higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PHYSICAL SCIENCE
(Second Paper)
NQF LEVEL 4

(10021004)

29 November 2019 (X-Paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 13 pages, 3 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. Start each section on a NEW page.
5. Leave ONE line between subquestions, for example between QUESTION 2.1 and QUESTION 2.2.
6. Use only a BLUE or BLACK pen.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round off final numerical answers to TWO decimal places.
9. Write neatly and legibly.

SECTION A

QUESTION 1

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

1.1 Absorb neutrons in a nuclear reactor

1.2 Reaction in which electrons are transferred

1.3 Process by which crude oil is separated into various fuels

1.4 Functional group of organic acids

1.5 Principle that states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the potential energy of the fluid

(5 × 1) **[5]**

QUESTION 2

Choose a term from COLUMN B that matches a description 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	React with acids to produce carbon dioxide	A	eutrophication
2.2	Compounds made up of carbon and hydrogen only	B	dead zone
		C	nitrates
2.3	Process leading to the elimination of all living organisms in an aquatic habitat	D	sulphates
2.4	Promote the growth of roots and stems	E	phosphates
2.5	Chemical process of monomers such as ethene or propene joining together	F	hydrocarbons
		G	polymerisation
		H	thermoset
		I	carbonates

(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. Correct the statement if it is FALSE.

3.1 Saturated hydrocarbons have single bonds between the carbon atoms.

3.2 The pressure in a fluid is directly proportional to the rate of flow.

3.3 A Geiger-Muller counter measures the ionising ability of radiation.

3.4 Hydrostatic pressure depends on the surface area of the liquid.

3.5 During electro-refining impure ore is connected to the positive pole of the power supply.

(5 × 2) **[10]**

QUESTION 4

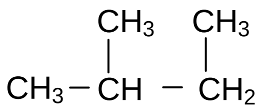
Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 Conserved in a nuclear reaction:

(i) mass
(ii) charge
(iii) energy

A (i) only
B (ii) only
C (i) and (ii)
D (ii) and (iii)

4.2 What is the IUPAC name for the organic compound given below?



A 1,2-dimethyl propane
B 2,3-dimethyl propane
C 2-methyl butane
D 3-methyl butane

4.3 Consider the reaction represented by the equation below.

⌘ $$CH_3CHCH_2 + H_2 \rightarrow CH_3CH_2CH_3$$

This reaction is an example of …

A hydration.
B dehydration.
C substitution.
D hydrogenation.

4.4 A hypothetical reaction in a closed container, represented by the balanced chemical equation below, is in a state of dynamic chemical equilibrium.

$$2\,A(g) + B_2(g) \leftrightarrows 2\,BA(g) \quad \Delta H > 0$$

The volume of the container is decreased leading to an increase in pressure at constant temperature. ⌘

How does this affect the rate of the forward reaction and the yield of BA (g)?

	RATE OF REVERSE REACTION	YIELD OF BA (g)
A	Decrease	Decrease
B	Decrease	Increase
C	Increase	Decrease
D	Increase	Increase

4.5 Which ONE of the following redox reactions is nonspontaneous under standard conditions?

A $Pt + I_2 \rightarrow Pt^{2+} + 2I^-$
B $Pt + C\ell_2 \rightarrow Pt^{2+} + 2C\ell^-$ ⌘
C $Cr + Ni^{2+} \rightarrow Cr^{2+} + Ni$
D $Sn^{2+} + 2Ag^+ \rightarrow Sn^{4+} + 2Ag$

(5 × 3) **[15]**

TOTAL SECTION A: 35

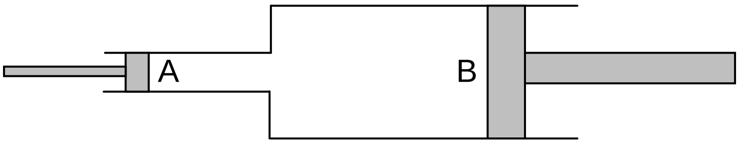
SECTION B

QUESTION 5

5.1 Water enters a typical garden hose of diameter 1,6 cm with a velocity of 3 $m.s^{-1}$.

Calculate the exit velocity of water from the garden hose when a nozzle of diameter 0,5 cm is attached to the end of the hose. (4)

5.2 In a hydraulic system, a piston A with a cross-sectional area of 20 cm^2 pushes on an incompressible liquid with a force of 30 N. The other end of the hydraulic pipe is connected to a second piston B with a cross-sectional surface area of 100 cm^2.

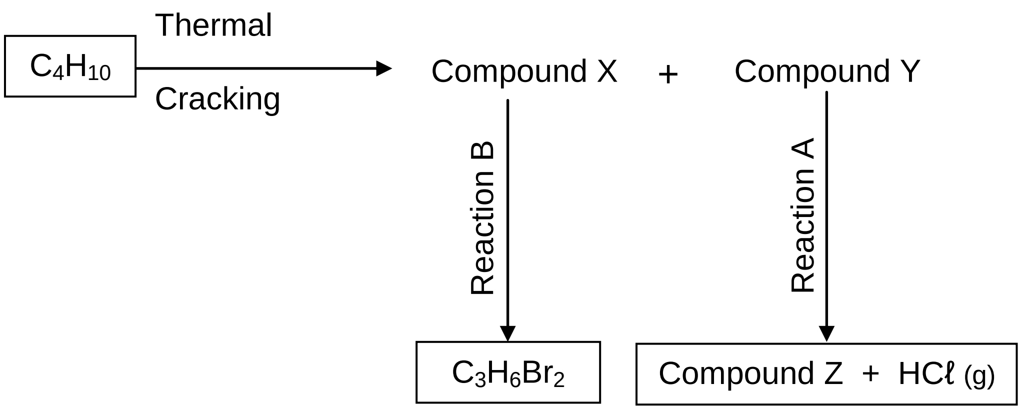


5.2.1 State Pascal's principle in words. (2)

5.2.2 Calculate the force exerted on piston B. (3)
[9]

QUESTION 6

6.1 The flow diagram below represents the thermal cracking of C_4H_{10} and the further reaction of its products.



6.1.1 What is the functional group of C_4H_{10}? (2)

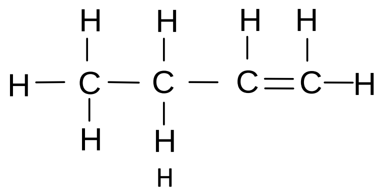
6.1.2 Write down the structural formula for compound X. (2)

6.1.3 Describe the reaction condition for Reaction A. (2)

6.1.4 Write down the molecular formula of compound Z. (2)

6.1.5 Which type of reaction is Reaction A? Choose from addition, substitution or elimination. (2)

6.2 An organic compound W has the following structural formula:



6.2.1 Name the homologous series to which compound W belongs. (1)

6.2.2 Write down the structural formula and IUPAC name of a chain isomer of W. (4)

6.2.3 Write a balanced chemical equation for the reaction between compound W and oxygen. (3)

6.2.4 Write down the structural formula of the major product formed when compound W reacts with HBr. (2)

6.3 The following results were tabulated by a student investigating the relationship between the boiling point and chain length of alcohols:

ALCOHOL		BOILING POINT IN °C
A	CH_3OH	65
B	CH_3CH_2OH	78
C	$CH_3CH_2CH_2OH$	97
D	$CH_3CH_2CH_2CH_2OH$	117

6.3.1 Write down a suitable conclusion for this investigation. (2)

6.3.2 Which ONE of the alcohols has the lowest vapour pressure? (1)

6.3.3 Give a reason for the answer to QUESTION 6.3.2. (2)

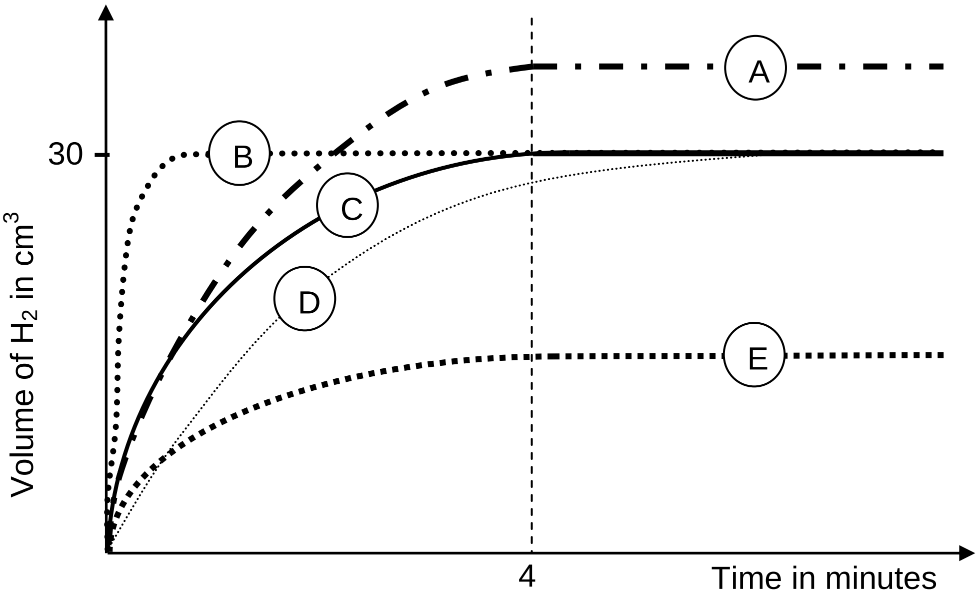
[25]

QUESTION 7

A student lets a piece of magnesium ribbon react with excess hydrochloric acid at a temperature of 25 °C. The balanced equation for the reaction is:

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

She measured the volume of hydrogen produced at 1-minute intervals and plotted graph C:



7.1 Determine the average rate of the reaction in $cm^3.s^{-1}$. (3)

7.2 Calculate the mass of magnesium used up in the reaction. Assume that the molar volume of hydrogen is 24 dm^3 at 25 °C. (5)

7.3 Which graph (A–E) would be obtained if she repeated the experiment with each of the following changes:

7.3.1 Added a suitable catalyst

7.3.2 Reduced room temperature to 15 °C

7.3.3 Used half the length of a magnesium ribbon

(3 × 2) (6)
[14]

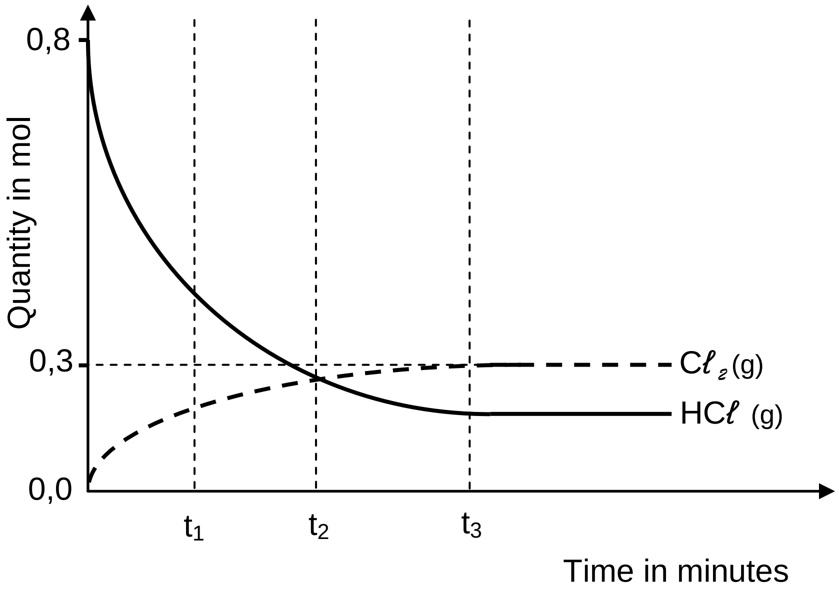
QUESTION 8

The reaction between hydrogen chloride and oxygen reaches chemical equilibrium in a closed container according to the following balanced equation:

$$4HC\ell\,(g) + O_2\,(g) \leftrightharpoons 2C\ell_2\,(g) + 2H_2O\,(g) \qquad \Delta H = -113\ kJ$$

In an experiment 0,8 mol $HC\ell$ (g) and some O_2 (g) were sealed in a 10 dm^3 flask. At equilibrium the flask contained 0,25 mol O_2 (g) and 0,3 mol $C\ell_2$ (g).

The following graph, NOT drawn to scale, shows how the quantity of some of the substances varied with time:



8.1 Compare the rate of the forward reaction with the rate of the reverse reaction at time t_1. Choose the answer from greater than, equal to or smaller than. (2)

8.2 Use the graph to give a reason for the answer to QUESTION 8.1. (2)

8.3 At what time does the system reach chemical equilibrium? Choose the answer from t_1, t_2 or t_3. (1)

8.4 Use the graph to give a reason for the answer to QUESTION 8.3. (2)

8.5 Calculate the equilibrium constant. (8)

8.6 Calculate the amount of O_2 (g) that was initially placed in the reaction container. (2)

[17]

QUESTION 9

A mixture X was prepared by adding 100 cm^3 of a potassium-hydroxide solution (KOH (aq)) of concentration 0,4 $mol.dm^{-3}$ to 500 cm^3 of a sodium-hydroxide solution (NaOH (aq)) of unknown concentration Y.

25 cm^3 of this mixture X was then placed in a conical flask. A few drops of a suitable indicator were added to the mixture. In a titration, 20 cm^3 hydrochloric acid (HCℓ (aq)) of concentration 0,25 $mol.dm^{3}$ was required to exactly neutralise the mixture in the conical flask.

9.1 You are supplied with the following list of indicators and their pH range:

Indicator	pH range
Phenolphthalein	8,3–10
Methyl orange	3,1–4,4
Bromothymol blue	6,0–7,6

9.1.1 Write down the name of a suitable indicator for this titration. (1)

9.1.2 Give ONE reason for the answer to QUESTION 9.1.1. (1)

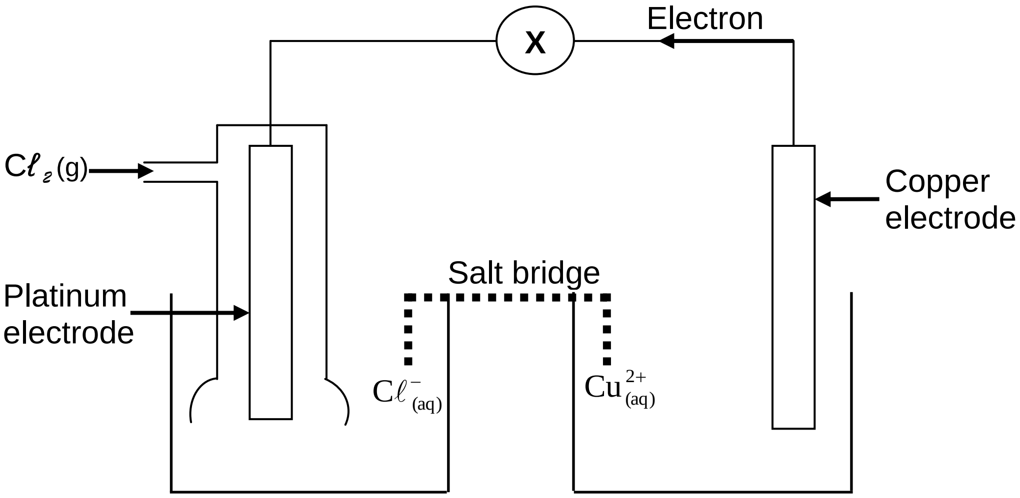
9.2 Calculate the number of moles of HCℓ used to exactly neutralise the mixture in the conical flask. (3)

9.3 What is the concentration of hydroxide ions (OH^- (aq)) in mixture X? (4)

9.4 Determine the unknown concentration Y. (8)
[17]

QUESTION 10

The following electrochemical cell was set up under standard conditions. Electrons flow from the copper electrode to the chlorine-gas electrode.



10.1 Is copper the anode or the cathode? ⌘ (1)

10.2 Give ONE reason why platinum is used as an electrode. (2)

10.3 Calculate the initial emf of this cell. (4)

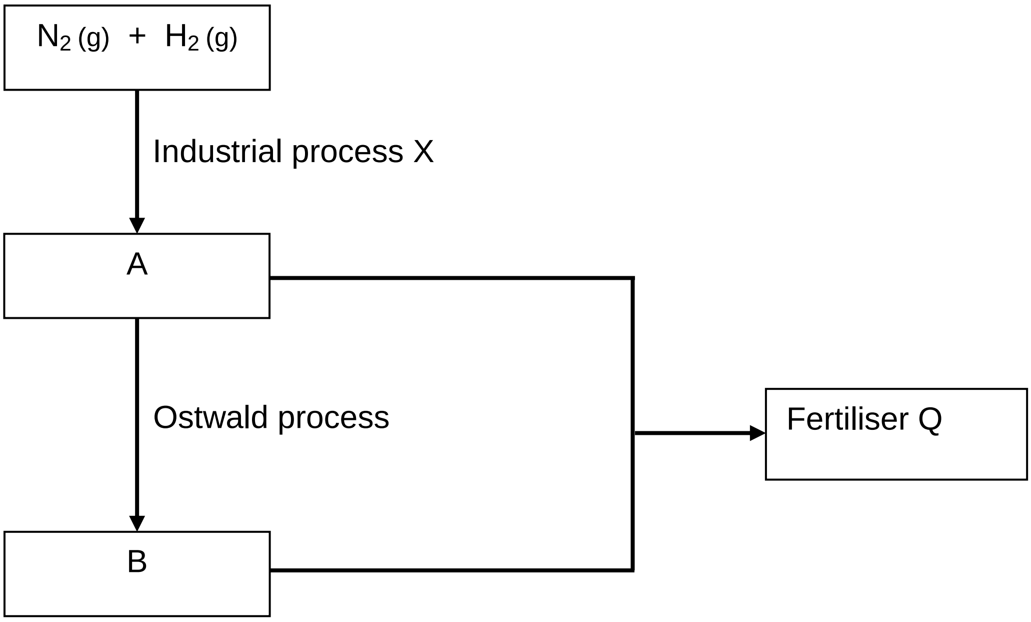
10.4 After delivering a current the concentration of the $C\ell^-$ (aq) increases to 1,25 $mol.dm^{-3}$. ⌘

Calculate the change in the mass of the copper electrode. Assume that the volume of electrolyte in the half cell remains constant at 200 cm^3. (6)

[13]

QUESTION 11

11.1 The flow diagram shows the formation of fertiliser Q.



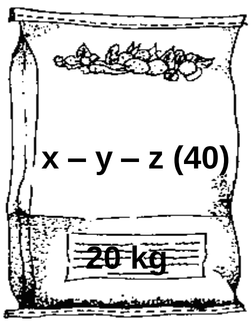
Write down the:

11.1.1 Name of industrial process X (1)

11.1.2 Name of substance B (1)

11.1.3 Balanced equation for the preparation of fertiliser Q from the reaction between compounds A and B (2)

11.2 The diagram below shows a bag of NPK-fertiliser of which the NPK-ratio is unknown. It is found that the mass of nitrogen in the bag is 1,6 kg and the mass of phosphorus is 2,4 kg.

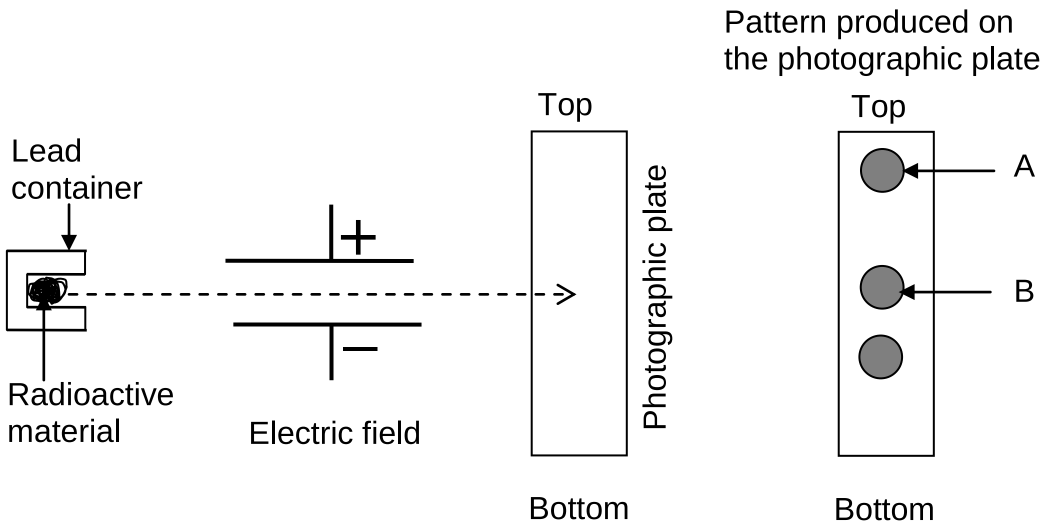


Calculate the NPK-ratio of the fertiliser. (4)

[8]

QUESTION 12

12.1 Some radioactive material is placed in a lead container. The radiation produced is allowed to pass through an electric field and then onto a photographic plate.



12.1.1 Why is the radioactive material stored in a lead container? (2)

12.1.2 Identify the type of radiation that produces B and give a reason for the answer. (2)

12.1.3 Name the type of radiation that produces pattern A. (2)

12.1.4 Give a reason for the answer to QUESTION 12.1.3. (2)

12.2 The nuclear equation below shows how a radioisotope of element X can be made from aluminium.

$$^{27}_{13}\mathrm{Al} + ^{1}_{0}\mathrm{n} \rightarrow \mathrm{X} + ^{4}_{2}\mathrm{He}$$

12.2.1 Write down the name of element X. (2)

12.2.2 Which nuclear changes occur in $^{27}_{13}\mathrm{Al}$ when this reaction occurs? (2)

[12]

TOTAL SECTION B: 115

GRAND TOTAL: 150

INFORMATION SHEET 1

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** $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$

INFORMATION SHEET 2

STANDARD REDUCTION POTENTIALS

Increasing oxidising ability ↑ (left side); Increasing reducing ability ↓ (right side)

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

INFORMATION SHEET 3

STANDARD REDUCTION POTENTIALS

Increasing oxidising ability

Increasing reducing ability

Half-reactions			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

(10021004)

PERIODIC TABLE OF ELEMENTS

KEY

Atomic number	29
Electronegativity	1,9
Symbol	Cu
Approximate relative atomic mass	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