MARITIME UNIVERSITY OF SZCZECIN

Institute of Mathematics, Physics and Chemistry
Department of Chemistry

EXERCISE INSTRUCTION

Laboratory Exercise 4

Properties of s– and p– block elements

Prepared by:	dr inż. Andrzej Kozłowski dr inż. Agnieszka Kalbarczyk-Jedynak dr Magdalena Ślączka-Wilk dr inż. Konrad Ćwirko mgr inż. Czesław Wiznerowicz Grażyna Gorzycka
Teacher in Charge:	dr Magdalena Ślączka-Wilk
Approved by:	dr inż. Agnieszka Kalbarczyk-Jedynak
Effective from: 01.10.2023	

EXERCISE SHEET

1	**Relation to subjects**: ESO/26, DiRMiUO/26, EOUNIE/26		
	Specialty/Subject	**Learning outcomes for the subject**	**Detailed learning outcomes for the subject**
	ESO/25 Technical chemistry	EKP1 K_W01, K_W02, K_U05 EKP2 K_U08, K_U09	SEKP3 – carrying out reactions characteristic for selected elements of the s and p block: reactions of alkali and alkaline earth metals; reactions of metals with oxygen, reactions of metals with acids; reactions of metals with different activities
	ESO/26 Chemistry of water, fuels and lubricants	EKP3 K_U014, K_U015, K_U016.	SEKP6 – Determination of total, calcium and magnesium hardness of boiler water
	DiRMiUO/26 Chemistry of water, fuels and lubricants	EKP3 K_U014, K_U015, K_U016.	SEKP6 – Determination of total, calcium and magnesium hardness of boiler water
	EOUNiE/26 Chemistry of water, fuels and lubricants	EKP3 K_U014, K_U015, K_U016.	SEKP6 – Determination of total, calcium and magnesium hardness of boiler water
2	**Purpose of the exercise:** 1. Expanding knowledge in the field of the periodic table of elements, systematics of chemical compounds and learning the basic chemical properties of elements from blocks s and p. 2. To consolidate the ability to record chemical reactions (formation of oxides, hydroxides, acids). 3. Understanding the method of removing water hardness by chemical method and recording appropriate reactions. 4. Acquiring the ability to assess the activity of metals on the basis of the periodic table of the voltage series of metals.		
3	**Prerequisites:** – general information on the periodic table of elements in macro and macroscopic terms, general chemical knowledge about selected elements of the s and p blocks.		
4	**Description of the laboratory workplace:** Basic laboratory equipment - a set of test tubes in a stand, burner, laboratory tongs, platinum wire, evaporator, solutions: 0,1M sodium hydroxide NaOH, 0,1M magnesium chloride $MgCl_2$, 2M ammonium chloride, 0,1M sodium carbonate, 0,1M strontium chloride, 0,1M barium chloride, 0,1M sodium sulphate (VI), 0,1M potassium chromate (VI), 2M acetic acid, 0,1M calcium carbonate, 0,1M calcium chloride, saturated solutions: barium nitrate (V), strontium nitrate (V), calcium nitrate (V), indicators: 0,05% alcohol solution of phenolphthalein, solids: magnesium ribbon		
5	**Risk assessment*:** Contact with solutions of salts, acids and bases and burning of the Mg ribbon - the likelihood of chemical or thermal burns is very low, the effects are minor. Final assessment – **MEDIUM** Security measures required: a. protective gloves,		

	b. protective glasses, c. protective lab coats.
6	**The course of the exercise** 1. Getting to know the workplace instructions for exercises (Appendix 2), 2. Performing individual exercises in accordance with the workplace manual.
7	**Exercise report:** 1. Develop an exercise in accordance with the instructions contained in the workplace manual. 2. Solve the given task and/or answer the questions included in the set of tasks and questions to be completed by the student.
8	**Archiving of research results:** submit an exercise report in the applicable form at the beginning of the next laboratory exercises
9	**Assessment method and criteria:** a. EKP1, EKP2 – the control of the knowledge of basic chemical concepts and the ability to use the basic periodic table to assess the chemical properties of selected elements will be carried out during classes, b. SEKP3 – the detailed effect of the student's education will be assessed on the basis of the observations, conclusions and solutions to tasks and problems given for independent solution/development: – mark 2,0 – the student has too little knowledge of the periodic table, the characteristic properties of selected elements in the s and p block and the activity of metals, or is unable to use it for simple practical tasks related to the above-mentioned issues; – mark 3,0 – has basic chemical knowledge of the periodic table and the properties of elements and a number of metal activities, and is able to use it to solve simple tasks and problems related to the above-mentioned issues; – mark 3,5 – 4,0 – has extended chemical knowledge in the field of chemical properties of elements and the periodic table and a number of activities of metals, and has the ability to solve complex tasks related to the above-mentioned issues in his specialty; – mark 4,5 – 5,0 – has the ability to apply complex chemical knowledge in the field of the properties of elements and a number of metal activities, and is able to solve complex and problematic tasks related to the above-mentioned issues in their field.
10	**References:** 1. https://assets.openstax.org/oscms-prodcms/media/documents/Chemistry2e-WEB.pdf (accessed 15.07.22). 2. A. Kozłowski, A. Kalbarczyk-Jedynak, M. Ślączka-Wilk, K. Ćwirko, C. Wiznerowicz, G. Gorzycka, Instrukcje stanowiskowe do ćwiczeń laboratoryjnych: Właściwości pierwiastków bloku s i p, AM Szczecin 2022 (in Polish). 3. J. E. McMurry, R. C. Fay, J. K. Robinson, Chemistry, 7th edition, global edition, publisher: Pearson, 2016. 4. A. Blackman, S. Bottle, S. Schmid, M. Mocerino, U. Wille, Chemistry, 2nd edition, publisher: John Wiley&Sons, 2012. 5. G. Curran, Chemistry, publisher: The Career Press, 2011. 6. J. T. Moore, Chemistry for Dummies, publisher: Wiley Publishing, 2015. 7. D. Kealy, P.J. Haines, Analytical Chemistry, publisher: BIOS Scientific Publishers Limited, 2002.

	8. Sparkcharts Chemistry, 2002 Spark Publishing, A Division of Barnes & Noble, Canada 2014. 9. M. D. Jackson, Chemistry, 2015 BarCharts, Inc. (Quickstudy.com). 10. M. Charmas, English for Students of Chemistry, Maria Curie-Skłodowska University Press, Lublin 2012. 11. Stundis H., Trześniowski W., Żmijewska S.: Ćwiczenia laboratoryjne z chemii nieorganicznej. WSM, Szczecin 1995 (in Polish). 12. M. Wesołowski, K. Szefer, D. Zimna, Zbiór zadań z analizy chemicznej, Wydawnictwa Naukowo – Techniczne, Warszawa 1997 (in Polish).
11	Notes

1. THEORY

KEYWORDS:

- atomic structure,
- the periodic table,
- selected reactions of s – and p – block elements,
- classification of chemical reactions; precipitation reactions.

Atomic structure

Atom – „the smallest complete unit of an element”. Atoms are composed of subatomic particles and these subatomic particles make up the atom. There are many subatomic particles, according to scientists, but there are three major ones:

- protons (p+); charge +1; mass: 1 (amu – atomic mass units); location: atom’s dense central core: in nucleus,
- neutrons (no); charge 0; mass: 1 (amu – atomic mass units); location: nucleus (atom’s dense central core),
- electrons (e–); charge –1; mass: 0.0005 (amu – atomic mass units); location: outside nucleus.

1 amu = 1/12 of carbon atom.
Nucleus – a center of the atom containing protons and neutrons.
Core (kernel) – nucleus plus electrons other than those in the valence energy level (shell).
Mass number (A) – protons plus neutrons.
Atomic number (Z) – number of protons. The atom is neutral so an equal number of positive and negative charges (protons and electrons) must be inside it. The number of protons = the number of electrons.

Example 1 – Determine the number of protons, electrons and neutrons in the following elemental notation (combination of the elemental symbol of an element plus, for example, the atomic number, mass number, charge):

$$^{20}_{10}\mathrm{Ne}$$

Answer: the atomic number of Ne is 10, so Z = 10; A = 20. The neon atom shows 10 protons, 10 electrons and 10 neutrons (A – Z: 20 – 10 = 10).

Isotopes – atoms with the same Z, different A.
Atomic mass – „is a weighted average of all naturally occurring isotopes”.

The Bohr model of atomic structure – electrons in atoms are in orbits of differing energy (Bohr used the term energy levels or shells in order to describe these orbits of differing energy) around the nucleus. Ground state is the energy level (shell) an electron normally occupies. Electrons can move to a higher-energy level – electron’s excited state, that is less stable, by absorbing energy. Electron can return to the ground state by releasing the energy it has absorbed. The closer an electron is to the nucleus, the less energy it has. Bohr also numbered the energy levels (shells) – the higher the shell (the energy level) number the farther away the electron is from the nucleus and obviously the higher the energy. Bohr also discovered that the various shells can hold differing numbers of electrons, for example, shell 1 (energy level 1) can hold up to 2 electrons, shell 2 can hold up to 8 electrons.

The quantum mechanical model of atomic structure: the quantum numbers:

- principal quantum number (n) – indicates energy level (shell); values: 1, 2, 3, 4 and so on,
- angular quantum number (l) – indicates sublevel (subshell); values: from 0 to n–1,
- magnetic quantum number (m_l) – indicates orbital; values: –l, 0, +l,
- spin quantum number (m_s) – indicates the electron; values: +1/2 or –1/2.

Table 1

The Four Quantum Numbers [4]

	Called	Symbol	Indicates	Values*
First Quantum Number	Principal	*n*	Energy Level	1 – 7
Second Quantum Number	Angular Momentum	*l*	Sublevel	0, 1, 2, 3 (or s, p, d, f)
Third Quantum Number	Magnetic	M_l	Orbital	+3, +2, +1, 0, –1, –2, –3
Fourth Quantum Number	Spin	M_s	Electron	+1/2 and –1/2

* – There are other possible values, but the listed values will cover all that you need to use for the elements that are currently known.

Oritals (instead of Bohr's orbits) often called „electron clouds" – this a space in which electrons are likely to be. Electrons exist in „clouds" around the atomic nucleus.

The information regarding the quantum numbers is necessary to construct the electron configuration of elements. The order of the sublevels: s, p, d, f: „**s**ome **p**eople **d**on't **f**orget", see the Table 2:

Table 2

Summary of the first four energy levels [4]

Principal Energy Level (n)	Type (s) of Sublevel	Number of Orbitals	Maximum number of Electrons
1	s	1	2
2	s p	1 3	2 6
3	s p d	1 3 5	2 6 10
4	s p d f	1 3 5 7	2 6 10 14

Each orbital (see the table above) can hold up to two electrons and the sublevels contain different numbers of orbitals.

Electron configuration – „a method of representing the pattern of electrons in an atom”. In other words this is the arrangement of electrons in a particular atom or element (element – is made up of one type of atom with the same atomic number). The order of filling sublevels, see the Fig. 1:

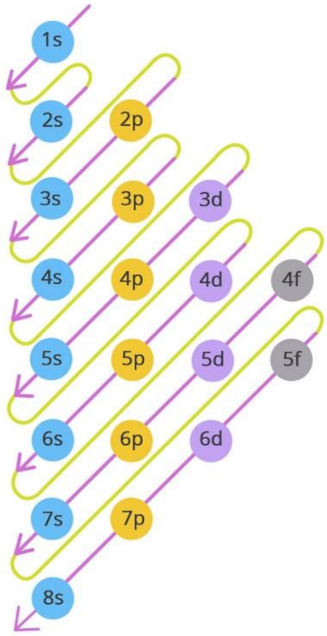

Fig. 1. The arrow diagram for the order of filling sublevels (subshells)
(source: https://www.aakash.ac.in/important-concepts/chemistry/aufbau-principle; accessed January, 27, 2022)

Things to remember (electron configuration!). Each energy level (shell; n = 1, n = 2, and so on) is divided into sublevels (s, p, d, f,..). The sublevels contain a certain number of orbitals. An orbital can be occupied by up to two electrons and an orbital is represented by squares or circles, electrons in a square or circle are represented by arrows. The electrons that are in the same orbital have the same value for the first 3 quantum numbers but must have a different value for m_s. See the Tab. 3 and the Fig. 2.

Table 3

Sublevel summary

Sublevel	Number of orbitals it contains (first four odd numbers)	Total number of electrons it can hold
s	1	2
p	3	6
d	5	10
f	7	14

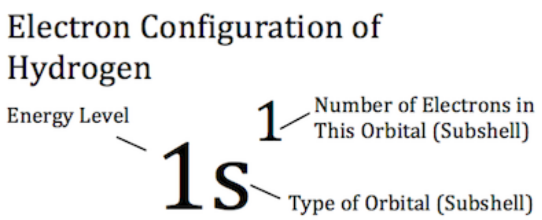

Fig. 2. The electron configuration of hydrogen
(source: https://socratic.org/questions/58bbbd4611ef6b730514bb49; accessed January, 27, 2022)

Hund's Rule: electrons fill s, p, d, f sublevels in order to maximize the number of unpaired electrons. In other words, we put one electron in each of the orbitals in a particular sublevel (subshell), before we double up the electrons in any particular orbital, see the Fig. 3.

Pauli Exclusion Principle: an orbital can hold up to two electrons: one with spin up (↑): $m_s = +1/2$, and one with spin down (↓): $m_s = –1/2$, see the Fig. 3.

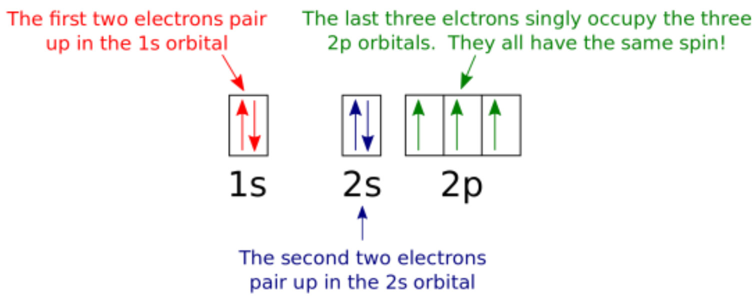

Fig. 3. Orbital configuration of nitrogen
(source: https://www.differencebetween.com/difference-between-orbital-diagram-and-electron-configuration/; accessed January, 27, 2022)

Example 2 – Write the full and the shorthand electron configuration for the element aluminum (Al).
The full electron configuration of Al: $1s^2 2s^2 2p^6 3s^2 3p^1$.
The shorthand electron configuration of Al: $[Ne]3s^2 3p^1$ kernel (core) configuration was replaced with the noble gas symbol [Ne] that it matches!! $3s^2 3p^1$ – this is the valence configuration.

Kernel (core) – nucleus plus all of the electrons other than those in the valence shell (valence electrons).

Example 3 – Write the full and the shorthand electron configuration of Mg.
The full electron configuration of Mg: $1s^2 2s^2 2p^6 3s^2$.
The shorthand electron configuration of Mg: $[Ne]3s^2$.

Valence electrons – electrons in the outermost shell (valence energy level). In other words valence electrons are the ones that are lost or gained or shared and these electrons are found in the highest energy level (outermost energy level).

Type of valence configuration:

- ns (s section – groups: 1 and 2 in the periodic table),
- ns, np (p section – groups: from 13 to 18 in the periodic table),
- (n – 1) d, ns (d section – groups: from 3 to 12 in the periodic table),
- (n – 2) f, (n – 1) d, ns (f section in the periodic table).

The Periodic Table

- The elements in the periodic table are arranged in order of increasing atomic number.
- The horizontal rows are called periods. Periods are numbered from 1 to 7 on the left-hand side of the table and the period indicates the energy level and also the energy level in which its valence electrons reside. For example Mg is found in the third period, it has 3 energy levels and its valence electrons are in the 3rd energy level (shell).
- The vertical columns are called groups or families. Groups are labeled at the top of the columns using Roman numerals and letters (the older method) or using just numbers from 1 to 18 (the newer method). The members of the family have similar properties! The group number indicates the valence electrons (groups: 1, 2, 13 – 18), for example the group 1 has 1 valence electron, the group 2 has two valence electrons and so on.

Four of the groups (columns: 1, 2, 17 and 18) have special family names. Column 1 – Alkali Metals (s section; s block elements); Column 2 – Alkaline Earth Metals (s section; s block elements); Column 17 – Halogens (p section; p block elements); Column 18 – Noble Gases (p section; p block elements).

Columns from 3 to 12 – Transition Metals (d section; d block elements); Lanthanides and Actinides – f section in the periodic table.

Column 13 – boron family; Column 14 – carbon family; Column 15 – nitrogen family (or pnictogens); Column 16 – oxygen family (or chalcogens).

Columns from 1 to 2 – the periodic table is made up of s section (Fig. 4).

Columns from 13 to 18 – the periodic table is made up of p section (Fig. 4).

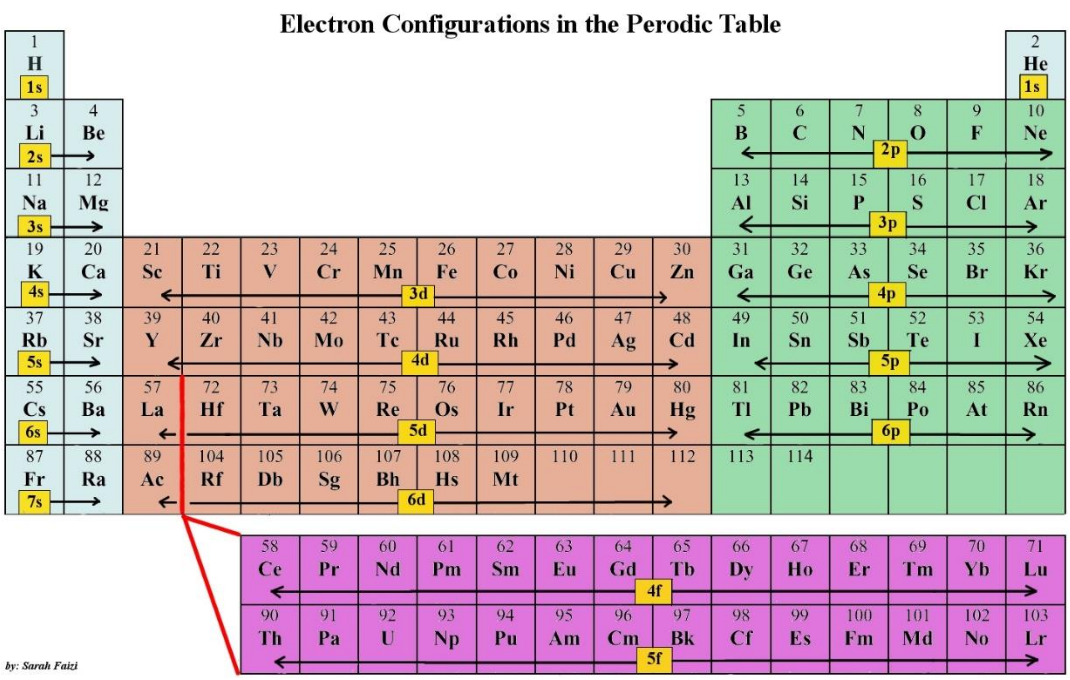

Fig. 4. Electron configurations in the Periodic Table; s, p, d, f – block elements (source:https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(McMurry)/01%3A_Structure_and_Bonding/1.03%3A_Atomic_Structure_–_Electron_Configurations; accessed January, 27, 2022)

– Most of the elements are considered metals (left-hand side and the middle of the periodic table; exception hydrogen). It means that these elements are solid (exception: mercury, Hg, it is liquid), shiny, good conductors of electricity and heat, they can be easily hammered and they can be drawn into thin wires.

  Nonmetals (the elements to the right of the periodic table) are poor conductors of heat and electricity, some of them are liquids, some of them are gases and solids, they are brittle, they cannot be easily hammered or drawn into wires.

  Metalloids (semimetals: B, Si, Ge, As, Sb, Te, At) have properties similar to metals and nonmetals. They conduct electricity but only partially that is why semimetals are applied in semiconductor and computer chip industry. For example silicon is used in making computer chips.

– Flame test (especially groups 1 and 2 – s– block elements – an easy method of first step identification). The flame test is used to identify a presence of certain metal ions in a compound, in a sample (Fig. 5). The ionic forms of s– block elements are applied in fireworks. Especially the ionic forms of barium, strontium and potassium are being ingredients in mentioned fireworks.

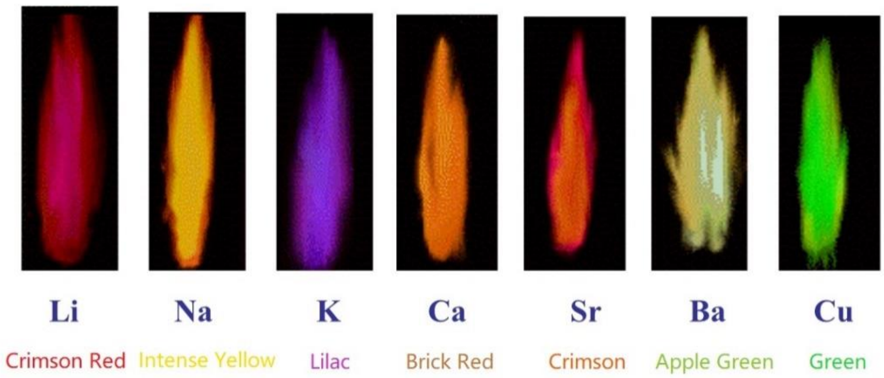

Fig. 5. Flame test
(source: http://www.canfortlab.com/Why-Is-A-Platinum-Wire-Used-For-Flame-Test--Why-Not-Iron-Wire-Nor-Aluminium-Wire-n27.html; accessed January, 27, 2022)

The selected reactions (reactions leading to basic and acidic solutions) of s– and p– block elements

Reactions of s– block elements

Metal + Oxygen $\longrightarrow$ Metal Oxide

Example: $4Na + O_2 \longrightarrow 2\,Na_2O$; $2Mg + O_2 \longrightarrow 2MgO$

Metal oxide + Water $\longrightarrow$ Hydroxide

Example: $MgO + H_2O \longrightarrow Mg(OH)_2$; $Na_2O + H_2O \longrightarrow 2NaOH$

Metal oxides that dissolve in water react with it and form basic solutions.

Reactions of p– block elements

Nonmetal + Oxygen $\longrightarrow$ Nonmetal Oxide

Example: $S + O_2 \longrightarrow SO_2$; $C + O_2 \longrightarrow CO_2$

Nonmetal oxide + Water $\longrightarrow$ Oxoacid

Example: $SO_2 + H_2O \longrightarrow H_2SO_3$; $CO_2 + H_2O \longrightarrow H_2CO_3$

$SO_3 + H_2O \longrightarrow H_2SO_4$

Nonmetal oxides that dissolve in water react with it and form acidic solutions.

Nonmetal + Hydrogen $\longrightarrow$ Gas The product of this reaction (Gas) dissolves in water and forms hydracids (for example: HCl, H_2S):

$$H_2 + Cl_2 \longrightarrow 2HCl_{(g)} \text{ Gas}$$

$HCl_{(g)}$ dissolves in water and forms $HCl_{(aq)}$

Classification of chemical reactions. Precipitation reactions

A synthesis reaction

A + B $\longrightarrow$ AB, where A, B – element or compound; AB - compound

Example: $2H_2 + O_2 \longrightarrow 2H_2O$; $2CO + O_2 \longrightarrow 2CO_2$

A decomposition reaction

AB $\longrightarrow$ A + B, where A, B – element or compound;

Example: $CaCO_3 \longrightarrow CaO + CO_2$; $2\,H_2O_2 \longrightarrow 2H_2O + O_2$

A single replacement reaction (when the elemental reactant is a metal)

A + BC $\longrightarrow$ AC + B, where A, B – element; AC, BC – compound

Example: $Mg + 2NaCl \longrightarrow MgCl_2 + 2Na$

A single replacement reaction (when the elemental reactant is a nonmetal)

A + BC $\longrightarrow$ BA + C, where A, C – element; BC, BA – compound

Example: $F_2 + 2NaI \longrightarrow 2NaF + I_2$

A double replacement reaction (double displacement reactions)

AB + CD $\longrightarrow$ AD + BC, where AB, CD, AD, BC – compounds

Example: $2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

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

A combustion reaction – reaction between a hydrocarbon and an oxygen

Example: $CH_4 + O_2 \longrightarrow CO_2\uparrow + 2H_2O$ combustion of methane

Precipitation reactions are reactions that involve the formation of an insoluble precipitate from mixing of two soluble compounds (ionic compounds). If a reaction product is soluble, it will stay dissolved in the aqueous solution if it is not (reaction product is insoluble: (↓), it will stay as a solid precipitate (Fig. 6).

Salt I+ Acid I $\longrightarrow$ Salt II↓ + Acid II; $AgNO_3 + HCl \longrightarrow AgCl\downarrow + HNO_3$ – the molecular equation.

$Ag^+ + \cancel{NO_3^-} + \cancel{H^+} + Cl^- \longrightarrow AgCl\downarrow + \cancel{H^+} + \cancel{NO_3^-}$ – the ionic equation

$Ag^+ + Cl^- \longrightarrow AgCl\downarrow$ – the net ionic equation

Salt I+ Base $\longrightarrow$ Salt II↓ + Hydroxide; $Na_2SO_4 + Ba(OH)_2 \longrightarrow BaSO_4\downarrow + 2NaOH$ – the molecular equation.

Salt I+ Salt II $\longrightarrow$ Salt III↓ + Salt IV; $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2NaCl$ – the molecular equation.

		Group I Alkali Metals			Group II Alkaline Earth Metals			Transition Metals					Post-transition Metals		
	Ammonium NH_4^+	Lithium Li^+	Sodium Na^+	Potassium K^+	Magnesium Mg^{2+}	Calcium Ca^{2+}	Barium Ba^{2+}	Iron (II) Fe^{2+}	Iron (III) Fe^{3+}	Copper (II) Cu^{2+}	Silver Ag^+	Zinc Zn^{2+}	Lead (II) Pb^{2+}	Aluminum Al^{3+}	
Fluoride F^-	soluble	slightly soluble	soluble	soluble	insoluble	insoluble	slightly soluble	slightly soluble	slightly soluble	soluble	soluble	soluble	insoluble	slightly soluble	Fluoride F^-
Chloride Cl^-	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	insoluble	soluble	insoluble	soluble	Chloride Cl^-
Bromide Br^-	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	insoluble	soluble	slightly soluble	soluble	Bromide Br^-
Iodide I^-	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble			insoluble		insoluble	soluble	Iodide I^-
Chlorate ClO_3^-	soluble	soluble	soluble	soluble	soluble	soluble	soluble		soluble		soluble		soluble	soluble	Chlorate ClO_3^-
Hydroxide OH^-	--	soluble	soluble	soluble	insoluble	slightly soluble	soluble	insoluble	insoluble	insoluble	slightly soluble	insoluble	insoluble	insoluble	Hydroxide OH^-
Sulfite SO_3^{2-}	soluble	soluble	soluble	soluble	soluble	insoluble	insoluble				insoluble	insoluble	insoluble		Sulfite SO_3^{2-}
Sulfate SO_4^{2-}	soluble	soluble	soluble	soluble	soluble	slightly soluble	insoluble	soluble	soluble	soluble	slightly soluble	soluble	insoluble	soluble	Sulfate SO_4^{2-}
Carbonate CO_3^{2-}	soluble	soluble	soluble	soluble	insoluble	insoluble	insoluble	insoluble		insoluble	insoluble	insoluble	insoluble		Carbonate CO_3^{2-}
Nitrite NO_2^-	soluble	soluble	soluble	soluble	soluble	soluble	soluble				insoluble		soluble		Nitrite NO_2^-
Nitrate NO_3^-	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	soluble	Nitrate NO_3^-
Phosphate PO_4^{3-}	soluble	insoluble	soluble	soluble	insoluble	insoluble	insoluble	insoluble	insoluble	insoluble	insoluble	insoluble	insoluble	insoluble	Phosphate PO_4^{3-}

Fig. 6. The solubility chart
(source: https://www.sigmaaldrich.com/PL/pl/technical-documents/technical-article/materials-science-and-engineering/solid-state-synthesis/solubility-rules-solubility-of-common-ionic-compounds accessed February,1, 2022)

Additional tasks and questions to be performed by the student:

1. For this chemical reaction: $CaCl_2 + K_2SO_4 \longrightarrow CaSO_4 + 2KCl$ write a net ionic equation and also identify the precipitate.
2. Potassium bromide plus silver nitrate – for this chemical reaction write a balanced chemical equation, write a net ionic equation and also identify the precipitate.
3. Fill in the blank and balance chemical equation:
   - $CaO + H_2O \longrightarrow$ ___________
   - $K_2O + H_2O \longrightarrow$ ___________
   - $N_2O_5 + H_2O \longrightarrow$ ___________
   - $H_2 + S \longrightarrow$ ___________
4. Write a full and a shorthand electron configuration for the given elements: Ca and S.
5. Determine the number of protons, electrons and neutrons in each of the following elemental notations: ^{22}Na; ^{86}Rb, ^{55}Mn, ^{27}Al.

2. INSTRUCTION 4 – LABORATORY EXERCISE 4

Experiment 1 – Burning magnesium; reaction of metal oxide with water

Materials and reagents:

Magnesium ribbon, laboratory gas burner (Bunsen burner), ceramic evaporating dish, phenolphthalein solution (alcoholic; 0.05%).

Experimental procedure:

Approximately 2 – 3 cm of magnesium ribbon grip in the crucible tongs and ignite it in the laboratory gas burner flame. As soon as the magnesium is lit (magnesium burns in air very actively), remove the ribbon from the flame and hold it over the ceramic evaporating dish (let the magnesium oxide – MgO fall into the ceramic evaporating dish). Then add a few drops of distilled water to the ceramic evaporating dish, stir it and add 2 – 3 drops of phenolphthalein.

Data analysis (after the experiment):

1. Write a balanced chemical equation for magnesium plus oxygen.
2. Write a balanced chemical equation for magnesium oxide plus water.
3. Indicate the presence of what kind of ions cause the color change of the phenolphthalein?

Experiment 2 – Sulfur combustion; reaction of non-metal oxide with water

Materials and reagents:

Solid sulfur, laboratory gas burner (Bunsen burner), combustion spoon, universal pH indicator.

Experimental procedure:

Put a small amount of sulfur in a combustion spoon and burn it in a Bunsen flame (laboratory gas burner) until it is alight. Put quickly the combustion spoon of burning sulfur into the Erlenmeyer flask (previously rinsed with water). Add distilled water, just a bit, then add a few drops of universal pH indicator. The universal pH indicator should change color because the water becomes acidic.

Data analysis (after the experiment):

1. Name the product of the reaction.
2. Write a balanced chemical equation for sulfur plus oxygen.
3. Write a balanced chemical equation for sulfur (IV) oxide plus water.
4. Indicate the presence of what kind of ions cause the color change of the universal pH indicator?

Experiment 3 – Flame test (selected salts of alkaline-earth elements)

Materials and reagents:

Laboratory gas burner (Bunsen burner), platinum wire, saturated solutions of: barium nitrate ($Ba(NO_3)_2$), strontium nitrate ($Sr(NO_3)_2$), calcium nitrate ($Ca\ (NO_3)_2$).

Experimental procedure:

Dip the cleaned platinum wire in a saturated solution of barium nitrate ($Ba(NO_3)_2$) and hold it in the flame of laboratory gas burner, note the color given off. Repeat the experiment for each of the other given salts.

Data analysis (after the experiment):

1. What causes the different colors in flame? (describe it on the basis of Bohr's theory).
2. What are the real – life applications of flame test?

Experiment 4 – Precipitation of carbonates

Materials and reagents:

Glass test tube set, micro spatula, solutions of sodium carbonate (0.1M Na_2CO_3), hydrochloric acid (2M HCl), calcium chloride (0.1M $CaCl_2$), strontium chloride (0.1M $SrCl_2$), barium chloride (0.1M $BaCl_2$).

Experimental procedure:

Pour about 2 cm^3 of calcium chloride solution (0.1M $CaCl_2$) to the first test tube. Pour about 2 cm^3 of strontium chloride solution (0.1M $SrCl_2$) to the second test tube and pour about 2 cm^3 of barium chloride solution (0.1M $BaCl_2$) to the third test tube. Add solution of sodium carbonate (0.1M Na_2CO_3) to each of three test tubes in order to get a precipitate (calcium carbonate, strontium carbonate and barium carbonate). Check the solubility of obtained carbonates in hydrochloric acid solution (2M HCl) – to each of three test tubes add dropwise solution of hydrochloric acid (2M HCl).

Data analysis (after the experiment):

1. Write the precipitation reactions – molecular and ionic form of the reactions.
2. Write the reactions between hydrochloric acid and obtained carbonates – molecular and ionic form of the reactions.

Experiment 5 – Precipitation of sulfates

Materials and reagents:

Glass test tube set, micro spatula, solutions of sodium sulfate (0.1M Na_2SO_4), hydrochloric acid (2M HCl), calcium chloride (0.1M $CaCl_2$), strontium chloride (0.1M $SrCl_2$), barium chloride (0.1M $BaCl_2$).

Experimental procedure:

Pour about 2 cm^3 of calcium chloride solution (0.1M $CaCl_2$) to the first test tube. Pour about 2 cm^3 of strontium chloride solution (0.1M $SrCl_2$) to the second test tube and pour about 2 cm^3 of barium chloride solution (0.1M $BaCl_2$) to the third test tube. Add solution of sodium sulfate (0.1M Na_2SO_4) to each of three test tubes in order to get a precipitate (calcium sulfate, strontium sulfate and barium sulfate). Check the solubility of obtained carbonates in hydrochloric acid solution (2M HCl) – to each of three test tubes add slowly solution of hydrochloric acid (2M HCl).

Data analysis (after the experiment):

1. Write the precipitation reactions – molecular and ionic form of the reactions.

Experiment 6 – Reaction of aluminum with copper(II) sulfate(VI) and copper(II) chloride

Materials and reagents:

Glass test tube set, aluminum foil, solutions of copper(II) sulfate(VI), copper(II) chloride, solid sodium chloride.

Experimental procedure:

Pour about 5 cm^3 of copper(II) sulfate(VI) (1% $CuSO_4$) solution into the first test tube and 5cm^3 of copper(II) chloride solution (1% $CuCl_2$) into the second test tube. Add aluminum foil (just a piece) to each of two test tubes. Record the changes (speed of the reaction, color of solution, etc.) in both test tubes. After a few minutes, add a pinch of sodium chloride (NaCl) to the first test tube and observe its effect on the reaction.

Data analysis (after the experiment):

1. Write the reactions of aluminum with copper(II) sulfate(VI) and copper(II) chloride.
2. Write the definition of passivity?
3. What is the effect of sodium chloride on the reaction rate (first test tube)?

3. Guidelines for writing the final laboratory report

1. First page of the report – The Laboratory Report Cover Sheet found on our website: https://www.am.szczecin.pl/en/facilities/institute-of-mathematics-physics-and-chemistry/department-of-chemistry/chemistry-lab-manuals/
2. Second page of the report – „The Theoretical Part" – on a maximum of one page including brief description of keywords.
3. Third page of the report – „The Experimental Part" – including all performed experiments with titles, raw data, reactions, calculations, tables, graphs, etc. It should be written in accordance with „Data analysis (after the experiment)".
4. Additional task/tasks given by the academic teacher.
5. References.

4. IN ORDER TO PASS THE LABORATORY EXERCISE STUDENTS MUST PASS „THE ENTRY TEST" AND SUBMIT THE FINAL LABORATORY REPORT AT THE NEXT LABORATORY MEETING. THE LAB REPORT MUST BE ACCEPTED BY THE ACADEMIC TEACHER.