HILLCREST HIGH SCHOOL
PHYSICAL SCIENCE
GRADE 11
PAPER 2- Chemistry

JUNE 2021
TIME: 2 HRS

Total: 100

Instructions

1. Answer ALL the questions.

2. This question paper consists of TWO sections:

3. SECTION A (10)
   SECTION B (90)

   Answer SECTIONS A and B in the ANSWER BOOK.

4. Non-programmable calculators may be used.

5. Appropriate mathematical instruments may be used.

6. Number the answers correctly according to the numbering system used in this question paper.

7. Data sheets and a periodic table are attached for your use.

8. Give brief motivations, discussions, et cetera where required.

9. Numbers must be rounded off to **two decimal** places.

SECTION A

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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) in the ANSWER BOOK.

1.1 Which one of the following is the best explanation for the high degree of solubility of NaCl in water?

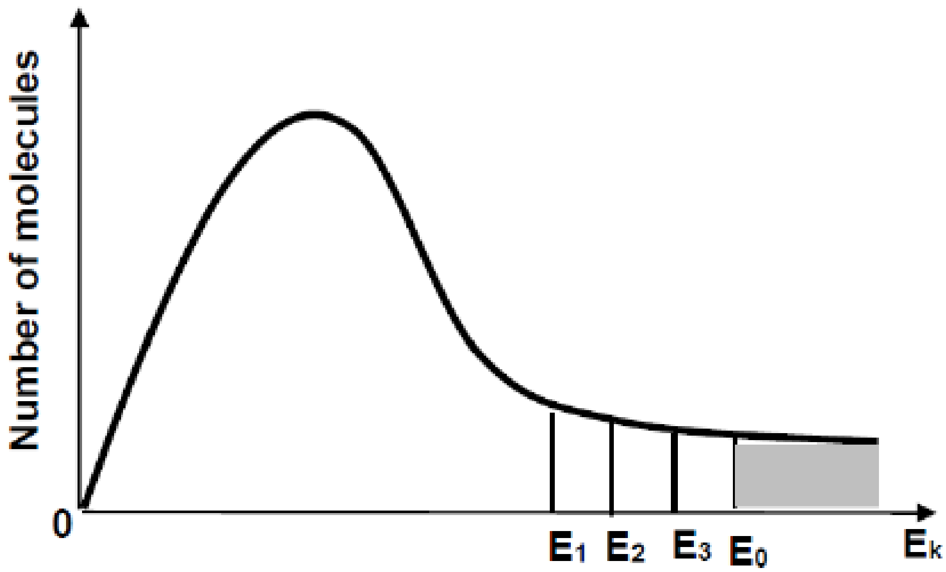
A Both molecules are polar

B Both molecules are ionic

C The electrostatic forces between the ions in NaCl are of the same order as that of the intermolecular forces in water.

D Water us ionic and NaCl is polar.

1.2 Three catalysts are used separately to increase the rate of a hypothetical reaction. In the diagram below, $\mathbf{E_1}$, $\mathbf{E_2}$ and $\mathbf{E_3}$ represent the effect of each catalyst on the activation energy ($\mathbf{E_0}$) for the reaction.



Which of the following is the activation energy for the reaction with the HIGHEST rate?

A $\mathbf{E_3}$

B $\mathbf{E_2}$

C $\mathbf{E_1}$

D $\mathbf{E_0}$

1.3 The complete combustion of propane is represented by the balanced equation below:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$$

30 cm^3 of propane is mixed with 200 cm^3 of oxygen and the mixture is ignited. What is the volume, in cm^3, of the CO_2 in the resulting gas mixture? (All the volumes are measured at the same temperature and pressure).

A 230

B 140

C 120

D 90

1.4 Which ONE of the following solutions can be stored in an aluminium container?

A $CuSO_4$ (aq)

B $ZnSO_4$ (aq)

C NaCl (aq)

D $Pb(NO_3)_2$ (aq)

1.5 The solution that will have the LOWEST concentration of H^+ is…

A 0.4 dm^3 of a 1 $mol.dm^3$ H_2SO_4 solution.

B 0.4 dm^3 of a 1 $mol.dm^3$ HCl solution.

C 0.4 dm^3 of a 1 $mol.dm^3$ CH_3COOH solution.

D 1 dm^3 of a 1 $mol.dm^{-3}$ HCl solution.

[2 X 5 = 10]

Question 2

2.1 A grade 11 learner dissolves 13,995 g of Cu $(NO_2)_2$ in water to make up a standard solution with a concentration of 0.15 $mol.dm^{-3}$.

2.1.1 Define a *standard solution*. (2)

2.1.2 Calculate the volume of water (in cm^3) required to prepare this solution. (4)

The learner then transfers some of the above solution to a volumetric flask, and adds 150 cm^3 of water to dilute it to a concentration of 0.05 $mol.dm^{-3}$.

2.13 Calculate the volume of the original solution that must be transferred to the volumetric flask to prepare the diluted solution. (4)

2.2 50g of a substance contains 24.68 g of **K**, 10.13 g of **S** and 15.19 g of **O**.

2.2.1 Determine the empirical formula of the compound. (4)

[14]

Question 3

3.1 30 g of Al and 1.50 moles of oxygen gas at **STP** are placed in a reaction chamber and allowed to react.
The balanced equation for the reaction is:

$$4Al + 3O_2 \longrightarrow 2\ Al_2O_3$$

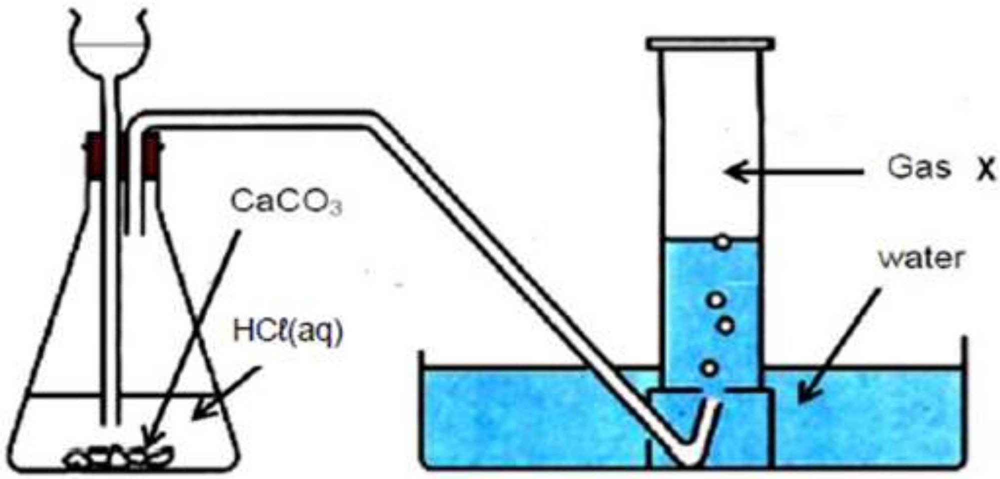
3.1.1 Explain what is meant by a **limiting reactant**. (2)

3.1.2 Calculate the volume of **excess** oxygen in the reaction chamber. (7)

[9]

Question 4

A group of Grade 12 learners uses the reaction between calcium carbonate and hydrochloric acid to investigate one of the factors that influence reaction rate. They use the apparatus shown below.



The reaction that takes place is represented by the following chemical equation:

$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + CO_{2(g)} + H_2O(\ell)$ $\Delta H < 0$

4.1 Two experiments are conducted by using the apparatus shown above. The conditions for each experiment are given in the table below.

Experiment	Mass of $CaCO_3(s)$(g)	State of division of $CaCO_3(s)$	Concentration of HCl (mol·dm^{-3})	Temperature of HCl(aq)(°C)
1	4	lumps	0,2	40
2	4	lumps	0,4	40

4.1.1 Define, in words, the term *reaction rate* in terms of THIS investigation. (2)

4.1.2 From the table above, write down the independent variable for this investigation. (1)

4.1.3 Give a reason why the learners must use equal masses and the same state of division of $CaCO_3(s)$. (1)

In another experiment, the learners obtain the following results for the decomposition of hydrogen peroxide:

$$2H_2O_{2\,(aq)} \longrightarrow 2H_2O_{(l)} + O_{2\,(g)}$$

TIME	H_2O_2 CONCENTRATION (mol.dm^3)
0	0.0200
200	0.0160
400	0.0131
600	0.0106
800	0.0086

4.2 Define reaction rate (2)

4.3 Calculate the AVERAGE rate of decomposition (in mol.dm^{-3}. s^{-1}) of $H_2O_{2\,(aq)}$ in the first 400 s. (3)

4.4 Calculate the mass of oxygen produced at the first 600 s if 50 cm^3 of hydrogen peroxide decomposes in this time interval. (5)

[14]

Question 5

5.1 Sulphurous acid reacts with water in two steps as represented by the equations below.

Equation I: $H_2SO_{3\,(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + HSO_3^-{}_{(aq)}$
Equation II: $HSO_3^-{}_{(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + SO_3^{2-}{}_{(aq)}$

5.1.1 Write down the FORMULA of a species that acts as an ampholyte in the above reactions. (1)

5.1.2 Write down the NAME of the conjugate base of hydrogen sulphite ion. (1)

5.2 Five grams (5 g) of an impure sample of sodium carbonate is added to 100 ml of a 0.2 mol.dm^{-3} solution of sulphuric acid. The acid is in excess. The equation for the reaction is given as follows:

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$$

5.2.1 Calculate the number of moles of sulphuric acid. (3)

The excess acid neutralizes 20 cm^3 of a solution of 0.2 mol.dm^{-3} of magnesium hydroxide according to the following equation:

$$H_2SO_4 + Mg\,(OH)_2 \longrightarrow MgSO_4 + 2H_2O$$

5.2.2 Calculate the mass of the impurity in the sodium carbonate sample. (7)

[12]

Question 6

6.1 Two half cells, Fe (s)/ Fe^{2+} (aq) and O_2 (g)/H_2O (l) in an acidic solution are used to set up an electrochemical cell. The cell works under standard conditions.

6.1.1 Write down the standard conditions which are applicable to this cell. (3)

6.1.2 Which half- cell represents the anode? (2)

6.1.3 Write down the balanced equation for the oxidation half reaction. (2)

6.1.4 Write down the balanced equation for the reduction half reaction. (2)

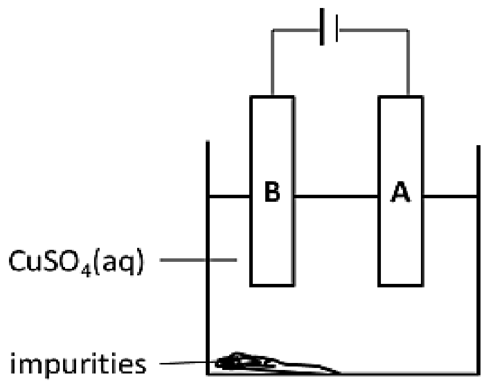
6.1.5 Write down the cell notation for this cell. (3)

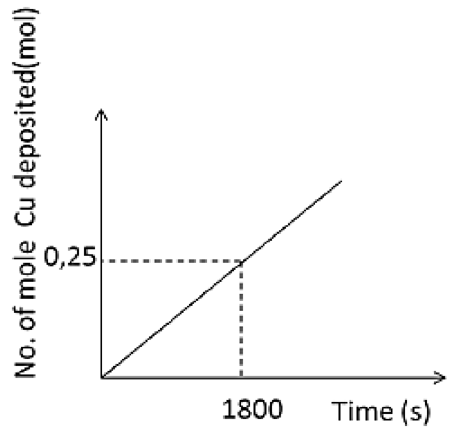
6.1.6 Calculate the emf of this cell. (3)

[15]

Question 7

High purity copper is obtained by electrolysis using a thin, pure copper cathode and an ACIDIFIED solution of copper (II) sulphate.





7.1 At which electrode would pure copper be deposited? (1)
Write only **A** or **B**.

7.2 Write down the reduction half-reaction for this cell. (2)

7.3 Use the graph to calculate the percentage purity of the impure copper that was used as the anode.
The mass of the impurities formed in an hour us 15.8 g when a constant current is used. (4)

7.4 The copper (II) sulphate is an electrolyte, and the concentration remains constant for the duration of the reaction.

7.4.1 Define an *electrolyte*. (2)
7.4.2 Explain why the concentration of the solution remains constant. (1)
[10]

Question 8

Oxygen and fluorine bond to form the OF_2 molecule.

8.1 Write down the **name** of OF_2. (1)

8.2 Define electronegativity. (2)

8.3 Calculate the difference in electronegativity between the oxygen and the fluorine atoms and use it to determine whether the covalent bond between oxygen and fluorine is POLAR or NON-POLAR. (2)

8.4 Draw the Lewis structure for the OF_2 molecule. (2)

8.5 What is meant by a "lone pair of electrons"? (2)

8.6 How many lone pairs of electrons are there on the oxygen atom of the OF_2 molecules? (1)

8.7 What is the shape of the OF_2 molecule? (2)

[12]

Question 9

Natural gas (CH_4) is a fuel. When it burns in air, it produces large quantities of energy as shown in the reaction below:

$$CH_4 + \ 2O_2 \longrightarrow CO_2 + \ 2H_2O + \text{energy}$$

The bond energies associated with the reactions and products are shown in the table below:

Bond	**Energy (Kj.mol^{-1})**
C – H	414
O – H	460
O = O	799
C = O	499

9.1 Calculate the enthalpy change (ΔH) for the reaction given above. (4)

Total 100

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

Half-reactions/*Halfreaksies*			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 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^θ (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

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$
Molar gas constant *Molêre gaskonstante*	R	$8{,}31\ J \cdot K^{-1} \cdot mol^{-1}$
Standard pressure Standaarddruk	p^{θ}	$1{,}013 \times 10^{5}\ Pa$
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^{3} \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^{+}]$
$K_w = [H_3O^{+}][OH^{-}] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$

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

KEY/*SLEUTEL*

	Atomic number / *Atoomgetal* ↓	
Electronegativity / *Elektronegatiwiteit* →	1,9 · 29 · Cu · 63,5	← Symbol / *Simbool*
	↑ Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	

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 (2,1)																	2 He 4
3 Li 7 (1,0)	4 Be 9 (1,5)											5 B 11 (2,0)	6 C 12 (2,5)	7 N 14 (3,0)	8 O 16 (3,5)	9 F 19 (4,0)	10 Ne 20
11 Na 23 (0,9)	12 Mg 24 (1,2)											13 Aℓ 27 (1,5)	14 Si 28 (1,8)	15 P 31 (2,1)	16 S 32 (2,5)	17 Cℓ 35,5 (3,0)	18 Ar 40
19 K 39 (0,8)	20 Ca 40 (1,0)	21 Sc 45 (1,3)	22 Ti 48 (1,5)	23 V 51 (1,6)	24 Cr 52 (1,6)	25 Mn 55 (1,5)	26 Fe 56 (1,8)	27 Co 59 (1,8)	28 Ni 59 (1,8)	29 Cu 63,5 (1,9)	30 Zn 65 (1,6)	31 Ga 70 (1,6)	32 Ge 73 (1,8)	33 As 75 (2,0)	34 Se 79 (2,4)	35 Br 80 (2,8)	36 Kr 84
37 Rb 86 (0,8)	38 Sr 88 (1,0)	39 Y 89 (1,2)	40 Zr 91 (1,4)	41 Nb 92	42 Mo 96 (1,8)	43 Tc (1,9)	44 Ru 101 (2,2)	45 Rh 103 (2,2)	46 Pd 106 (2,2)	47 Ag 108 (1,9)	48 Cd 112 (1,7)	49 In 115 (1,7)	50 Sn 119 (1,8)	51 Sb 122 (1,9)	52 Te 128 (2,1)	53 I 127 (2,5)	54 Xe 131
55 Cs 133 (0,7)	56 Ba 137 (0,9)	57 La 139	72 Hf 179 (1,6)	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 Tℓ 204 (1,8)	82 Pb 207 (1,8)	83 Bi 209 (1,9)	84 Po (2,0)	85 At (2,5)	86 Rn
87 Fr (0,7)	88 Ra 226 (0,9)	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