ELEMENTS, COMPOUNDS AND MIXTURES

Essential Question: How are elements, compounds, and mixtures related?

Matter is anything that has mass and takes up space (volume)

There are different types of Matter: Pure Substances (elements and compounds) and Mixtures

The composition (structure) of a substance determines its Matter type.

Characteristics of Pure Substances

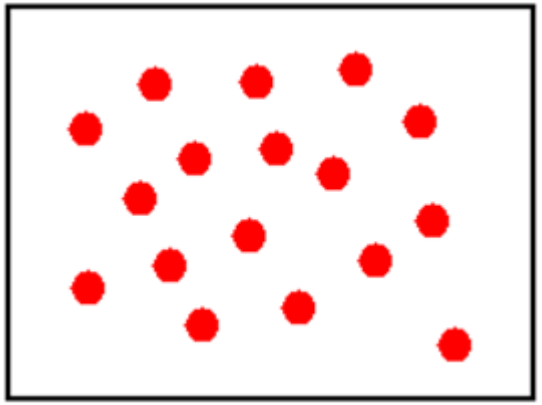
- Fixed composition
- Distinct properties
- Cannot be separated into simpler substances by physical methods
- Can only be changed in identity and properties by chemical methods
- Properties do not vary one sample to another sample

Types of Pure Substances:

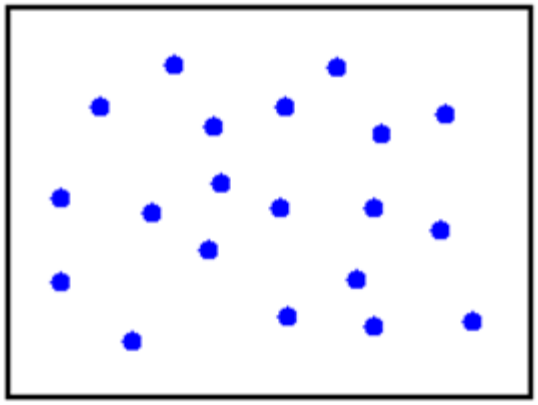
Elements And Compounds

Elements

- Made up of one type of atom
- Cannot be broken down by physical and chemical methods
- Examples: Oxygen, Nitrogen, Carbon



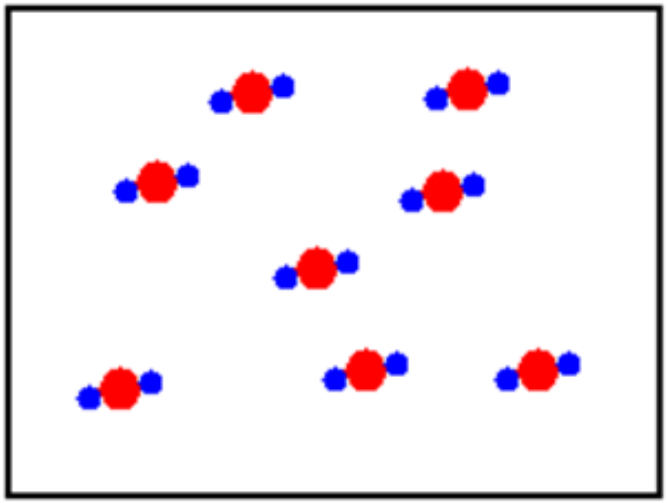
Sample of the Element Lead

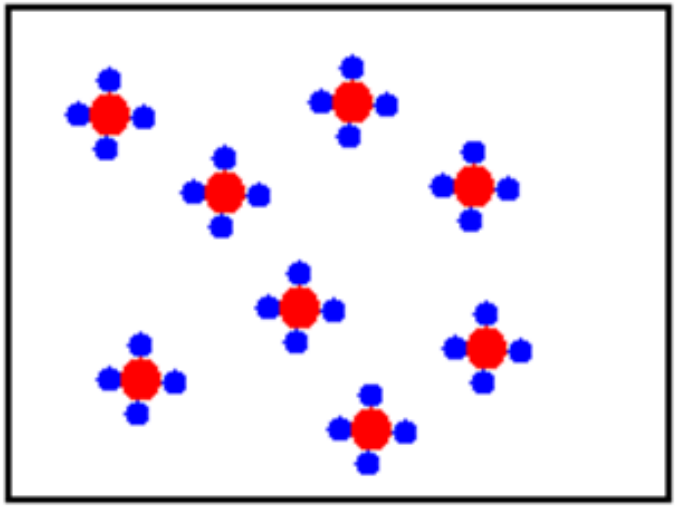


Sample of the Element Chlorine

Compounds

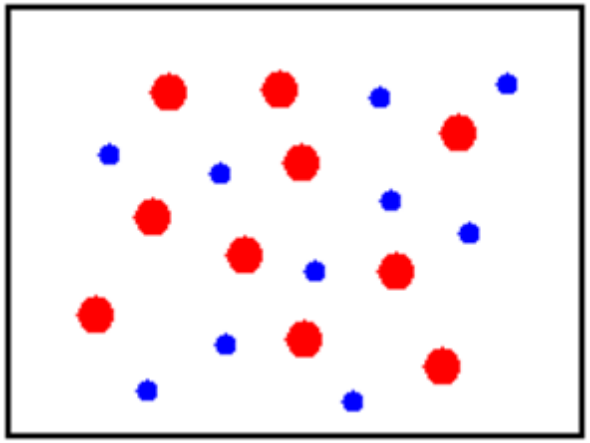
- Form when two or more different elements join (bond) together chemically
- Composition is identical in each sample
- Can be separated only by chemical methods
- Properties of a compound are totally different than the properties of the elements that form them
- Examples: Water, Carbon dioxide, Sugar



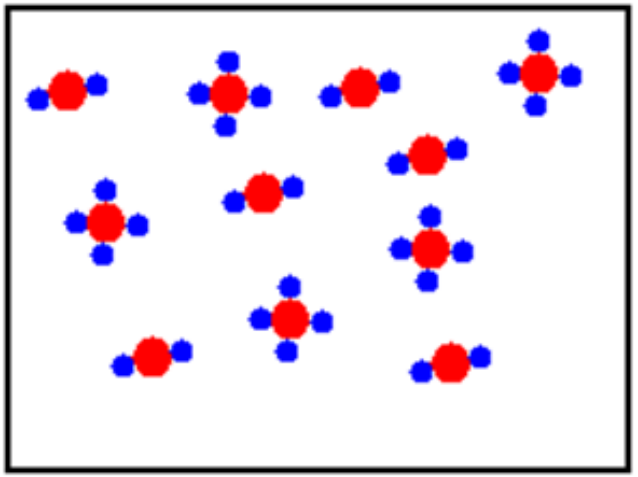


Mixtures

- Form when elements and/or compounds are combined physically
- Properties of a mixture are related to its components
- Composition varies from sample to sample
- Can be separated by physical methods
- Examples of Mixtures: Tea, Perfume, Air, Salad, Beach sand, oil and vinegar salad dressing, etc.



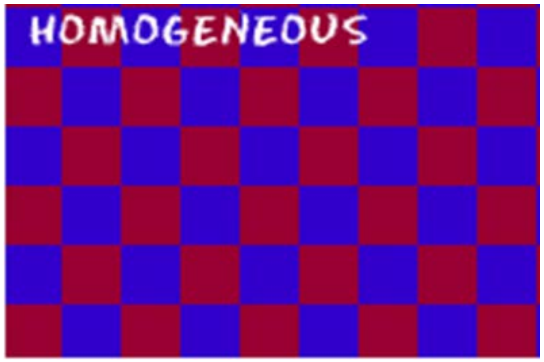
Mixture of Different Elements



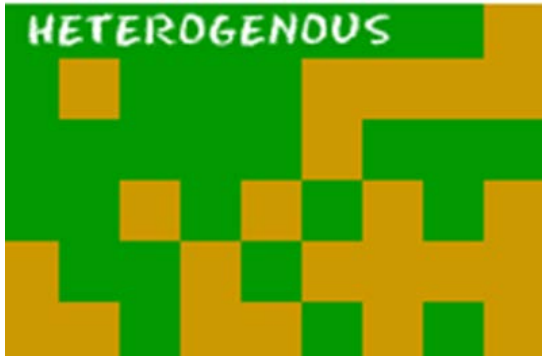
Mixture of Different Compounds

Mixtures

Mixtures are often referred to as homogeneous or heterogeneous.



- Homogeneous mixtures (Solutions) have a uniform distribution.
- For example: Tea, Perfume, Air



- Heterogeneous mixtures do not have a uniform distribution.
- Parts are often visible
- For example: Salad, Beach Sand, Oil and Vinegar dressing

Colloids

- In a colloid the particles are mixed together but not dissolved.
- The particles are relatively large and are kept permanently suspended.
- A colloid will not separate upon standing.
- The particles are constantly colliding, and this allows a colloid to scatter light – thus colloids often seem cloudy.

Solutions

- A solution is a type of homogeneous mixture formed when one substance dissolves in another.
- It is the best mixed of all mixtures.
- A solution always has a substance that is dissolved and a substance that does the dissolving.
- The substance that is dissolved is the solute and the substance that does the dissolving is the solvent.

Alloys

An **alloy** is a mixture of a metal with at least one other element.

Steel is a common example of an alloy. It contains iron mixed with carbon and other elements. Adding other elements to a metal changes its structure and so changes its properties.

The final alloy may have very different properties to the original metal.

By changing the amount of each element in an alloy, material scientists can custom-make alloys to fit a given job.

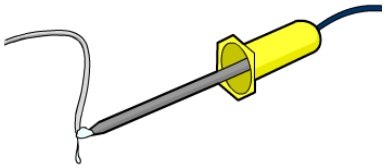
What types of alloys are there?

Alloys have been used for thousands of years. **Bronze**, an alloy of copper and tin, was commonly used by civilizations before iron extraction methods were developed.

Other well-known alloys include:

- **brass:** an alloy of copper and zinc. It does not tarnish and is used for door knobs, buttons and musical instruments.

- **solder:** an alloy of zinc and lead. It is used in electronics to attach components to circuit boards.



- **amalgam**: an alloy of mercury and silver or tin. It is used for dental fillings because it can be shaped when warm and resists corrosion.

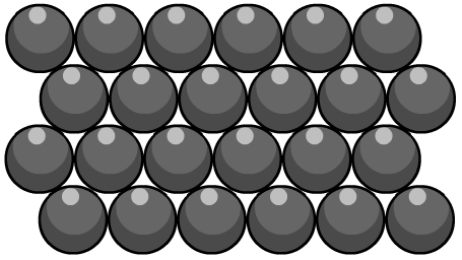
What is steel?

Steel is an alloy of iron and other elements, including carbon, nickel and chromium.

Steel is stronger than pure iron and can be used for everything from sauce pan…to suspension bridges!

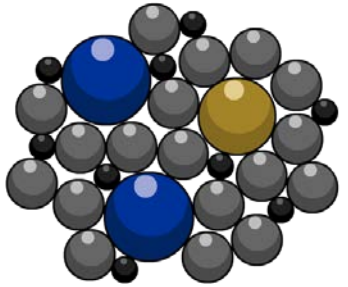
Why is steel stronger than iron?

The atoms in pure iron are arranged in densely-packed layers. These layers can slide over each other. This makes pure iron a very soft material.



The atoms of other elements are different sizes. When other elements are added to iron, their atoms distort the regular structure of the iron atoms.

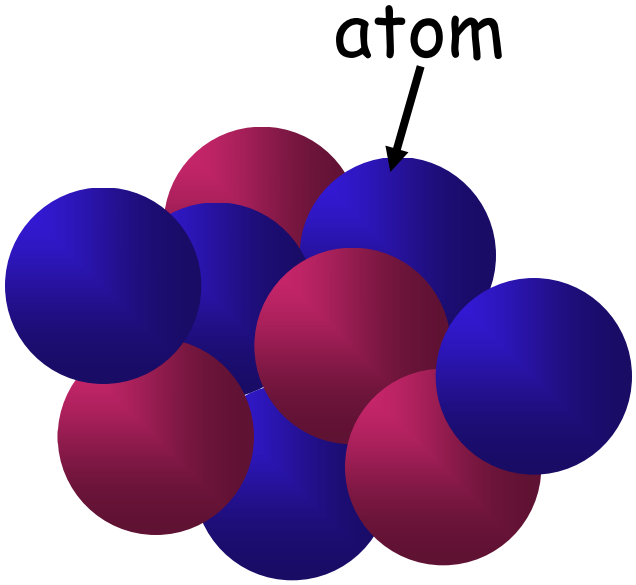
It is more difficult for the layers of iron atoms in steel to slide over each other and so this alloy is stronger than pure iron.



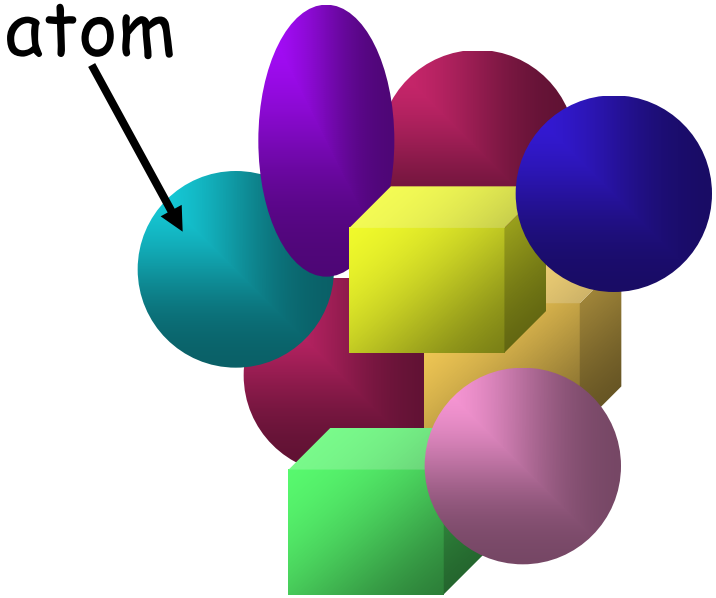
Mixtures vs. Compounds

	Mixture	Compound
Composition	Variable composition – you can vary the amount of each substance in a mixture.	Definite composition – you cannot vary the amount of each element in a compound.
Joined or not	The different substances are not chemically joined together.	The different elements are chemically joined together.
Properties	Each substance in the mixture keeps its own properties.	The compound has properties different from the elements it contains.
Separation	Each substance is easily separated from the mixture.	It can only be separated into its elements using chemical reactions.
Examples	Air, sea water, most rocks.	Water, carbon dioxide, magnesium oxide, sodium chloride.

A compound is a substance that is made from more than one element.

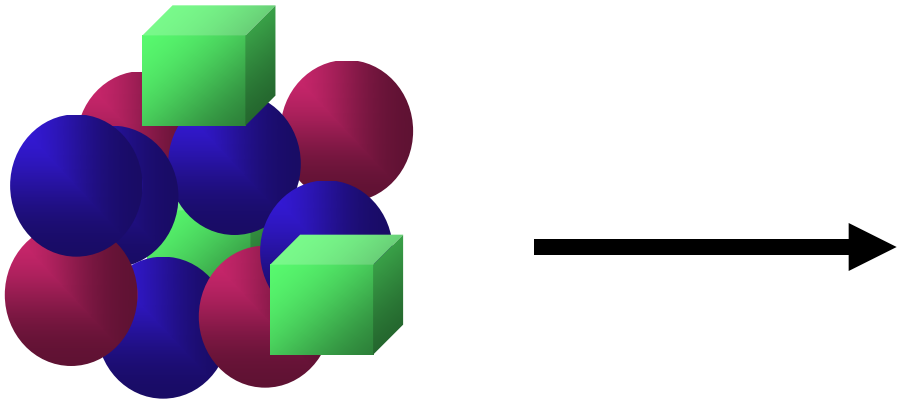


A compound made up of 2 different elements



A compound made up of 7 different elements

A compound can be broken down into elements



An element

An element

A compound made up of 3 different elements

An element

Types of Compounds

There are two basic types of compounds. They are distinguished by the manner in which the atoms bind to one another in the compound. These two types are called "molecular" compounds and "salts" (or equivalently "ionic" compounds):

Molecular compounds:	These compounds are made up of molecules whose atoms bind to one another through "covalent" bonds.
Ionic compounds (Salts):	The atoms in salts are held together with "ionic" bonds. Unlike molecules, salts always form solids in a regular array called a "crystalline solid".

Names of covalent compounds

The chemical formulas for covalent compounds are referred to as molecular formulas because these compounds exist as separate, discrete molecules. Typically, a molecular formula begins with the nonmetal that is closest to the lower left corner of the periodic table, except that hydrogen is almost never written first (H_2O is the prominent exception). Then the other nonmetal symbols are listed. Numerical subscripts are used if there is more than one of a particular atom. For example, we have already seen CH_4, the molecular formula for methane.

Naming *binary* (two-element) covalent compounds is similar to naming simple ionic compounds. The first element in the formula is simply listed using the name of the element. The second element is named by taking the stem of the element name and adding the suffix *-ide*.

OXIDES

✓What is an oxide

Oxides are chemical compounds of oxygen with other elements.

✓Composition and construction

Oxides do not contain chemical bonds between oxygen atoms (as opposed to peroxides – H_2O_2, BaO_2 etc.). All elements form oxides (except helium, neon, argon). In oxides, oxygen exhibits a constant value and a negative degree of oxidation (-2).

The oxides of the s – elements, p – elements – metals and transition d – and f – elements are ionic compounds:

The oxides of the p – elements – on metals and transition d – and f – elements – SO_3, Mn_2O_7, MnO_2 etc. are ionic compounds:

Na_2O, Cs_2O, Rb_2O	–	Oxides of s – elements
PbO, SnO	–	Oxides of p – elements metals
MnO, CrO	–	Oxides of d – elements
CeO, Th_2O_3	–	Oxides of f – elements

N_2O_3, N_2O_5, SO_3	–	Oxides of p – elements non metals
MnO_2, Cr_2O_3, Mn_2O_7, CrO_3	–	Oxides of d – elements
Ce_2O_3, ThO_2	–	Oxides of f – elements

✓Classification

There are different ways to classify oxides. The most commonly used approach is to classify oxides based on the properties of the hydroxides and oxo acids that the respective oxides form directly or that correspond to them. Based on this, the oxides are:

- Basic: These oxides form or correspond to basic hydroxides. They interact with acids. These are compounds with an ionic chemical bond. These are CaO, MgO, CrO, MnO, Na_2O etc.

- Acidic: These oxides form or correspond to oxygen containing acids. They interact with bases. They are compounds with covalent bond. Among them are CO_2, SO_2, SiO_2 etc.

- Amphoteric: These oxides form or correspond to amphoteric hydroxides. They interact with acids and bases, forming complexes. They are compounds with covalent bond. These are Al_2O_3, MnO_2, ZnO etc.

- Neutral: These oxides do not form or correspond to basic hydroxides nor to oxygen containing acids. They are compounds with covalent bond. These are N_2O, CO, NO etc.

✓Properties of oxides by periods

Generally, by increasing the sequence number of the element involved in the respective oxide, the nature of the oxides varies from basic through the amphoteric to the acidic.

III period

Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl_2O_7
основен	основен	амфотерен	киселинен	киселинен	киселинен	киселинен

→

✓Properties of oxides by families (groups)

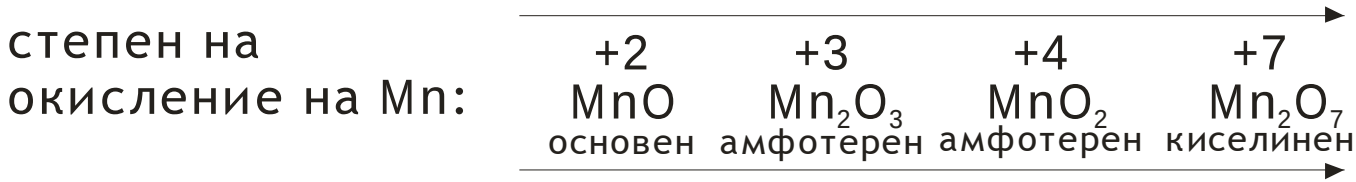
The character of the oxides varies from acidic, through amphoteric to basic.

III group

B_2O_3	Al_2O_3	Ga_2O_3	Tl_2O_3
киселинен	амфотерен	амфотерен	основен

→

When a chemical element forms several oxides, the acidic nature of the oxide increases with increasing oxidation state:



From the above, it follows that the oxides of the elements of the IA and IIA groups are basic, the oxides of the elements of the VIA and VIIA groups are acidic (без Po) and the oxides of the elements of the IIIA, IVA and VA groups are amphoteric (next to B – At line).

✓Properties of oxides

➢Physical properties

Oxides with ionic bond are: Solid crystal compounds with high melting point – CaO, MgO, Na_2O etc.

Oxides with ionic bond are:

- ✓Solid – P_2O_5;
- ✓Liquid – H_2O, Mn_2O_7 etc.;
- ✓Gases – SO_3, CO_2, NO

Oxides may be differently colored:

Colour	oxide
colourless	NO, SO_2, CO_2, H_2O
white	CaO, ZnO
black	FeO, CuO
red	Fe_2O_3, Cu_2O
blue	N_2O_3
red - brown	NO_2
yellow	PbO

➢ Chemical properties

➢ Reactions with no change in the oxidation state of the chemical element involved in the oxide.

❖ For basic oxides

- ✓ with water (only the oxides of s – elements)
- ✓ with acidic oxides
- ✓ with acids

❖ For acidic oxides

- ✓ with water – form acids
- ✓ with basic oxides
- ✓ with bases

❖ For amphoteric oxides

- ✓ with acidic oxides
- ✓ with basic oxides
- ✓ with acids
- ✓ with bases

❖ For neutral oxides

– do not interact with acids, bases and other oxides.

- they are chemically inert compounds.

➢ Reactions with change in the oxidation state of the chemical element involved in the oxide.

A number of oxides may participate in oxidative reduction processes in which the degree of oxidation of the oxide component is changed. Many of these processes are fundamental in metallurgy.

Obtaining:

- In the immediate oxidation of the elements and their compounds:

$S + O_2 \rightarrow SO_2$	$4NH_3 + 5O_2 \xrightarrow{Pt} 4NO + 6H_2O$
$C + O_2 \rightarrow CO_2$	$2PbS + 3O_2 \xrightarrow{t^o} 2PbO + 2SO_2$

- Thermal decomposition of hydroxides and salts:

$2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$ $\qquad$ $CaCO_3 \rightarrow CaO + CO_2$

- Interaction of chemical elements with water (on heating):

$C + H_2O \longrightarrow CO + H_2 - Q$ (синтез газ)

редуктор $C^0 - 2e^- \longrightarrow C^{+2}$ | 2 | 1 окисление

окислитель $2H^{+1} + 2e^- \longrightarrow H_2^0$ | | 1 редукция

- Oxidation and reduction of oxides:

$2CO + O_2 \rightarrow 2CO_2$

редуктор $C^{+2} - 2e^- \longrightarrow C^{+4}$ | 4 | 2 окисление

окислитель $O_2^0 + 2.2e^- \longrightarrow 2O^{-2}$ | | 1 редукция

$CO_2 + C \rightleftarrows 2CO - Q$

редуктор $C^{+2} - 2e^- \longrightarrow C^{+4}$ | 2 | 1 окисление

окислитель $C^0 + 2e^- \longrightarrow C^{+2}$ | | 1 редукция

HYDROXIDES

✓What is a hydroxide

In chemistry, hydroxide is the most common name for the diatomic anion OH, consisting of oxygen and hydrogen atoms, usually derived from the dissociation of a base. It is one of the simplest diatomic ions known. Hydroxide ion is a kind of ligand. It donates one pair of electrons, behaving as a Lewis base.

✓Composition and construction

According to Arrhenius's theory the acids are electrolytes which in aquas solution are dissociated only to one type of cations – hydrogen cations (H^+) and an acidic anions, and the bases are electrolytes which in aquas solution are dissociated to metal cations and only one type of anions – hydroxyl anions (OH^-).

The character of the hydroxides is changing through the PT as follows:

-By periods – from basic, through amphoteric to acidic at the end of the period;

-By families (groups) – in the main groups – with increase of the atomic number of the element the acidic properties decrease and the basic properties increase.

✓Classification

The hydroxides are obtained or may be considered as a result of the interaction of an oxide with water, i.e. they correspond to the defined oxides.

Hydroxides may be classified as :

- Basic: correspond to the basic oxides. These are hydroxides of metals- s-elements and p-, d- and f-elements in their lowest valence. Such are NaOH, $Ca(OH)_2$ etc.

- Acidic: correspond to the acidic oxides. These are hydroxides of non-metals (p-elements) and d- and f-elements in high valence.

- Amphoteric: correspond to the amphoteric oxides. These are hydroxides of metals – d- and f-elements in medium valence and some p-elements with weak metal or non-metal character. Such are $Al(OH)_3$, $Zn(OH)_2$ etc.