Institute of Mathematics, Physics and Chemistry

Department of Chemistry

Technical chemistry laboratory

Laboratory exercise

Properties of s-block elements

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EXERCISE SHEET

<table>
<tr><td rowspan="5">1</td><td colspan="3">Relation to subjects: ESO/26, DiRMiUO/26, EOUNIE/26</td></tr>
<tr><td>Specialty/Subject</td><td>Learning outcomes for the subject</td><td>Detailed learning outcomes for the subject</td></tr>
<tr><td>ESO/25 Technical chemistry</td><td>EKP1
K_W01, K_W02, K_U05

EKP2
K_U08, K_U09</td><td>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.</td></tr>
<tr><td>ESO/26 Chemistry of water, fuels and lubricants</td><td>EKP3
K_U014, K_U015, K_U016.</td><td>SEKP6 – Determination of total, calcium and magnesium hardness of boiler water</td></tr>
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K_U014, K_U015, K_U016.</td><td>SEKP6 – Determination of total, calcium and magnesium hardness of boiler water</td></tr>
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K_U014, K_U015, K_U016.</td><td>SEKP6 – Determination of total, calcium and magnesium hardness of boiler water</td></tr>
<tr><td>2</td><td colspan="3">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.</td></tr>
<tr><td>3</td><td colspan="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.</td></tr>
<tr><td>4</td><td colspan="3">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</td></tr>
<tr><td>5</td><td colspan="3">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.</td></tr>
</table>

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	**Literature:** 1. Stundis H., Trześniowski W., Żmijewska S.: *Ćwiczenia laboratoryjne z chemii nieorganicznej*. WSM, Szczecin 1995. 2. Kozłowski A., Gabriel-Półrolniczak U., Ćwirko K., *Instrukcja stanowiskowa do ćwiczeń laboratoryjnych: Właściwości pierwiastków bloku s i p,* AM Szczecin, 2013. 3. Cox P.A. translation of Z. Zawadzki: *Chemia nieorganiczna*. PWN. Warsaw 2006. 4. Drapała T.: *Chemia ogólna i nieorganiczna*. SGGW, Warsaw 1994. 5. Bielański A.: *Chemia ogólna i nieorganiczna.* PWN, Warsaw 1994. 6. Jones L., Atkins P., *Chemia ogólna*. Cząsteczki, materia reakcje, WN PWN, Warsaw 2004. 7. Mastalerz P.: *Elementarna chemia nieorganiczna*. Wydawnictwo Chemiczne. Warsaw 2000. 8. Śliwa A.: *Obliczenia chemiczne. Zbiór zadań.* PWN. Warsaw 1994. 9. Pazdro M. *Zbiór zadań z chemii dla szkół średnich*. 10. Kozłowski A., *Materiały dydaktyczne z chemii technicznej*, developed for the purposes of auditorium classes (not published). 11. Resources Open AGH. http://open.agh.edu.pl/open2/
1	Notes

APPENDIX 1 – MANUAL

1. SCOPE OF THE EXERCISE

Issues and keywords:

- periodic table of elements (groups, periods, blocks of elements s, p, d, f);
- electron structure of elements (shells, subshells, Pauli exclusion principle, Hund's rules, element valence);
- chemical properties of the elements of the s-block;
- systematics of inorganic compounds;
- formation of oxides, hydroxides and salts;
- water hardness and its removal;
- chemical activity of metals.

2. THEORETICAL INTRODUCTION TO THE EXERCISE

2.1. The law of periodicity. Periodic table

118 elements are known today, 88 of which are found in nature in an easily detectable amount. Several more have been obtained by nuclear reactions in an analytically quantifiable amount, and the few recently detected elements so far have been obtained in the smallest indeterminate amount, but nevertheless their chemical individuality has been unequivocally proven. All the elements are grouped in a table called the „Periodic Table of the Elements”. Already in the first years of the nineteenth century, attempts were made to arrange the elements in a logical way. The first attempts at systematizing the elements did not lead to satisfactory results. Such attempts were made by; Döbereiner (triads), Newlands (ranks) and Meyer (very similar to Mendeleev's system). It was not until 1870 that Mendeleev resolved the problem properly. He developed the **law of periodicity**, the later expression of which is the present periodic table, presented in a modern form in Fig. 1.

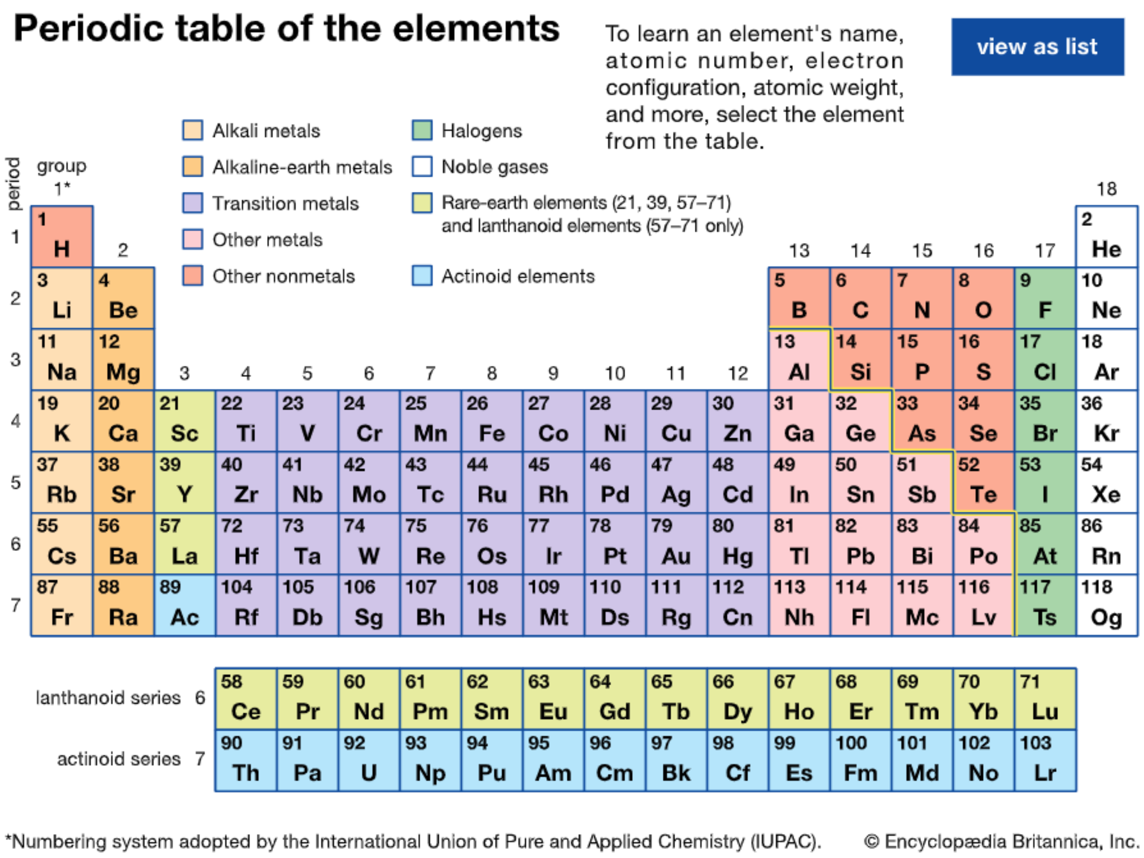


Fig. 1. Periodic Table of the Elements
source: https://www.britannica.com/science/periodic-table
(accessed October, 1, 2021)

D.I. Mendeleev arranged the elements according to the increasing atomic mass and determined that:

– elements arranged according to increasing atomic mass show repeatability (periodicity) of their properties (the so-called law of periodicity);
– in the table of the periodic table, it leaves spaces for elements that are probably existing, but not yet discovered;
– in several places in the system, the order of the elements should be rearranged, considering that the similarity of their properties in the same group is more important than their increasing atomic mass.

The properties of the elements gradually change over the period. He placed horizontal rows of elements with repeating properties one below other. This became the basis for dividing the table of elements into eighteen vertical columns called groups of elements. All vertical groups have a name. And so, the roots of the main groups of the s-block, corresponding to the group number, constitute:

– **1 – alkali metals** block **s**
– **2 – alkaline earth metals** block **s**

S-BLOCK ELEMENTS

2.1.1. Characteristics of alkali metals

The common feature of alkali metals (Table 1) is a valence shell composed of one s-orbital with only one electron (**ns^1**). The valency of the alkali metals is constant. They always occur in the **+I** oxidation state. This is related to the persistence of the configuration on shells closer to the kernel (Table 2). Beginning with lithium, the electron is farther from the nucleus in each successive alkali metal. The detachment of this electron is therefore easier, therefore the reactivity of alkali metals increases with the increase of the atomic mass of the element. Lithiums have the lowest electronegativity among elements of the periodic table. Their electronegativities are correspondingly: **Li** –1.0; **Na** –0.9; **K** –0.8; **Rb –**0.8; **Cs** –0.7, it decreases as the distance of the valence electron increases.

Table 1

Physical properties of alkali metals

Z	Symbol	Valence electrons	Density [g/cm³]	Melting temp. [K]	Boiling temp. [K]	Ion radius [°A]	Ionization energy [(J/kmol)·10^{-6}]	Energy of hydration [(J/kmol)·10^{-6}]	E^0 M^+/M [V]
3	Li	$2s^1$	0.53	454	1640	0.68	519	506	–3.02
11	Na	$3s^1$	0.97	371	1163	0.98	496	398	–2.71
19	K	$4s^1$	0.86	336	1040	1.33	419	318	–2.93
37	Rb	$5s^1$	1.53	312	970	1.48	402	288	–2.99
55	Cs	$6s^1$	1.90	302	958	1.67	367	260	–2.99

Characteristics of alkali metals - electron configuration

Table 2

Element	Symbol	Arrangement of electrons in shells	Electron configuration
Lithium	Li	K^2L^1	$1s^2\underline{2s^1}$
Sodium	Na	$K^2L^8M^1$	$1s^22s^22p^6\underline{3s^1}$
Potassium	K	$K^2L^8M^8N^1$	$1s^22s^22p^63s^23p^6\underline{4s^1}$
Rubidium	Rb	$K^2L^8M^{18}N^8N^1$	$1s^22s^22p^63s^23p^64s^23d^{10}4p^6\underline{5s^1}$
Caesium	Cs	$K^2L^8M^{18}N^{18}O^8P^1$	$1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^6\underline{6s^1}$
Francium	Fr	$K^2L^8M^{18}N^{32}O^{18}P^8Q^1$	$1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^66s^24f^{14}5d^{10}6p^6\underline{7s^1}$

2.1.1.1. Physical properties of alkali metals

Structure – crystalline.
Colour – silvery white.
Gloss – metallic.
Density – very light – lithium, sodium and potassium are less dense than water.
Melting points – low (30 –180°C).
Electrical conductivity – very good.
Hardness – very soft.

Alkali metals are extremely reactive. To prevent alkali metal from reacting with environment, it is stored in a container with kerosene or other non-reactive liquid. In the case of rubidium and cesium, this is not enough. They react with the liquid. Both metals are stored in vacuum glass ampoules filled with inert gas.

2.1.1.2. Chemical properties of alkali metals

Lithiums are the most reactive chemical elements (the strongest reducing agents). Lithium has the lowest standard potential (Table 3) because it has a very high hydration energy.

Table 3

Values of standard lithium metals

Element	Standard potential E^0[V]
Lithium	–3.05
Sodium	–2.71
Potassium	–2.93
Rubidium	–2.92
Caesium	–2.92

2.1.1.3. Identification of alkali metal salts by flame method

The excited atoms of the elements give a spectrum in the range of visible waves, which are known as the **flame test** is used to **identify the elements** as they colour the flame in a characteristic colour:

- lithium – carmine,
- sodium – yellow,
- potassium – purple,
- rubidium – violet-pink,
- caesium – blue.

2.1.1.4. The reactions of alkali metals

1. Combustion

Only with lithium, the normal product of combustion in air is a simple oxide.

$$4Li + O_2 \longrightarrow Li_2O \quad \text{(lithium oxide)}$$
$$2Na + O_2 \longrightarrow Na_2O_2 \quad \text{(sodium peroxide)}$$
$$K + O_2 \longrightarrow KO_2 \quad \text{(potassium superoxide)}$$

Sodium peroxide reacts with carbon dioxide to form sodium carbonate and free oxygen:

$$2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$$

This process is used to remove CO_2 from the air in submarines and breathing apparatus.

2. Reaction with water (Me – any lithium metal)

$$2Me + 2H_2O \longrightarrow 2MeOH + H_2$$

Sodium peroxide reacts violently with water to give off hydrogen peroxide:

$$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$$

Dioxidane is a 3% hydrogen peroxide solution, while its 30% solution is perhydrol. Concentrated 80% hydrogen peroxide (so-called Ignolina) was used in rocket engineering and turbine propulsion (e.g. during World War II, V1 and V2 rockets and for torpedo propulsion).

3. Reactions with acids: All alkali metals react with acids to give salts and hydrogen:

$$2Li + 2HCl \longrightarrow 2LiCl + H_2$$
$$2Na + H_2SO_3 \longrightarrow Na_2SO_3 + H_2$$
$$6K + 2H_3PO_4 \longrightarrow 2K_3PO_4 + 3H_2$$

2.1.1.5. The use of alkali metals:

- Lithium (Li) – additive to alloys, deoxidizer in the production of other metals, for the production of anodes in batteries with a long life (lithium cell), in medicine (lithium carbonate – used in the treatment of depression);
- Sodium (Na) – metallurgy, soda glass production, fertilizers, coolant in nuclear reactors, bleaching agents and detergents, kitchen;
- Potassium (K) – coolant in nuclear reactors, fertilizers, covering the inside of photocells, grey soap;
- Rubidium (Rb) – component of fluorescent lamps, geochronology and photocells;
- Caesium (Cs) – scintillation counters (it is an ionizing radiation detector), catalysts, photocells;
- Francium (Fr) – uranium ore presence indicator.

2.1.2. Characteristics of alkaline earth metals

They have the **ns^2** electron configuration – two valence electrons on the **s** subshell. As a result of excitation, one of the s electrons goes to the **p** subshell. Compared to alkali metals, they have a smaller volume (the greater charge of the nucleus attracts more electrons) and a greater density (which results from the previous one). The reactivity of alkaline earth metals, although lower than that of alkali metals, is significant and increases with increasing atomic number. All beryllium are in the **+II** oxidation state. They show strong reducing properties. Due to the small size of the atom and the relatively high electronegativity of beryllium for the rest of the group, it tends to form covalent bonds, while other metals with much larger atom sizes and lower electronegativity occur mainly in ionic compounds.

2.1.2.1. Physical properties of alkaline earth metals (Table 4)

- Metals.
- Silvery white colour.

– Low density.
– Easily fusible.
– Soft (except beryllium).

Table 4

Physical properties of alkaline earth metals

Z	Symbol	Valence electrons	Density [g/cm^3]	Melting temp. [K]	Boiling temp. [K]	Ion radius [°A]	Ionization energy [(J/kmol)·10^{-6}]	Energy of hydration [(J/kmol)·10^{-6}]	E^0 M^+/M [V]
4	Be	$2s^2$	1.84	1556	2750	0.30	1780	2380	–1.70
12	Mg	$3s^2$	1.74	929	1400	0.65	1470	1910	–2.34
20	Ca	$4s^2$	1.55	1123	1750	0.94	1140	1650	–2.87
38	Sr	$5s^2$	2.60	1043	1640	1.10	1050	1480	–2.89
56	Ba	$6s^2$	3.74	983	1950	1.29	960	1270	–2.90

2.1.2.2. Occurrence of alkaline earth metals

Alkaline earth metals are not free because they are highly reactive. Magnesium and calcium are common in the earth's crust. Strontium and bar are less common, aberyl is even less common. Radium occurs only in trace amounts (about $6 \cdot 10^{-7}$ ppm) in uranium ores.

2.1.2.3. Chemical properties of alkaline earth metals

Flame colouring:

– Calcium (Ca) – brick red,
– Strontium (Sr)– carmine red (intense red),
– Barium (Ba) – yellow green.

2.1.2.4. Beryllium reactions

Reaction with oxygen

– Mg – burns with a bright flame;
– Ca, Sr, Ba – they react violently with oxygen, therefore they are stored under kerosene;
– Ba and Sr – they also form peroxides: $Me + O_2 \longrightarrow MeO_2$.

None of the alkaline earth metals does not form peroxides (as opposed to alkali metals). Peroxides are formed under more drastic conditions than alkaline earth oxides and any alkali metal oxides.

Reaction with water

– Be does not react with water (for the reaction of beryllium with water to be effective, it should be heated almost to the boil).
– Mg only reacts when hot.
– Ca, Ba reacts violently like Na and K.

The strength and solubility of alkaline earth hydroxides increases with the increase of the atomic mass of the element.

Reactions with acids

Alkaline earth metals displace hydrogen from acids to form salts. Beryllium does not undergo cold digestion with nitric acid(V) (it undergoes passivation). Dilute sulfuric(VI) and hydrochloric acid reacts with beryllium already at room temperature.

2.1.2.5. Beryllium amphoterism

Beryllium is the only s-block element showing an amphoteric character, the rest are basic in character.

$$Be + 2HCl \longrightarrow BeCl_2 + H_2$$
$$Be + 2NaOH + 2H_2O \longrightarrow Na_2[Be(OH)_4] + H_2$$

All beryllium compounds taste sweet and are highly poisonous. Inhalation of beryllium and its compounds may cause serious respiratory diseases, and contact of soluble beryllium compounds with the skin may cause inflammation.

2.1.2.6. Water hardness

The presence of various salts, mainly bicarbonates, chloride and calcium sulphates of magnesium, causes the so-called water hardness, which prevents the foaming of soap and other detergents. When boiling water with high hardness, so-called **limescale** – sediment formed from insoluble calcium and magnesium compounds, which it may contain:

- calcium and magnesium carbonates ($CaCO_3$, $MgCO_3$);
- calcium and magnesium sulphates ($CaSO_4$, $MgSO_4$);
- calcium and magnesium phosphates ($Ca_3(PO_4)_2$, $Mg_3(PO_4)_2$);
- calcium and magnesium silicates ($CaSiO_2$, $MgSiO_2$);
- magnesium hydroxide $Mg(OH)_2$.

As a result of the process of boiling untreated water, bicarbonate HCO_3^- ions decompose into carbonate CO_3^{2-} according to the reaction:

$$Ca(HCO_3)_2 \longrightarrow CaCO_3 + CO_2 + H_2O$$

At the time of decomposition, the most difficult soluble carbonates precipitate in the form of a sediment (scale) containing mainly $CaCO_3$ (solubility 14 mg/dm^3) and $MgCO_3$ (solubility 106 mg/ dm^3).

The hardness of water caused by the presence of bicarbonates is called **transient hardness**, which, apart from boiling the water, can be removed by introducing an alkaline solution.:

$$Ca(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow 2CaCO_3 + 2H_2O$$

when there is magnesium bicarbonate in the water, magnesium hydroxide still precipitates:

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$$

Permanent water hardness (that is caused by the presence of chlorides or sulphates) is removed by distillation or demineralization using ion exchangers (ion exchangers). Ionites are macromolecular substances with a complex structure.

Limescale is undesirable as it causes heat energy losses and creates corrosive conditions. The efficiency of boilers and heat exchangers is lower when limescale appears. The scale has low thermal permeability – settling inside the elements of the heating system reduces its efficiency, because less heat can penetrate through the scale-covered walls of the devices. A 1 mm thick layer of limescale reduces the efficiency by approx. 46%. It can also cause local underheating (or overheating) or a reduction in pipe cross-section, reduced flow, flow instability, water level oscillation, and corrosion under sediments, which can lead to system failure.

3. PERFORMING THE EXERCISE

Experiment 1 – Combustion of magnesium, reaction of metal oxide with water

Materials and reagents:

Magnesium ribbon, laboratory gas burner, ceramic evaporating dish, 0.05% alcoholic phenolphthalein solution.

Performance:

Grab about 2 – 3 cm of magnesium ribbon with the tongs and ignite it in the laboratory gas burner flame. Immediately after the magnesium has ignited, remove the ribbon from the flame and hold it over the dish so that the magnesium oxide formed falls into the empty ceramic evaporating dish. Then add a few drops of distilled water, mix the whole thing with a glass rod and add a drop of phenolphthalein.

Elaboration of the results

1. Describe the observed phenomenon.
2. Write the chemical equation of the reaction of oxide formation during the combustion of metallic magnesium in a flame and the reaction between magnesium oxide and water.
3. Indicate which ions cause the discolouration of phenolphthalein?

Experiment 2 – Dissolution of magnesium hydroxide in acid and ammonium salt solution

Materials and reagents:

Test tube rack, glass rod, magnesium chloride solution (0.1 M $MgCl_2$), sodium hydroxide solution (0.1 M NaOH), hydrochloric acid solution (2 M HCl), ammonium chloride solution (2 M NH_4Cl).

Performance:

Into two test tubes, add 2 cm^3 of magnesium salt solution (0.1 M $MgCl_2$), then add dropwise solution of sodium hydroxide (0.1 M NaOH) to each of them until a precipitate is formed. Into the first test tube keep adding dropwise (count the drops) solution of hydrochloric acid (2 M HCl) until the precipitate is completely dissolved. Into the second test tube keep adding dropwise (count the drops) solution of ammonium chloride (2M NH_4Cl) until the precipitate is completely dissolved.

Elaboration of the results:

In which case was it necessary to use a larger volume of the reagent solution in order to dissolve the precipitate? Give the molecular and ionic equations of the reaction of:

1) obtaining magnesium hydroxide,
2) dissolving magnesium hydroxide in acid,
3) dissolution of magnesium hydroxide in ammonium salt solution.

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

Materials and reagents:

Platinum wire, burner, saturated solutions: barium nitrate(V) ($Ba(NO_3)_2$), strontium nitrate(V) ($Sr(NO_3)_2$), calcium nitrate(V) ($Ca(NO_3)_2$).

Performance:

Clean the platinum wire terminated with a loop thoroughly by immersing it in concentrated nitric(V) acid (conc. HNO_3), and then annealing in the oxidizing zone of the laboratory gas burner flame (clean platinum wire should not discolour the flame).

Then immerse the cleaned platinum wire in a saturated solution of barium nitrate(V) ($Ba(NO_3)_2$), and re-introduce it into the laboratory gas burner flame, paying attention to the characteristic colour of the flame. Repeat the experiment with saturated solutions of strontium(V) nitrate ($Sr(NO_3)_2$) and calcium ($Ca(NO_3)_2$). Before each experiment, the wire should be cleaned in concentrated nitric(V) acid (conc. HNO_3) and annealed in the flame of a laboratory gas burner.

Elaboration of the results

1. Explain the observed phenomenon on the basis of Bohr's model.
2. Why do some salts cause flame colouring-and others not?
3. What are the real-life applications of flame colouring?

Experiment 4 – Precipitation of carbonates

Materials and reagents:

Rack with test tubes, micro spatula, sodium carbonate solution (0.1 M Na_2CO_3); hydrochloric acid solution (2 M HCl); calcium chloride solution (0,1 M $CaCl_2$), strontium chloride solution (0.1 M $SrCl_2$); barium chloride solution (0.1 M $BaCl_2$).

Performance:

Take three test tubes, pour about 2 cm^3 of calcium chloride ($CaCl_2$) into the first test tube, about 2 cm^3 of strontium chloride ($SrCl_2$) into the second test tube and finally about 2 cm^3 of barium chloride ($BaCl_2$) into the third test tube. In the next step to three test tubes containing successively solutions of calcium (0.1 M $CaCl_2$), strontium (0.1 M $SrCl_2$) and barium (0.1 M $BaCl_2$) solutions, add sodium carbonate solution (0.1 M Na_2CO_3) (until a precipitate is obtained). Then check the solubility of the obtained carbonates in the solution of hydrochloric acid (2 M HCl) by adding carefully a few drops of acid solution into three test tubes (with obtained precipitates).

Elaboration of the results

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

Experiment 5 – Precipitation of sulphates

Materials and reagents:

Rack with test tubes, micro spatula, sodium sulphate(VI) solution (0.1 M Na_2SO_4); hydrochloric acid solution (2 M HCl); calcium chloride solution (0.1 M $CaCl_2$), strontium chloride solution (0.1 M $SrCl_2$); barium chloride solution (0.1 M $BaCl_2$).

Performance:

Precipitate the sulphates(VI) of calcium, strontium and barium. For this purpose, to three test tubes containing successively saline solutions of: calcium (0.1 M $CaCl_2$), strontium (0.1 M $SrCl_2$) and barium (0.1 M $BaCl_2$), add a few drops (equal amounts) of sodium sulphate (0.1 M Na_2SO_4). Investigate the solubility of the obtained sediments in the hydrochloric acid solution (2 M HCl).

Elaboration of the results

1. Write down the molecular and ionic chemical equations of the reactions of the obtained sulphates.
2. Compare the solubility of the obtained sulphates(VI) in 2 M HCl solution.

4. DEVELOPMENT OF THE EXERCISES

1. Prepare a report according to the guidelines in the experimental section.
2. Place the cover sheet as the first page of the report.
3. After the theoretical part has been concisely developed, include in the report the study of individual experiments and the solved task/additional tasks given by the academic teacher.

5. THE FORM AND CONDITIONS FOR PASSING THE LABORATORY EXERCISE

1. Passing the so-called „entry test" before starting the exercise.
2. Submission of a correct written laboratory report on the performed exercise in accordance with the guidelines for the preparation of the laboratory report, please see the link below: https://www.am.szczecin.pl/en/facilities/institute-of-mathematics-physics-and-chemistry/department-of-chemistry/technical-chemistry/tech-chemistry-lab-manuals/

I. Examples of a task with a solution

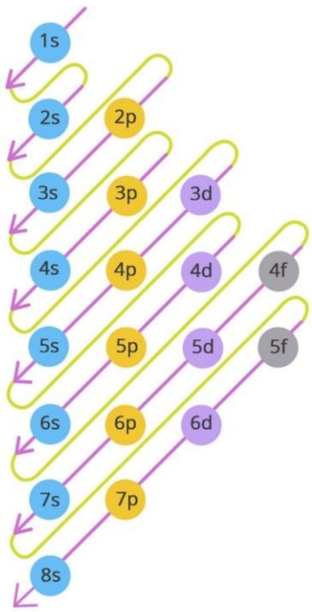
Example

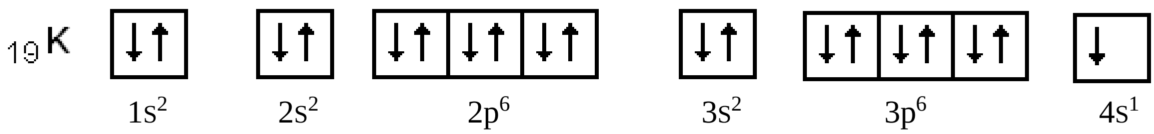
Write down orbital electron configuration of an element at atomic number 19 (without using the periodic table). Based on its electronic structure, determine:

– number of valence electrons,
– period,
– group,
– elements block,
– number of unpaired electrons.

Solution

The atomic number of the given element $_{19}\mathbf{X}$ tells us that there are 19 protons in its nucleus. Since the element is neutral in the free state, it means that it also has **19 electrons** on its shells. When writing down the electron configuration, we can use a „pyramid", which makes it easier for us to fill the energy levels of orbitals with new electrons.





1) the element has four energy levels (shells) (because the highest energy level is **4**s[1]) – so it will be in **period 4**;
2) its last shell (valence) is the 4s**[1]**, shell with **1 valence electron** on it;
3) Since the element has **1 valence electron** on the last shell – it will be located in the **group 1**;
4) since its last and furthest from the nucleus is **4s**[1], the element will belong to the **s-block**.

II. Tasks and questions to be completed by the student

Tasks (s-block)

1. How many grams of magnesium oxide are produced by burning 15 g of metallic magnesium in oxygen?
2. What mass of oxygen is needed to burn 20 g of metallic magnesium?
3. Discuss the reactivity of the elements of groups 1, 2 with water (give the equations of reactions with water, chemical names, value of oxidation degrees).
4. Write the chemical equations of:
   a) obtaining metallic magnesium from magnesium chloride in sea water in the industry;
   b) the action of water on calcium.
5. What mass of calcium oxide can be obtained by thermally decomposing 200g of calcium carbonate?
6. Five physical properties of magnesium oxide are listed below. From among them, select and underline two that justify the application of this compound to the interior of blast furnaces.
   – has a high melting point; has a high boiling point;
   – is a solid; the molten one is electrically conductive; is white.
7. Write in molecular form the equation of the reaction that occurs in the stomach after taking a drug containing magnesium oxide by a person suffering from hyperacidity.
   Determine what chemical nature (acidic, basic, neutral) the magnesium oxide exhibits in this reaction.
8. Mark which set of properties characterizes the sodium element:
   a) colourless gas, odourless, does not support combustion, sparingly soluble in water;
   b) yellow solid, not electrically conductive;
   c) a silvery-white, glossy solid, quickly tarnishing in air, soft, less than water density;
   d) a silvery-white glossy solid, brittle, hard, denser than water.
9. From the properties listed below, select those that are true for sodium hydroxide:
   a) dissolving it in water is an endothermic process,
   b) its concentrated aqueous solution burns the skin,
   c) it is hygroscopic,
   d) its solution is a weak electrolyte,
   e) absorbs carbon monoxide(IV) from the air, forming sodium carbonate.

   Calcium chloride is one of the salts whose presence in water causes the so-called permanent hardness of water. It can be removed by adding a small amount of sodium carbonate to the water. Write a net-ionic form of the chemical equation for the reaction that removes the permanent hardness caused by the presence of calcium chloride with sodium carbonate.