Inorganic Chemistry Tasks with Exemplary Solutions

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By

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Cambridge Scholars Publishing

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I dedicate this book to my parents:

My mother Yordanka and my father Manol.

With love and gratitude!

Periodic Table of the Elements

Atomic Number
Symbol
Name
Atomic Mass

Atomic mass values reflect the IUPAC accepted values as of 09/2013.

Masses expressed in [a;b] format show the lower and upper limit of atomic mass depending on the physical and chemical history of the element.

Masses expressed in < > format are the mass numbers of the longest-lived isotope for elements with no stable nucleus.

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen [1.00784;1.00811]																	2 He Helium 4.002602(2)
3 Li Lithium [6.938;6.997]	4 Be Beryllium 9.0121831(5)											5 B Boron [10.806;10.821]	6 C Carbon [12.0096;12.0116]	7 N Nitrogen [14.00643;14.00728]	8 O Oxygen [15.99903;15.99977]	9 F Fluorine 18.998403163(6)	10 Ne Neon 20.1797(6)
11 Na Sodium 22.98976928(2)	12 Mg Magnesium [24.304,24.307]											13 Al Aluminum 26.9815386(8)	14 Si Silicon [28.084;28.086]	15 P Phosphorus 30.973761998(5)	16 S Sulfur [32.059;32.076]	17 Cl Chlorine [35.446;35.457]	18 Ar Argon 39.948(1)
19 K Potassium 39.0983(1)	20 Ca Calcium 40.078(4)	21 Sc Scandium 44.955908(5)	22 Ti Titanium 47.867(1)	23 V Vanadium 50.9415(1)	24 Cr Chromium 51.9961(6)	25 Mn Manganese 54.938045(5)	26 Fe Iron 55.845(2)	27 Co Cobalt 58.933194(4)	28 Ni Nickel 58.6934(4)	29 Cu Copper 63.546(3)	30 Zn Zinc 65.38(2)	31 Ga Gallium 69.723(1)	32 Ge Germanium 72.630(8)	33 As Arsenic 74.921595(6)	34 Se Selenium 78.971(8)	35 Br Bromine [79.901,79.907]	36 Kr Krypton 83.798(2)
37 Rb Rubidium 85.4678(3)	38 Sr Strontium 87.62(1)	39 Y Yttrium 88.90584(2)	40 Zr Zirconium 91.224(2)	41 Nb Niobium 92.90637(2)	42 Mo Molybdenum 95.95(1)	43 Tc Technetium <98>	44 Ru Ruthenium 101.07(2)	45 Rh Rhodium 102.90550(2)	46 Pd Palladium 106.42(1)	47 Ag Silver 107.8682(2)	48 Cd Cadmium 112.414(4)	49 In Indium 114.818(1)	50 Sn Tin 118.710(7)	51 Sb Antimony 121.760(1)	52 Te Tellurium 127.60(3)	53 I Iodine 126.90447(3)	54 Xe Xenon 131.293(6)
55 Cs Cesium 132.90545196(6)	56 Ba Barium 137.327(7)	57-71	72 Hf Hafnium 178.49(2)	73 Ta Tantalum 180.94788(2)	74 W Tungsten 183.84(1)	75 Re Rhenium 186.207(1)	76 Os Osmium 190.23(3)	77 Ir Iridium 192.217(3)	78 Pt Platinum 195.084(9)	79 Au Gold 196.966569(5)	80 Hg Mercury 200.592(3)	81 Tl Thallium [204.382;204.385]	82 Pb Lead 207.2(1)	83 Bi Bismuth 208.98040(1)	84 Po Polonium <209>	85 At Astatine <210>	86 Rn Radon <222>
87 Fr Francium <223>	88 Ra Radium <226>	89-103	104 Rf Rutherfordium <267>	105 Db Dubnium <268>	106 Sg Seaborgium <271>	107 Bh Bohrium <272>	108 Hs Hassium <270>	109 Mt Meitnerium <276>	110 Ds Darmstadtium <281>	111 Rg Roentgenium <280>	112 Cn Copernicium <285>	113 Uut Ununtrium unknown	114 Fl Flerovium <289>	115 Uup Ununpentium unknown	116 Lv Livermorium <293>	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

Lanthanide Series	57 La Lanthanum 138.90547(7)	58 Ce Cerium 140.116(1)	59 Pr Praseodymium 140.90766(2)	60 Nd Neodymium 144.242(3)	61 Pm Promethium <145>	62 Sm Samarium 150.36(2)	63 Eu Europium 151.964(1)	64 Gd Gadolinium 157.25(3)	65 Tb Terbium 158.92535(2)	66 Dy Dysprosium 162.500(1)	67 Ho Holmium 164.93033(2)	68 Er Erbium 167.259(3)	69 Tm Thulium 168.93422(2)	70 Yb Ytterbium 173.054(5)	71 Lu Lutetium 174.9668(1)
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ACKNOWLEDGMENTS

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PREFACE

This edition of the book "Inorganic Chemistry Tasks with Exemplary Solutions" - a collection of solved problems in chemistry is dedicated to people interested in chemistry and participants in National competitions, in National and International Olympiads in Chemistry. The book has been developed to help prepare competitors for successful qualifying performance.

The aim of the book is to offer exemplary solutions to problems, in which it is shown to young people that in addition to a full and complete representation of the chemical properties of substances by means of chemical equations, a commentary on the processes involved is also necessary.

For example:

- If hydrolysis processes are considered, the commentary should point out the solubility of the substance in water, describe the hydrolysis process in detail and the nature of the medium.
- Ion-exchange processes that affect the interaction between acids, bases, and salts are represented by molecular, full-ion, and short-ion equations, and it is emphasized that a reaction takes place when a gas, precipitate, or weak electrolyte is produced.
- In redox processes it is necessary to denote the electronic transitions, the oxidant and the reductant, the electronic balance.
- If one is solving a problem for a chemical element, one must characterize the atom of the element, present its electronic structure, as well as its electronic formula, physical and chemical properties.

Due to the considerable length, the material is divided into seventeen chapters and two parts. The first part includes 9 chapters dealing with problems of inorganic chemistry and the second part - 8 chapters with problems related to the properties of the chemical elements of the seven A groups of the Periodic Table and the properties of the metals of the B groups.

The two parts contain the solutions of 222 inorganic chemistry problems.

Problems with appropriate solutions can be the basis for a good preparation in chemistry, for national competitions, for national and international chemistry Olympiads, but also for gaining in-depth knowledge necessary for successful performance during the study of chemistry, as well as medicine at university, and then - in professional career.

I hope that the proposed exemplary solutions will be a useful and interesting tool for developing skills of analysis, comparison, generalization, searching for relationships and dependencies and will facilitate the preparation of young people for successful competitive performances.

Ilia Manolov

PART ONE

I

Problems Related to Proof Reactions of Compounds and Ions

Task 1

Five tubes contained solutions of HCl, HNO_3 , H_2SO_4 , CO_2 , and H_2S, respectively. By means of what qualitative reactions can the substances in these solutions be proved? Express the reactions with chemical equations.

Exemplary solution:

The five tubes contained solutions of substances with acidic properties. The litmus will turn red from all the solutions, therefore these substances cannot be distinguished using litmus. In aqueous solution they dissociate and give off hydrogen cations and acid anions.

$$HCl \longrightarrow H^+ + Cl^-$$

$$HNO_3 \longrightarrow H^+ + NO_3^-$$

$$H_2SO_4 \longrightarrow 2\,H^+ + SO_4^{2-}$$

Hydrochloric, nitric and sulfuric acids are strong electrolytes and dissociate completely in aqueous solution.

Carbonic acid is a weak and perishable dibasic acid and dissociates reversibly in two steps:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

Total

$$H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$$

Hydrogen sulfide acid is a weak, dibasic acid, dissociates bidentate:

$$H_2S \rightleftharpoons H^+ + HS^-$$

$$HS^- \rightleftharpoons H^+ + S^{2-}$$

Ion exchange reactions are not related to electron transfer. Ion exchange reactions take place when a gas, precipitate or weak electrolyte is produced as a result of the interaction. Ion exchange reactions are expressed by three types of equations: molecular, full ion and short ion equations.

Chloride ions from hydrochloric acid are proved with silver nitrate solution. A white precipitate of silver chloride is obtained.

$$HCl + AgNO_3 \longrightarrow AgCl\downarrow + HNO_3$$

$$\underbrace{H^+ + Cl^-} + \underbrace{Ag^+ + NO_3^-} \longrightarrow AgCl\downarrow + \underbrace{H^+ + NO_3^-}$$

$$Ag^+ + Cl^- \longrightarrow AgCl\downarrow$$

By the light, the precipitate of silver chloride turns violet (silver salts are photosensitive). It dissolves readily in ammonia due to the formation of the complex salt diammonium silver chloride.

$$AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$$

Sulfate, carbonate and sulfide ions form insoluble salts, but only silver halides change color in daylight or direct sunlight.

Reagent for the demonstration of sulfuric acid and sulfate ions are barium ions. Mixing a solution of sulfuric acid and barium dichloride produces a white precipitate of barium sulfate.

$$H_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2\,HCl$$

$$\underbrace{2\,H^+ + SO_4^{-2}} + \underbrace{Ba^{+2} + 2\,Cl^-} \longrightarrow BaSO_4\downarrow + \underbrace{2\,H^+ + 2\,Cl^-}$$

$$Ba^{+2} + SO_4^{-2} \longrightarrow BaSO_4\downarrow$$

The aqueous solution of carbon dioxide represents the weak and perishable carbonic acid. It is a weak electrolyte and decomposes reversibly with the evolution of carbon dioxide and water.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^{-2}$$

Carbonic acid is dibasic and its dissociation occurs in two steps.

Reagent for proving carbonic acid and carbonate ions is clear lime water $Ca(OH)_2$.

$$Ca(OH)_2 + H_2CO_3 \longrightarrow CaCO_3\downarrow + 2\,H_2O$$

$$\underbrace{Ca^{+2} + 2\,OH^-} + \underbrace{2\,H^+ + CO_3^{-2}}_{\upharpoonleft\downharpoonright\; H_2CO_3} \longrightarrow CaCO_3\downarrow + 2\,H_2O$$

$$Ca^{+2} + CO_3^{-2} \longrightarrow CaCO_3\downarrow$$

Mixing the two solutions separates a white precipitate of calcium carbonate.

Hydrogen sulfide is a gas with the smell of rotten eggs. In water as a dibasic acid it dissociates to two degrees.

The silver ions form with the sulfide ions a black precipitate of disilver sulfide.

$$H_2S + 2AgNO_3 \longrightarrow Ag_2S\downarrow + 2HNO_3$$

$$\underbrace{2H^+ + S^{2-}} + \underbrace{2Ag^+ + 2NO_3^-} \longrightarrow Ag_2S\downarrow + \underbrace{2H^+ + 2NO_3^-}$$

$$2Ag^+ + S^{2-} \longrightarrow Ag_2S\downarrow$$

Nitric acid is highly oxidative, which is a prerequisite for its interaction with metals after hydrogen in Order of Relative Activity of Metals, for example copper. The redox process occurs in two stages.

$$Cu + \underbrace{2H^+ + 2NO_3^-} \longrightarrow CuO + 2NO_2 + H_2O$$

$$CuO + \underbrace{2H^+ + 2NO_3^-} \longrightarrow \underbrace{Cu^{+2} + 2NO_3^-} + H_2O$$

Sum equation:

$$Cu + \underbrace{4H^+ + 4NO_3^-} \longrightarrow \underbrace{Cu^{+2} + 2NO_3^-} + 2NO_2\uparrow + 2H_2O$$

The emitted nitrogen dioxide is red-brown in color, which is unequivocal evidence of nitric acid.

Processes involving a change in the degree of oxidation of particles and a transfer of electrons from one type of particle (atoms, ions or molecules) to another type of particle are redox processes. Reducers are particles that give up electrons and increase their oxidation state. The process is oxidation coupled with electron giving up. Oxidizers are particles that accept electrons and lower their oxidation rate. The process is a reduction in which electrons are taken up.

The interaction of copper with nitric acid is an oxidation-reduction process.

$$\begin{array}{lll|c|c|c} Cu^{0} - 2e^{-} & \longrightarrow & Cu^{+2} & 2 & & 1 \\ & & & & 2 & \\ N^{+5} + e^{-} & \longrightarrow & N^{+4} & 1 & & 2 \end{array}$$

Task 2

Express with chemical equations the hydrolysis of salts: Na_2S, KCl, $CuSO_4$ and $Pb(NO_3)_2$. Are you able to recognize them 1) with an indicator and 2) with appropriate reagents? Indicate conditions that favor hydrolysis processes.

Exemplary solution:

According to Arrhenius' theory, salts are the product of the interaction between acids and bases. The products of neutralization are salt and water. Salts are electrolytes which, when dissolved in water, dissociate into metal or other cations and acid anions.

Salts produced by neutralization of strong bases and weak acids, weak bases and strong acids, weak bases and weak acids hydrolyze. Salts derived from strong bases and strong acids do not hydrolyse.

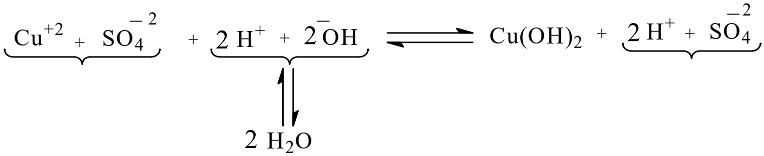
Hydrolysis is the reverse process of neutralization and is the interaction of molecules or ions of the solute with solvent molecules to change the pH of the solution.

$$\underbrace{2Na^{+} + S^{-2}} + \underbrace{2H^{+} + 2\bar{O}H}_{\substack{\uparrow\downarrow \\ 2H_2O}} \rightleftharpoons H_2S + \underbrace{2Na^{+} + 2\bar{O}H}$$

The sulfide ion from the salt binds to the hydrogen ions from the water in the weak electrolyte hydrogen sulfide. In excess, the hydroxide ions remain in solution, which determine the alkaline character of the medium. pH > 7. Violet or red litmus immersed in the disodium sulfide solution turns blue.

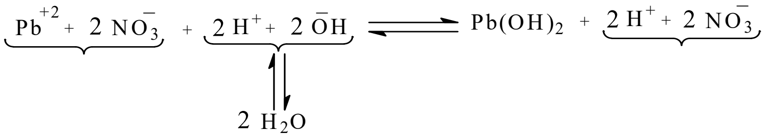
Potassium chloride does not hydrolyze because it is a salt of the strong potassium base and the strong hydrochloric acid.

Copper sulfate is a product of the weak base copper dihydroxide and the strong sulfuric acid. The hydrolysis is represented by the following equation:



The copper ions from the salt bind to the hydroxide ions from the water in the weak electrolyte copper dihydroxide. In excess, hydrogen ions remain in solution, which determines the acidic character of the solution. pH < 7. The blue or violet litmus turns red.

Lead dinitrate is a product of the weak base lead dihydroxide and the strong nitric acid. The salt hydrolyzes.



The lead ions from the salt bind to the hydroxide ions from the water in the weak electrolyte lead dihydroxide. In excess, hydrogen ions remain in solution, which determine the acidic character of the solution. **pH < 7**. The blue or violet litmus turns red.

The aqueous solution of disodium sulfide colors the litmus blue, the aqueous solutions of copper sulfate and lead dinitrate color the litmus red. The potassium chloride solution is neutral and does not change the color of the litmus.

No precipitation reactions are known for the alkali elements because insoluble compounds of the alkali elements have not been described. Sodium ions color the flame of the spirit lamp yellow.

Sulfide ions interact with silver nitrate solution. When aqueous solutions of disodium sulfide and silver nitrate are mixed, a black precipitate of disilver sulfide is released.

$$Na_2S + 2\,AgNO_3 \longrightarrow Ag_2S\downarrow + 2\,NaNO_3$$

$$\underbrace{2Na^+ + S^{2-}} + \underbrace{2\,Ag^+ + 2NO_3^-} \longrightarrow Ag_2S\downarrow + \underbrace{2Na^+ + 2NO_3^-}$$

$$2\,Ag^+ + S^{2-} \longrightarrow Ag_2S\downarrow$$

When an aqueous solution of disodium sulfide is mixed with hydrochloric acid, the stronger hydrochloric acid displaces the weaker hydrogen sulfide acid from the salt and a gas with the odor of rotten eggs is given off. This is unequivocal evidence of hydrogen sulfide acid and sulfide ions.

$$Na_2S + 2\,HCl \longrightarrow 2\,NaCl + H_2S\uparrow$$

$$\underbrace{2Na^+ + S^{2-}} + \underbrace{2\,H^+ + 2\,Cl^-} \longrightarrow H_2S\uparrow + \underbrace{2\,Na^+ + 2\,Cl^-}$$

$$2\,H^+ + S^{2-} \longrightarrow H_2S\uparrow$$

The potassium ions color the flame of the spirit lamp violet. Chloride ions with silver nitrate solution form a white precipitate of silver chloride.

$$KCl + AgNO_3 \longrightarrow KNO_3 + AgCl\downarrow$$

$$\underbrace{K^+ + Cl^-} + \underbrace{Ag^+ + NO_3^-} \longrightarrow AgCl\downarrow + \underbrace{K^+ + NO_3^-}$$

$$Ag^+ + Cl^- \longrightarrow AgCl\downarrow$$

Copper sulfate can be proved by both the cationic and the anionic part.

$$CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2\downarrow + Na_2SO_4$$

$$\underbrace{Cu^{+2} + SO_4^{-2}} + \underbrace{2Na^{+} + 2\overline{O}H} \longrightarrow Cu(OH)_2\downarrow + \underbrace{2Na^{+} + SO_4^{-2}}$$

$$Cu^{+2} + 2\overline{O}H \longrightarrow Cu(OH)_2\downarrow$$

If an aqueous solution of copper sulfate is added to an aqueous solution of sodium base, a sky-blue precipitate of copper dihydroxide is given off. Thus the copper ions are proved.

Sulfate ions are demonstrated with barium ions. A white precipitate of barium sulfate isseparated.

$$CuSO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + CuCl_2$$

$$\underbrace{Cu^{+2} + SO_4^{-2}} + \underbrace{Ba^{+2} + 2Cl^{-}} \longrightarrow BaSO_4\downarrow + \underbrace{Cu^{+2} + 2Cl^{-}}$$

$$Ba^{+2} + SO_4^{-2} \longrightarrow BaSO_4\downarrow$$

Lead dinitrate can be recognized by the determination of lead cations and nitrate anions. The lead ions, when reacted with hydrochloric acid or soluble chlorides, form a white precipitate of lead dichloride.

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$$

$$\underbrace{Pb^{+2} + 2NO_3^{-}} + \underbrace{2H^{+} + 2Cl^{-}} \longrightarrow PbCl_2\downarrow + \underbrace{2H^{+} + NO_3^{-}}$$

$$Pb^{+2} + 2Cl^{-} \longrightarrow PbCl_2\downarrow$$

No insoluble nitrates are known, no reagent exists to characterize nitrate anions by precipitate formation.

Hydrolysis is an endothermic process. It has been found that at high temperature and high dilutions the rate of hydrolysis increases, while at concentrated solutions and low temperature it decreases.

Task 3

Suggest a way to distinguish aqueous solutions of $CuSO_4$, $Fe_2(SO_4)_3$ and $Pb(NO_3)_2$ using only one reagent. Why can't thesesolutions be distinguished with litmus?

Exemplary solution:

Aqueous solutions of the three salts $CuSO_4$, Fe_2 $(SO_4)_3$ and $Pb(NO_3)_2$ can be identified with a sodium base aqueous solution.

$$CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2\downarrow + Na_2SO_4$$

$$\underbrace{Cu^{+2} + SO_4^{-2}} + \underbrace{2Na^+ + 2\bar{O}H} \longrightarrow Cu(OH)_2\downarrow + \underbrace{2Na^+ + SO_4^{-2}}$$

$$Cu^{+2} + 2\bar{O}H \longrightarrow Cu(OH)_2\downarrow$$

If an aqueous solution of copper sulfate is added to an aqueous solution of sodium base, a sky- blue precipitate of copper dihydroxide is given off.

$$Fe_2(SO_4)_3 + 6NaOH \longrightarrow 2Fe(OH)_3\downarrow + 3Na_2SO_4$$

$$\underbrace{2Fe^{+3} + 3SO_4^{-2}} + \underbrace{6Na^+ + 6\bar{O}H} \longrightarrow 2Fe(OH)_3\downarrow + \underbrace{6Na^+ + 3SO_4^{-2}}$$

$$Fe^{+3} + 3\bar{O}H \longrightarrow Fe(OH)_3\downarrow$$

If an aqueous solution of ferric trisulfate is added to an aqueous solution of sodium base, a rusty brown precipitate of ferric trihydroxide is separated.

$$Pb(NO_3)_2 + 2\,NaOH \longrightarrow Pb(OH)_2\downarrow + 2\,NaNO_3$$

$$\underbrace{Pb^{+2} + 2NO_3^-} + \underbrace{2Na^+ + 2OH^-} \longrightarrow Pb(OH)_2\downarrow + \underbrace{2Na^+ + 2\,NO_3^-}$$

$$Pb^{+2} + 2\,OH^- \longrightarrow Pb(OH)_2\downarrow$$

When aqueous solutions of lead dinitrate and sodium base are mixed, white lead dihydroxide precipitates. It is useful to recall that if an additional amount of sodium base solution is added, the lead dihydroxide precipitate dissolves because a water-soluble complex compound is formed. The same precipitate is also dissolved in mineral acids. This confirms the amphoteric nature of lead and its dihydroxide.

The solutions of the three salts cannot be distinguished with litmus because all three solutions stain the litmus red. All three salts are products of weak bases and strong acids, which means that in aqueous solution they hydrolyze.

$$\underbrace{Cu^{+2} + SO_4^{-2}} + \underbrace{2\,H^+ + 2\,OH^-}_{\upharpoonleft\downharpoonright\; 2\,H_2O} \rightleftharpoons Cu(OH)_2 + \underbrace{2\,H^+ + SO_4^{-2}}$$

$$\underbrace{2Fe^{+3} + 3\,SO_4^{-2}} + \underbrace{6\,H^+ + 6\,OH^-}_{\upharpoonleft\downharpoonright\; 6\,H_2O} \rightleftharpoons 2\,Fe(OH)_3 + \underbrace{6\,H^+ + 3\,SO_4^{-2}}$$

$$\underbrace{Pb^{+2} + 2\,NO_3^-} + \underbrace{2\,H^+ + 2\,OH^-}_{\upharpoonleft\downharpoonright\; 2\,H_2O} \rightleftharpoons Pb(OH)_2 + \underbrace{2\,H^+ + 2\,NO_3^-}$$

In all three salts, the metal ions from the salts bind with the hydroxide ions from the water to form weak electrolytes. The hydrogen ions from the water remain in excess in the solutions and determine the acidic character of their aqueous solutions. Aqueous solutions of the three salts are acidic (pH < 7) and color the blue and violet litmus red. The salts cannot be distinguished using litmus.

Task 4

Aqueous solutions of sodium sulfate, silver nitrate, barium chloride, potassium chloride, sodium phosphate, sulfuric acid and sodium base are given.

Express with chemical equations the possible interactions between them. Explain which reagents can be used to prove the corresponding substances.

Exemplary solution:

	Na_2SO_4	$AgNO_3$	$BaCl_2$	KCl	Na_3PO_4	H_2SO_4	NaOH
Na_2SO_4	-	+	+	-	-	-	-
$AgNO_3$	+	-	+	+	+	+	+
$BaCl_2$	+	+	-	-	+	+	+
KCl	-	+	-	-	-	-	-
Na_3PO_4	-	+	+	-	-	+	-
H_2SO_4	-	-	+	+	+	-	+
NaOH	-	+	+	-	-	+	-

Disodium sulfate interacts with silver nitrate and barium dichloride. An interaction takes place between electrolyte solutions when a gas, precipitate or weak electrolyte is released. In the equations below, a white precipitate of disilver sulfate and a white precipitate of barium sulfate are separated.

$$Na_2SO_4 + 2AgNO_3 \longrightarrow Ag_2SO_4\downarrow + 2NaNO_3$$

$$\underbrace{2Na^{+} + SO_4^{-2}} + \underbrace{2Ag^{+} + 2NO_3^{-}} \longrightarrow Ag_2SO_4\downarrow + \underbrace{2Na^{+} + 2NO_3^{-}}$$

$$2Ag^{+} + SO_4^{-2} \longrightarrow Ag_2SO_4\downarrow$$