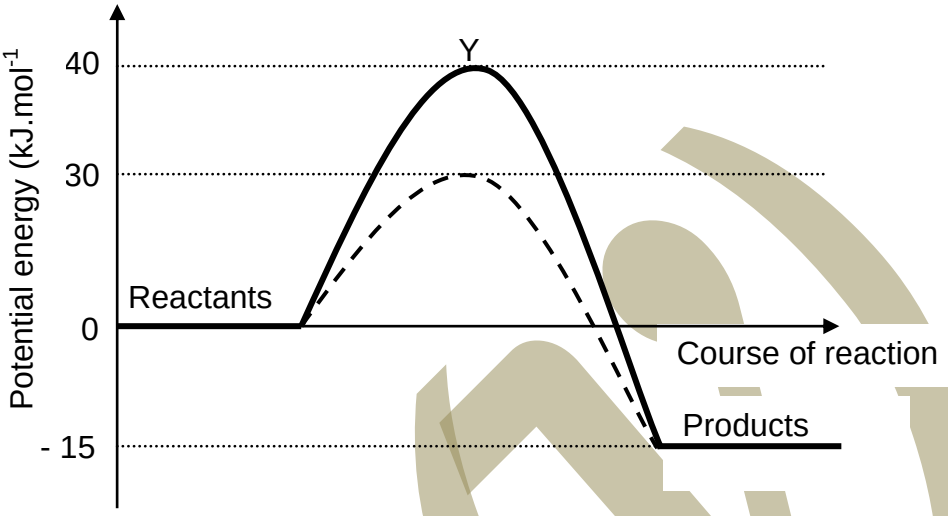
8.1.2 Write down an investigative question for this experiment. (2)

8.1.3 Use the graph to calculate the reaction time when the concentration of KI is 1,0 mol · dm^{-3}. (3)

8.1.4 Use the Kinetic Molecular Theory to explain why the rate of a reaction increases when the concentration of the reactants increase. (4)

QUESTION 8 (Continued)

8.2 The graph illustrates the potential energy changes during the course of a reaction that is un-catalysed (———) and catalysed (– – –)



8.2.1 What does Y represent? (1)

8.2.2 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (1)

8.2.3 What is the activation energy for the un-catalysed forward reaction? (1)

8.2.4 Calculate the activation energy for the reverse catalysed reaction. (2)

8.3 4 mol $SO_2(g)$ and 3 mol $O_2(g)$ are sealed in a 2 dm^3 container. At equilibrium, the system contained 3 mol $SO_2(g)$.

The following equilibrium reaction took place:

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

8.3.1 Calculate the equilibrium constant for this reaction. (9)

8.3.2 Indicate whether an increase in temperature will INCREASE, DECREASE or have NO EFFECT on the equilibrium constant. (1)

8.3.3 Give an explanation for the answer to question 8.2.2 (3)

[28]

QUESTION 9 (Start on a new page.)

9.1 Hydrogen sulphite ions react with water according to the following balanced equation:

$$HSO_3^-(aq) + H_2O(\ell) \rightleftharpoons H_2SO_3(aq) + OH^-(aq)$$

9.1.1 Define *acid* according to the Bronsted-Lowry theory. (2)

9.1.2 Write down the formula of the TWO bases in the above equation. (2)

9.1.3 Write down the formula of TWO ampholytes represented in the above reaction. (2)

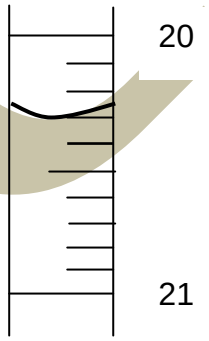
9.2 During a titration small amounts of an acid was added from a burette into a conical flask containing a base and an indicator.

24 cm^3 of a 1,0 $mol \cdot dm^{-3}$ $(COOH)_2$ solution was added from a burette into a conical flask containing 20 cm^3 of a NaOH solution of concentration 1,2 $mol \cdot dm^{-3}$.

The balanced equation for the reaction is as follows:

$$2\ NaOH(aq) + (COOH)_2\ (aq) \rightarrow (COONa)_2(aq) + 2H_2O(\ell)$$

9.2.1 Record the reading on the burette illustrated below.

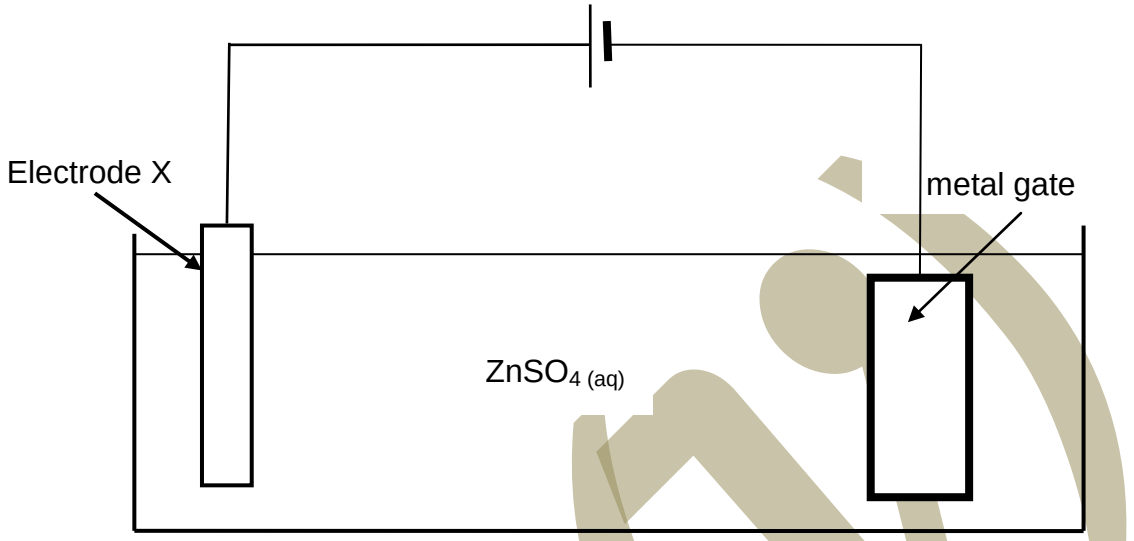


(2)

9.2.2 Use a suitable calculation to determine if the end-point has been reached. All calculations must be approximated to THREE decimals. (8)
[16]

QUESTION 10 (Start on a new page.)

A company used the following apparatus to electroplate a metal gate with zinc.



10.1 Define the term *electrolysis*. (2)

10.2 Give a reason why a direct-current (DC) source is used in this experiment. (2)

10.3 What energy conversion occurs in an electrolytic cell? (2)

10.4 Write down the half-reaction occurring at the metal gate. (2)

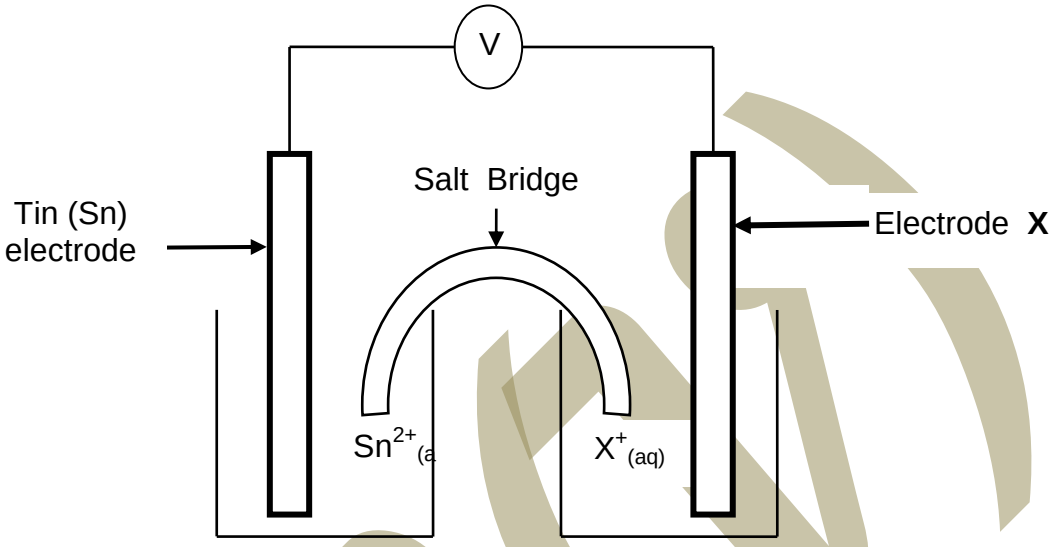
10.5 Name TWO changes that must be made to this apparatus if the gate was to be electroplated with platinum. (2)

10.6 When this cell functions will the concentration of Zinc ions INCREASE, DECREASE or REMAIN CONSTANT? Give a reason for the answer. (3)

[13]

QUESTION 11 (Start on a new page)

A voltaic cell is constructed by connecting a tin half-cell to a metal X as shown in the sketch below. In the external circuit electrons flow from the tin electrode to metal X.



11.1 Write down TWO standard conditions applicable to this cell. (2)

11.2 If the initial reading on the voltmeter is 0,94 V under standard conditions, use a suitable calculation to identify metal X. (5)

11.3 What substance is the REDUCING AGENT in this reaction? (2)

11.4 Will the initial cell potential INCREASE, DECREASE or REMAIN THE SAME if the following changes are made to this cell?

11.4.1 The concentration of Sn^{2+}(aq) is increased

11.4.2 The size of the tin electrode is decreased

(2 × 1) (2)

11.5 If this cell delivers 0,1 mol of electrons from the tin electrode to metal X, calculate the change in the mass of the tin electrode. (5)

[16]

QUESTION 12 (Start on a new page)

12.1 Name TWO sources of renewable energy that are pollution free and suitable for the production of electricity on a large scale. (2)

12.2 Give TWO uses of radioactivity besides the production of electricity. (2)

12.3 A nuclear decay is represented below.

Step 1 $^{210}_{83}Bi \rightarrow {}^{210}_{84}Po + X$

Step 2 $^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + Y$

12.3.1 What type of decay is represented by step 1?
(Choose from ALPHA, BETA or GAMMA) (2)

12.3.2 Write down the formula for Y. (2)

12.3.3 The half-life of step 2 is 144 days.
Calculate the mass of pure Polonium (Po) left from an original sample of 20 g after 288 days. (2)
[10]

TOTAL SECTION B: 115
GRAND TOTAL: 150

DATA FOR PHYSICAL SCIENCES
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

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$c = \frac{n}{V}$ or $c = \frac{m}{MV}$
$q = I \Delta t$ $W = Vq$	$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ or $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ or $E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent}$

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																	**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

Electronegativity → 29 / 1,9 **Cu** / 63,5 ← Symbol

Approximate relative atomic mass

TABLE 3A: 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 3B: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability ↓

↑ Increasing reducing ability

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