

CAPE WINELANDS EDUCATION DISTRICT

CAPS

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

SEPTEMBER 2015

MARKS 150

TIME 3 hours

This question paper consists of 15 pages and 4 data sheets.

Please turn over

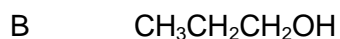
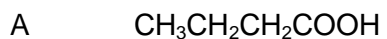
INSTRUCTIONS AND INFORMATION.

1. Write your name on the top of your ANSWER PAGE.
2. Answer ALL the questions on your ANSWER PAGE.
3. You may use a non-programmable calculator.
4. You may use appropriate mathematical instruments.
5. Number the answers correctly according to the numbering system used in this question paper.
6. YOU ARE ADVISED TO USE THE ATTACHED DATA SHEETS.
7. Give brief motivations, discussions, et cetera where required.
8. Round off your final numerical answers to a minimum of TWO decimal places.

QUESTION 1 [START ON A NEW PAGE]

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) on your ANSWER PAGE.

1.1 Which ONE of the following compounds belong to the same homologous series as propanoic acid?



(2)

1.2 Which ONE of the following liquids will have the highest melting point?

A ethanol

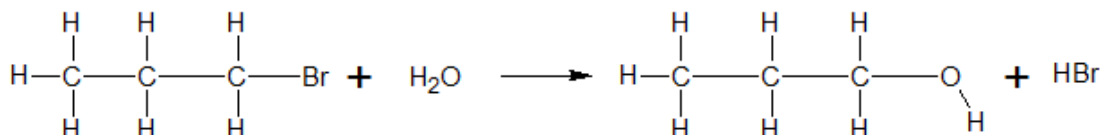
B propan-1-ol

C butan-1-ol

D pentan-1-ol

(2)

1.3 Consider the reaction represented by the equation below:



This reaction is an example of:

A hydrogenation

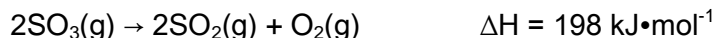
B halogenation

C hydrolysis

D hydration

(2)

- 1.4 Consider the reaction represented by the balanced equation below:



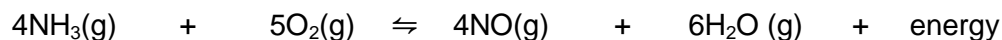
Which ONE of the following is TRUE for this reaction?

When 2 moles of $\text{SO}_2(\text{g})$ are formed ...

- A 198 kJ of energy is absorbed.
 - B 198 kJ of energy is released.
 - C 396 kJ of energy is absorbed.
 - D 396 kJ of energy is released. (2)
- 1.5 The K_c value for a certain reaction is 0,0023. This small K_c value indicates that...

- A equilibrium should be achieved at a slow rate.
- B at equilibrium there will be a large yield of products.
- C at equilibrium the rate of the forward reaction will be smaller than the rate of the reverse reaction.
- D the concentration of the reactants at equilibrium is greater than the concentration of products. (2)

- 1.6 The following reaction has reached equilibrium in a closed container at a temperature of 359 K:



Which ONE of the following will increase the equilibrium concentration of NH_3 ?

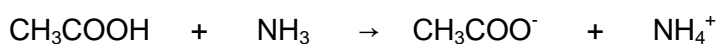
- A Add a catalyst.
- B Remove $\text{NO}(\text{g})$ from the container.
- C Increase the volume of the container.
- D The temperature is increased to 400 K. (2)

1.7 In the titration of ethanoic acid (CH_3COOH) and sodium hydroxide (NaOH) the pH at the end point is 8,72. The most suitable indicator for this titration will be...

- A methyl orange.
- B phenolphthalein.
- C bromothymol blue.
- D universal indicator.

(2)

1.8 Which one of the following is a conjugate acid-base pair in the following reaction?



	Acid	Conjugate base
A	NH_3	NH_4^+
B	CH_3COO^-	NH_4^+
C	CH_3COOH	NH_3
D	CH_3COOH	CH_3COO^-

(2)

1.9 Which ONE of the following is an example of a galvanic cell?

- A The cell that is used in a torch.
- B The cell in which electroplating occurs.
- C The cell in which copper is refined.
- D The cell in which chlorine is prepared from brine (saltwater).

(2)

1.10 Which ONE of the following is a primary nutrient in plants?

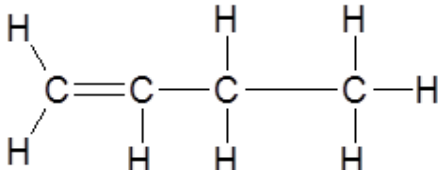
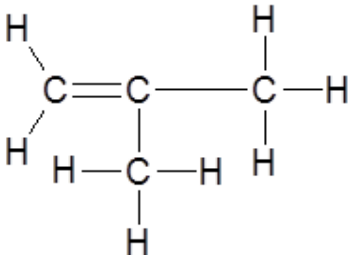
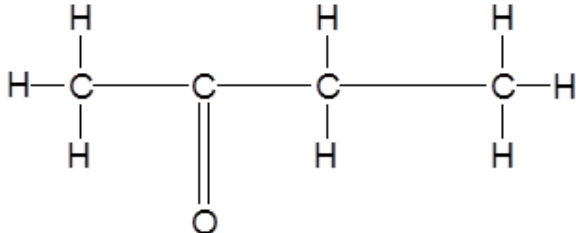
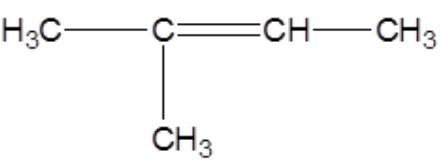
- A C
- B H
- C O
- D N

(2)

[20]

QUESTION 2 [START ON A NEW PAGE]

Consider the organic compounds represented by the letters **A** to **G** in the table below:

A		B	
			
C But-2-ene	D $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$		E Methyl propanoate
F		G	
			

- 2.1 Define the term **hydrocarbon**. (2)
- 2.2 Write down the LETTER that represents...
- 2.2.1 a chain isomer of compound **A**. (1)
- 2.2.2 a positional isomer of compound **A**. (1)
- 2.2.3 a functional isomer of compound **D**. (1)
- 2.3 Define the term **structural isomer**. (2)
- 2.4 Write down the IUPAC name of compound **B**. (2)
- 2.5 Write down the molecular formula of compound **C**. (1)
- 2.6 Write down the structural formula of compound **E**. (2)
- 2.7 Write down the structural formula for the functional group of compound **C**. (1)

- 2.8 Write down the IUPAC name of the compound that contains a carboxyl group. (1)
- 2.9 Is compound **A** SATURATED or UNSATURATED? Give a reason for your answer. (2)
- 2.10 Write down the name of the homologous series to which compound **B** belongs. (1)

[17]**QUESTION 3 [START ON A NEW PAGE]**

A learner conducts a scientific investigation to compare the boiling points of organic compounds belonging to different homologous series. Propan-1-ol, ethanoic acid and propanal are used for the investigation. His results are shown in the table below.

Compound	Boiling Point (°C)
Compound A	48
Compound B	97
Compound C	118

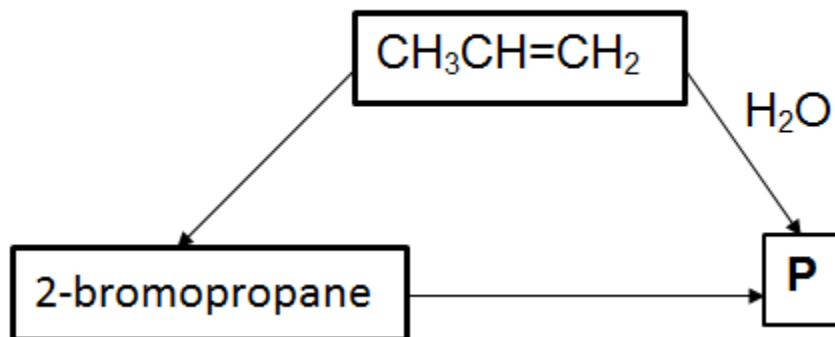
- 3.1 For this investigation, name the ...
- 3.1.1 independent variable. (1)
- 3.1.2 dependent variable. (1)
- 3.2 Will the vapour pressure of propanal be LOWER or HIGHER than the vapour pressure of propan-1-ol? Explain your answer by referring to the type of INTERMOLECULAR FORCES present and ENERGY. (4)
- 3.3 Identify:
- 3.3.1 Compound A (1)
- 3.3.2 Compound B (1)
- 3.3.3 Compound C (1)
- 3.4 Will the boiling point of butan-1-ol be HIGHER or LOWER than the boiling point of propan-1-ol? Explain the answer referring to the INTERMOLECULAR FORCES. (2)

[11]

QUESTION 4 [START ON A NEW PAGE]

4.1 The flow diagram below shows the preparation of two organic compounds, using propene as one of the reactants.

4.1.1 Use structural formulae to write down a balanced chemical equation for the reaction between propene and water to produce compound **P**. (4)



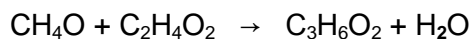
4.1.2 Write down the IUPAC name of compound **P**. (1)

4.1.3 Compound **P** can also be obtained from 2-bromopropane. Write down the:

(a) type of reaction that converts 2-bromopropane to **P**. (1)

(b) conditions under which the conversion can occur. (2)

4.2 A learner is preparing an ester using methanol (molecular formula: CH_4O) and ethanoic acid (molecular formula: $\text{C}_2\text{H}_4\text{O}_2$). The balanced chemical equation for this reaction is given below:



4.2.1 What type of reaction is represented by the equation above? (1)

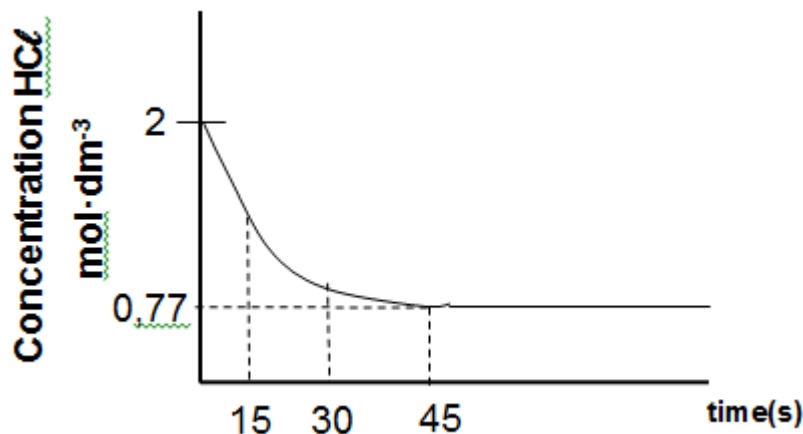
4.2.2 Write down the NAME or FORMULA of the catalyst needed in this reaction. (1)

4.2.3 When 50 g of methanol fully reacts with excess ethanoic acid, it produces 68,88 g $\text{C}_3\text{H}_6\text{O}_2$. Calculate the percentage purity of the methanol. (5)

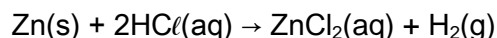
[15]

QUESTION 5 [START ON A NEW PAGE]

A learner investigates the factors that influence the rate of reaction. He adds 50 g of Zn granules to 500 cm³ hydrochloric acid (HCl) with a concentration of 2 mol·dm⁻³. Assume that the zinc is completely covered by the hydrochloric acid. The hydrochloric acid has a temperature of 20 °C. The change in the concentration of HCl during this reaction is shown in the graph below:



The balanced equation for this reaction is

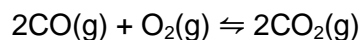


- 5.1 Write down TWO observations for this experiment. (2)
- 5.2 Define the term **reaction rate**. (2)
- 5.3 Calculate the average reaction rate for this reaction over 45 s. (4)
- 5.4 How does the initial rate of the reaction change if each of the following changes are made: Write only INCREASE, DECREASE or STAY THE SAME.
- 5.4.1 Increase the temperature of the hydrochloric acid to 30 °C. (1)
- 5.4.2 Use 600 cm³ of the 2 mol·dm⁻³ hydrochloric solution instead of 500 cm³. (1)
- 5.4.3 Add copper sulfate as a catalyst. (1)

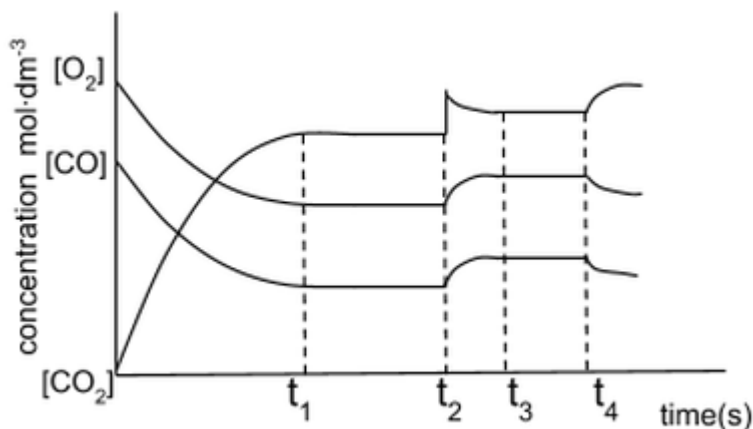
[11]

QUESTION 6 [START ON A NEW PAGE]

Carbon monoxide gas (CO) and oxygen gas (O₂) are placed in a closed container. They are allowed react to form carbon dioxide (CO₂). The balanced equation for this reaction is:



The graph below shows concentration changes of reactants and products for this reaction over time. Use this information to answer the following questions:



- 6.1 Explain the term **chemical equilibrium**. (2)
- 6.2 At which times interval(s) is/(are) the reaction at equilibrium? (2)
- 6.3 Does the FORWARD or the REVERSE reaction have the faster reaction rate during the interval t₂ to t₃ ? (1)
- 6.4 The temperature is decreased at t₄. Is the reaction EXOTHERMIC or ENDOTHERMIC? (1)
- 6.5 Explain the answer to QUESTION 6.4 (3)
- 6.6 What change is made to at t₂? (1)
- 6.7 How will the change made at t₂ influence the value of K_c for this reaction? Write only INCREASE, DECREASE or REMAIN THE SAME. (1)
- 6.8 Initially 63 g of CO and 9,11 g of O₂ is placed in a 2 dm³ container. At equilibrium the concentration of CO₂ is 0,15 mol·dm⁻³. Calculate the value of K_c for this reaction. (10)

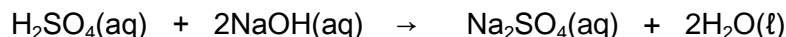
[21]

QUESTION 7 [START ON A NEW PAGE]

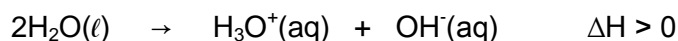
- 7.1 In an acid-base titration 50,0 cm³ of a 0,20 mol·dm⁻³ sodium hydroxide (NaOH) solution was placed in a conical flask and a few drops of indicator was added. The burette was filled with sulfuric acid (H₂SO₄) of unknown concentration. The experiment was repeated three times and the following results were obtained:

Experiment	Volume of H ₂ SO ₄ (cm ³)
1	20,2
2	19,8
3	20,0

The balanced equation for the reaction is:



- 7.1.1 Define the term **endpoint** of a titration. (2)
- 7.1.2 Sulfuric acid is a diprotic acid. Explain the term **diprotic acid**. (1)
- 7.1.3 Explain why sulfuric acid is a strong acid. (2)
- 7.1.4 Calculate the average volume of sulfuric acid used for the titration. (1)
- 7.1.5 Calculate the concentration of the sulfuric acid solution. (5)
- 7.2 The balanced chemical equation for the self-ionisation of water is:



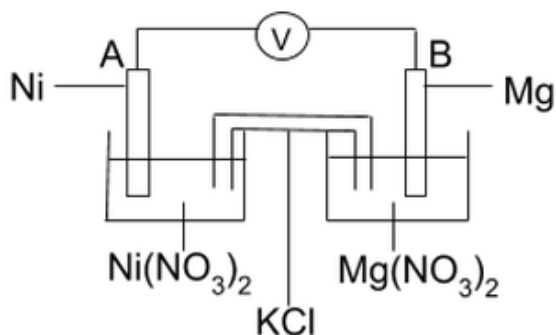
At 25 °C the dissociation constant, K_c , (also known as K_w) for this reaction is 10^{-14} and the pH = 7.

- 7.2.1 Explain why water is classified as an **ampholyte**. (2)
- 7.2.2 Write down the concentration of the hydroxide ions (OH⁻) at 25 °C. (1)
- 7.2.3 Write down an equation for the dissociation constant (K_w) for the above reaction. (2)
- 7.3 If water is heated to a temperature of 75 °C, the value of K_w changes to $10^{-12,7}$.
- 7.3.1 What effect will this change in temperature have on the pH of the water? Write down INCREASE ABOVE 7, DECREASE BELOW 7 or REMAIN 7. (1)
- 7.3.2 Explain your answer in QUESTION 7.3.1 using Le Chatelier's Principle. (2)

[19]

QUESTION 8 [START ON A NEW PAGE]

- 8.1 In the cell below a nickel electrode is connected to a magnesium electrode. The cell is set up under standard conditions. Both electrodes are placed in electrolytes, connected with a salt bridge.

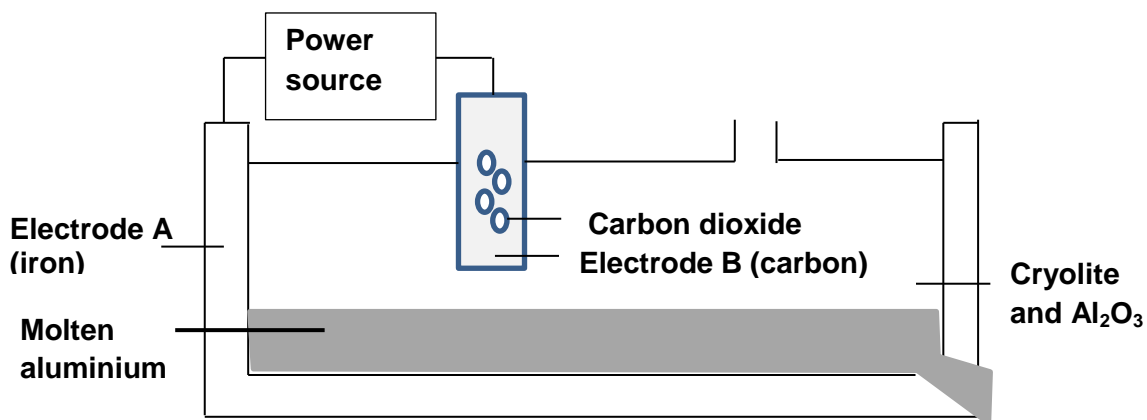


- 8.1.1 Write down the energy conversion that occurs in this cell. (2)
- 8.1.2 Define the term **electrolyte**. (2)
- 8.1.3 Which electrode, **A** or **B**, is the anode? (1)
- 8.1.4 Write down the reduction half-reaction that occurs in this cell. (2)
- 8.1.5 Calculate the reading on the voltmeter for this cell. (4)

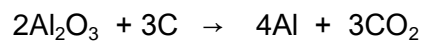
The voltmeter is now replaced with an ammeter.

- 8.1.6 In which direction do the electrons flow in the external circuit? Write down **ONLY** from **A to B** or from **B to A**? (1)
- 8.1.7 Explain the function of the salt bridge in this cell by referring to the movement of electrons and ions. (3)
- 8.1.8 Write down the cell notation for this cell. (3)

- 8.2 Bauxite ore is dissolved in molten cryolite and purified to Al_2O_3 . From the bauxite, pure molten aluminium is obtained. The cell used for the extraction of aluminium is shown in the sketch below.



The net cell reaction for this cell is given as:

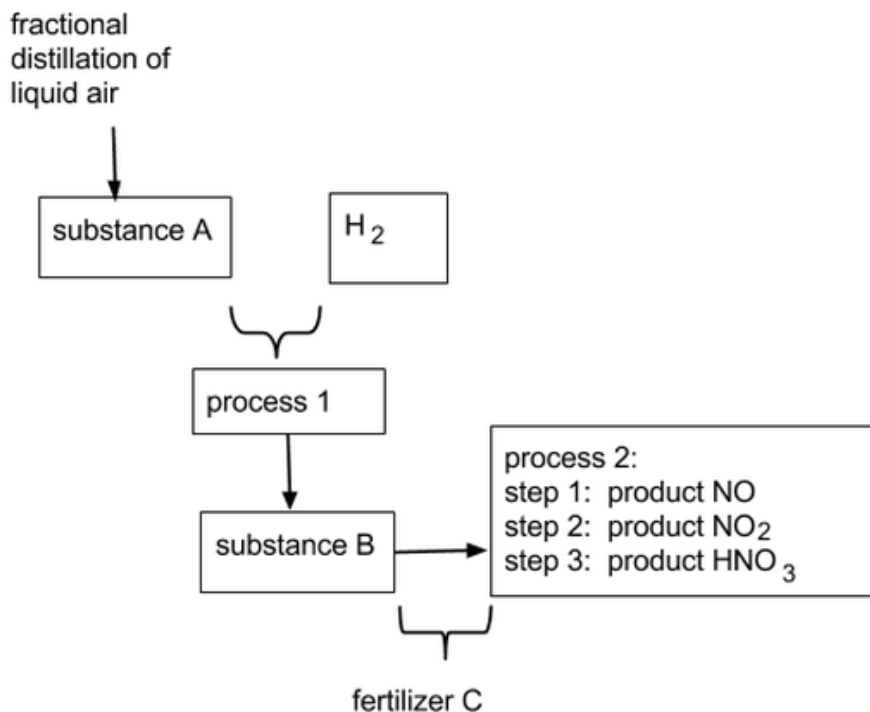


- 8.2.1 Write down the reduction half reaction for this cell. (2)
- 8.2.2 Which one of electrode A or electrode B should be connected to the positive terminal of the power source? (1)
- 8.2.3 Write down the formula of the oxidising agent in this reaction. (1)

[22]

QUESTION 9 [START ON A NEW PAGE]

- 9.1 The diagram below illustrates the processes used to manufacture a certain fertiliser. Study the diagram and answer the questions that follow:



- 9.1 Write down the NAME or FORMULA of substance A that is obtained by the fractional distillation of liquid air. (1)
- 9.2 Write down the balanced chemical equation for the reaction that occurs in process 1. (3)
- 9.3 Write down the name of substance B that forms as a result of process 1. (1)
- 9.4 Write down the balanced equation for the catalytic oxidation of ammonia, which is represented by step 1 of process 2. (3)
- 9.5 Write down the name of fertiliser C that forms when substance B reacts with HNO₃. (1)
- 9.6 What process occurs when fertiliser C runs into rivers? (1)
- 9.7 The NPK ratio for a 1,5 kg bag of fertiliser C is 1:0:0(40). Calculate the mass of nitrogen in the bag of fertiliser. (4)

[14]**TOTAL 150**

**INFORMATION FOR PHYSICAL SCIENCES GR 12
PAPER 2 (CHEMISTRY)**

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^θ	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature	T^θ	273 K
Charge on electron	e	$-1,6 \times 10^{-19} \text{ C}$

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ at 298 K	
$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta$	
$E_{\text{cell}}^\theta = E_{\text{reduction}}^\theta - E_{\text{oxidation}}^\theta$	
$E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta$	

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)																																																																																																																																																																																																																																																																																																																																																																																																												
1 H 1	4 He 4	3 Li 7	4 Be 9	11 Na 23	12 Mg 24	19 K 39	20 Ca 40	21 Sc 45	22 Ti 48	23 V 51	24 Cr 52	25 Mn 55	26 Fe 56	27 Co 59	28 Ni 59	29 Cu 63,5	30 Zn 65	31 Ga 70	32 Ge 73	33 As 75	34 Se 79	35 Br 80	36 Kr 84	37 Rb 86	38 Sr 88	39 Y 89	40 Zr 91	41 Nb 92	42 Mo 96	43 Tc 98	44 Ru 101	45 Rh 103	46 Pd 106	47 Ag 108	48 Cd 112	49 In 115	50 Sn 119	51 Sb 122	52 Te 128	53 I 127	54 Xe 131	55 Cs 133	56 Ba 137	57 La 139	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																																																																																																																																																																																																																																																																																																																																																																			
87 Fr 226	88 Ra 226	89 Ac	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	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og	119 Tennessine	120 Copernicium	121 Nihonium	122 Flerovium	123 Moscovium	124 Livermorium	125 Tennessine	126 Oganesson	127 Unbinilium	128 Untriseptium	129 Unquadium	130 Unseptennium	131 Unhexium	132 Unpentium	133 Unquadrium	134 Untrium	135 Unbinilium	136 Unnonium	137 Unoctium	138 Unheptium	139 Unsexium	140 Unpentium	141 Unquadium	142 Untrium	143 Unbinilium	144 Unnonium	145 Unoctium	146 Unheptium	147 Unsexium	148 Unpentium	149 Unquadium	150 Untrium	151 Unbinilium	152 Unnonium	153 Unoctium	154 Unheptium	155 Unsexium	156 Unpentium	157 Unquadium	158 Untrium	159 Unbinilium	160 Unnonium	161 Unoctium	162 Unheptium	163 Unsexium	164 Unpentium	165 Unquadium	166 Untrium	167 Unbinilium	168 Unnonium	169 Unoctium	170 Unheptium	171 Unsexium	172 Unpentium	173 Unquadium	174 Untrium	175 Unbinilium	176 Unnonium	177 Unoctium	178 Unheptium	179 Unsexium	180 Unpentium	181 Unquadium	182 Untrium	183 Unbinilium	184 Unnonium	185 Unoctium	186 Unheptium	187 Unsexium	188 Unpentium	189 Unquadium	190 Untrium	191 Unbinilium	192 Unnonium	193 Unoctium	194 Unheptium	195 Unsexium	196 Unpentium	197 Unquadium	198 Untrium	199 Unbinilium	200 Unnonium	201 Unoctium	202 Unheptium	203 Unsexium	204 Unpentium	205 Unquadium	206 Untrium	207 Unbinilium	208 Unnonium	209 Unoctium	210 Unheptium	211 Unsexium	212 Unpentium	213 Unquadium	214 Untrium	215 Unbinilium	216 Unnonium	217 Unoctium	218 Unheptium	219 Unsexium	220 Unpentium	221 Unquadium	222 Untrium	223 Unbinilium	224 Unnonium	225 Unoctium	226 Unheptium	227 Unsexium	228 Unpentium	229 Unquadium	230 Untrium	231 Unbinilium	232 Unnonium	233 Unoctium	234 Unheptium	235 Unsexium	236 Unpentium	237 Unquadium	238 Untrium	239 Unbinilium	240 Unnonium	241 Unoctium	242 Unheptium	243 Unsexium	244 Unpentium	245 Unquadium	246 Untrium	247 Unbinilium	248 Unnonium	249 Unoctium	250 Unheptium	251 Unsexium	252 Unpentium	253 Unquadium	254 Untrium	255 Unbinilium	256 Unnonium	257 Unoctium	258 Unheptium	259 Unsexium	260 Unpentium	261 Unquadium	262 Untrium	263 Unbinilium	264 Unnonium	265 Unoctium	266 Unheptium	267 Unsexium	268 Unpentium	269 Unquadium	270 Untrium	271 Unbinilium	272 Unnonium	273 Unoctium	274 Unheptium	275 Unsexium	276 Unpentium	277 Unquadium	278 Untrium	279 Unbinilium	280 Unnonium	281 Unoctium	282 Unheptium	283 Unsexium	284 Unpentium	285 Unquadium	286 Untrium	287 Unbinilium	288 Unnonium	289 Unoctium	290 Unheptium	291 Unsexium	292 Unpentium	293 Unquadium	294 Untrium	295 Unbinilium	296 Unnonium	297 Unoctium	298 Unheptium	299 Unsexium	300 Unpentium	301 Unquadium	302 Untrium	303 Unbinilium	304 Unnonium	305 Unoctium	306 Unheptium	307 Unsexium	308 Unpentium	309 Unquadium	310 Untrium	311 Unbinilium	312 Unnonium	313 Unoctium	314 Unheptium	315 Unsexium	316 Unpentium	317 Unquadium	318 Untrium	319 Unbinilium	320 Unnonium	321 Unoctium	322 Unheptium	323 Unsexium	324 Unpentium	325 Unquadium	326 Untrium	327 Unbinilium	328 Unnonium	329 Unoctium	330 Unheptium	331 Unsexium	332 Unpentium	333 Unquadium	334 Untrium	335 Unbinilium	336 Unnonium	337 Unoctium	338 Unheptium	339 Unsexium	340 Unpentium	341 Unquadium	342 Untrium	343 Unbinilium	344 Unnonium	345 Unoctium	346 Unheptium	347 Unsexium	348 Unpentium	349 Unquadium	350 Untrium	351 Unbinilium	352 Unnonium	353 Unoctium	354 Unheptium	355 Unsexium	356 Unpentium	357 Unquadium	358 Untrium	359 Unbinilium	360 Unnonium	361 Unoctium	362 Unheptium	363 Unsexium	364 Unpentium	365 Unquadium	366 Untrium	367 Unbinilium	368 Unnonium	369 Unoctium	370 Unheptium	371 Unsexium	372 Unpentium	373 Unquadium	374 Untrium	375 Unbinilium	376 Unnonium	377 Unoctium	378 Unheptium	379 Unsexium	380 Unpentium	381 Unquadium	382 Untrium	383 Unbinilium	384 Unnonium	385 Unoctium	386 Unheptium	387 Unsexium	388 Unpentium	389 Unquadium	390 Untrium	391 Unbinilium	392 Unnonium	393 Unoctium	394 Unheptium	395 Unsexium	396 Unpentium	397 Unquadium	398 Untrium	399 Unbinilium	400 Unnonium	401 Unoctium	402 Unheptium	403 Unsexium	404 Unpentium	405 Unquadium	406 Untrium	407 Unbinilium	408 Unnonium	409 Unoctium	410 Unheptium	411 Unsexium	412 Unpentium	413 Unquadium	414 Untrium	415 Unbinilium	416 Unnonium	417 Unoctium	418 Unheptium	419 Unsexium	420 Unpentium	421 Unquadium	422 Untrium	423 Unbinilium	424 Unnonium	425 Unoctium	426 Unheptium	427 Unsexium	428 Unpentium	429 Unquadium	430 Untrium	431 Unbinilium	432 Unnonium	433 Unoctium	434 Unheptium	435 Unsexium	436 Unpentium	437 Unquadium	438 Untrium	439 Unbinilium	440 Unnonium	441 Unoctium	442 Unheptium	443 Unsexium	444 Unpentium	445 Unquadium	446 Untrium	447 Unbinilium	448 Unnonium	449 Unoctium	450 Unheptium	451 Unsexium	452 Unpentium	453 Unquadium	454 Untrium	455 Unbinilium	456 Unnonium	457 Unoctium	458 Unheptium	459 Unsexium	460 Unpentium	461 Unquadium	462 Untrium	463 Unbinilium	464 Unnonium	465 Unoctium	466 Unheptium	467 Unsexium	468 Unpentium	469 Unquadium	470 Untrium	471 Unbinilium	472 Unnonium	473 Unoctium	474 Unheptium	475 Unsexium	476 Unpentium	477 Unquadium	478 Untrium	479 Unbinilium	480 Unnonium	481 Unoctium	482 Unheptium	483 Unsexium	484 Unpentium	485 Unquadium	486 Untrium	487 Unbinilium	488 Unnonium	489 Unoctium	490 Unheptium	491 Unsexium	492 Unpentium	493 Unquadium	494 Untrium	495 Unbinilium	496 Unnonium	497 Unoctium	498 Unheptium	499 Unsexium	500 Unpentium

KEY/SLEUTEL

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

Example: ${}_{29}^{63,5}\text{Cu}$

TABLE 4A: STANDARD REDUCTION POTENTIALS

Half-reactions		E^{\ominus} (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
$Cl_2(g) + 2e^-$	$\rightleftharpoons 2Cl^-$	+ 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
$Br_2(l) + 2e^-$	$\rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons NO(g) + 2H_2O$	+ 0,98
$Hg^{2+} + 2e^-$	$\rightleftharpoons Hg(l)$	+ 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
$Al^{3+} + 3e^-$	$\rightleftharpoons Al$	- 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

Half-reactions		E° (V)
$\text{Li}^{+} + \text{e}^{-}$	\rightleftharpoons Li	- 3,05
$\text{K}^{+} + \text{e}^{-}$	\rightleftharpoons K	- 2,93
$\text{Cs}^{+} + \text{e}^{-}$	\rightleftharpoons Cs	- 2,92
$\text{Ba}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Ba	- 2,90
$\text{Sr}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Sr	- 2,89
$\text{Ca}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Ca	- 2,87
$\text{Na}^{+} + \text{e}^{-}$	\rightleftharpoons Na	- 2,71
$\text{Mg}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Mg	- 2,36
$\text{Al}^{3+} + 3\text{e}^{-}$	\rightleftharpoons Al	- 1,66
$\text{Mn}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Mn	- 1,18
$\text{Cr}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Cr	- 0,91
$2\text{H}_2\text{O} + 2\text{e}^{-}$	\rightleftharpoons $\text{H}_2(\text{g}) + 2\text{OH}^{-}$	- 0,83
$\text{Zn}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Zn	- 0,76
$\text{Cr}^{3+} + 3\text{e}^{-}$	\rightleftharpoons Cr	- 0,74
$\text{Fe}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Fe	- 0,44
$\text{Cr}^{3+} + \text{e}^{-}$	\rightleftharpoons Cr^{2+}	- 0,41
$\text{Cd}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Cd	- 0,40
$\text{Co}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Co	- 0,28
$\text{Ni}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Ni	- 0,27
$\text{Sn}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Sn	- 0,14
$\text{Pb}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Pb	- 0,13
$\text{Fe}^{3+} + 3\text{e}^{-}$	\rightleftharpoons Fe	- 0,08
$2\text{H}^{+} + 2\text{e}^{-}$	\rightleftharpoons $\text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^{+} + 2\text{e}^{-}$	\rightleftharpoons $\text{H}_2\text{S}(\text{g})$	+ 0,14
$\text{Sn}^{4+} + 2\text{e}^{-}$	\rightleftharpoons Sn^{2+}	+ 0,15
$\text{Cu}^{2+} + \text{e}^{-}$	\rightleftharpoons Cu^{+}	+ 0,16
$\text{SO}_4^{2-} + 4\text{H}^{+} + 2\text{e}^{-}$	\rightleftharpoons $\text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+ 0,17
$\text{Cu}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Cu	+ 0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^{-}$	\rightleftharpoons 4OH^{-}	+ 0,40
$\text{SO}_2 + 4\text{H}^{+} + 4\text{e}^{-}$	\rightleftharpoons $\text{S} + 2\text{H}_2\text{O}$	+ 0,45
$\text{Cu}^{+} + \text{e}^{-}$	\rightleftharpoons Cu	+ 0,52
$\text{I}_2 + 2\text{e}^{-}$	\rightleftharpoons 2I^{-}	+ 0,54
$\text{O}_2(\text{g}) + 2\text{H}^{+} + 2\text{e}^{-}$	\rightleftharpoons H_2O_2	+ 0,68
$\text{Fe}^{3+} + \text{e}^{-}$	\rightleftharpoons Fe^{2+}	+ 0,77
$\text{NO}_3^{-} + 2\text{H}^{+} + \text{e}^{-}$	\rightleftharpoons $\text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+ 0,80
$\text{Ag}^{+} + \text{e}^{-}$	\rightleftharpoons Ag	+ 0,80
$\text{Hg}^{2+} + 2\text{e}^{-}$	\rightleftharpoons $\text{Hg}(\text{l})$	+ 0,85
$\text{NO}_3^{-} + 4\text{H}^{+} + 3\text{e}^{-}$	\rightleftharpoons $\text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+ 0,96
$\text{Br}_2(\text{l}) + 2\text{e}^{-}$	\rightleftharpoons 2Br^{-}	+ 1,07
$\text{Pt}^{2+} + 2\text{e}^{-}$	\rightleftharpoons Pt	+ 1,20
$\text{MnO}_2 + 4\text{H}^{+} + 2\text{e}^{-}$	\rightleftharpoons $\text{Mn}^{2+} + 2\text{H}_2\text{O}$	+ 1,23
$\text{O}_2(\text{g}) + 4\text{H}^{+} + 4\text{e}^{-}$	\rightleftharpoons $2\text{H}_2\text{O}$	+ 1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^{+} + 6\text{e}^{-}$	\rightleftharpoons $2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+ 1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^{-}$	\rightleftharpoons 2Cl^{-}	+ 1,36
$\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{e}^{-}$	\rightleftharpoons $\text{Mn}^{2+} + 4\text{H}_2\text{O}$	+ 1,51
$\text{H}_2\text{O}_2 + 2\text{H}^{+} + 2\text{e}^{-}$	\rightleftharpoons $2\text{H}_2\text{O}$	+ 1,77
$\text{Co}^{3+} + \text{e}^{-}$	\rightleftharpoons Co^{2+}	+ 1,81
$\text{F}_2(\text{g}) + 2\text{e}^{-}$	\rightleftharpoons 2F^{-}	+ 2,87

Increasing oxidising ability

Increasing reducing ability