

CHAPTER 1

Safety in the laboratory classes

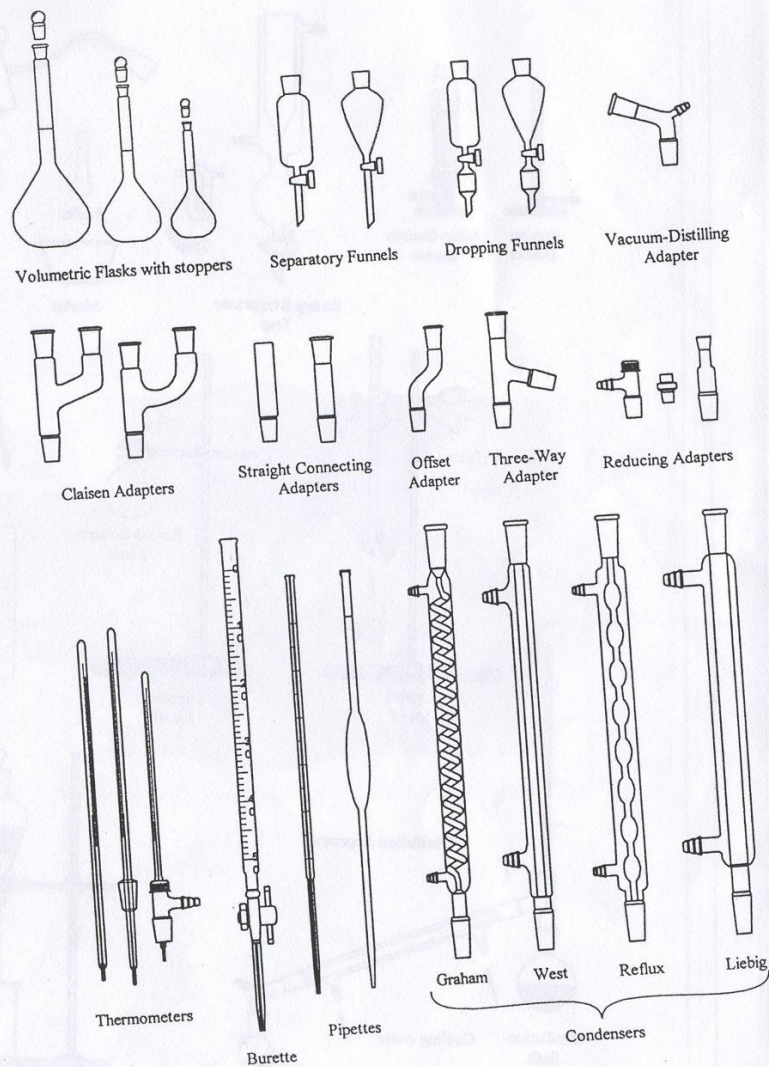
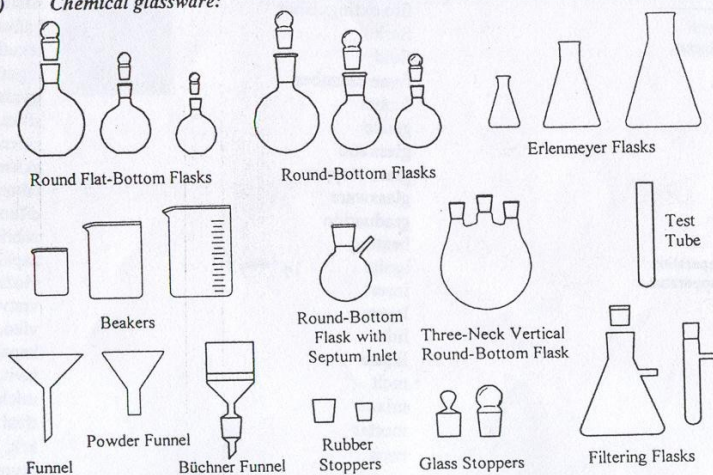
a) General Instructions:

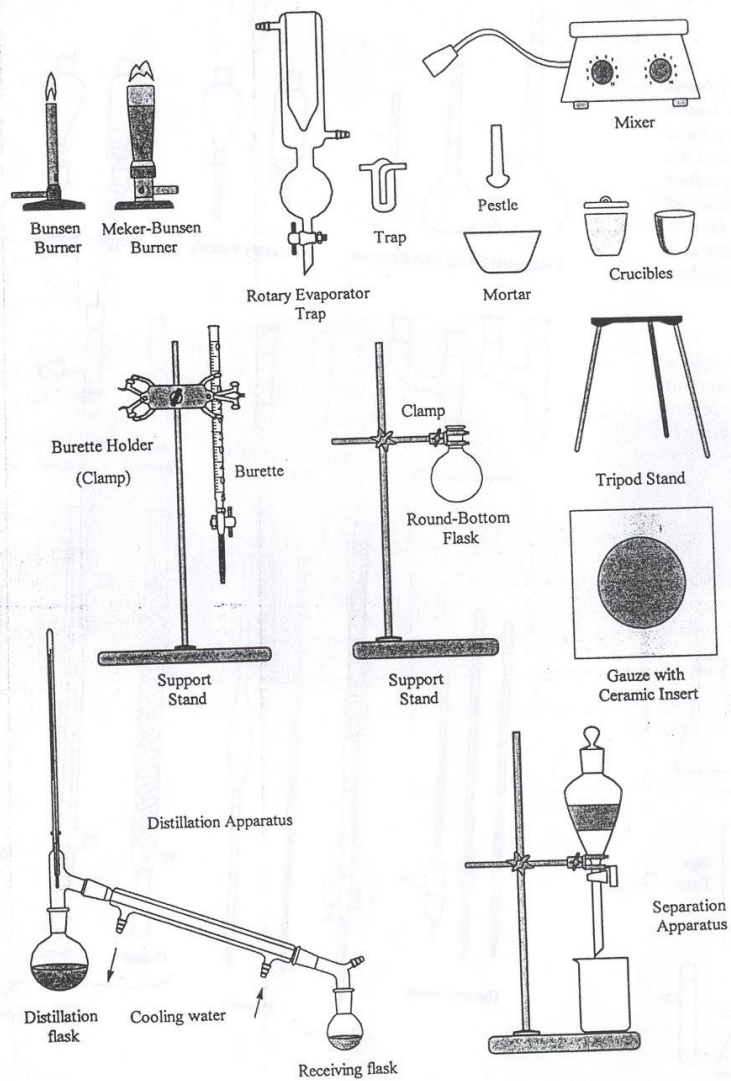
There are some general instructions in safety precautions in the laboratory work. Most accidents could be prevented if proper precautions are taken. The attention, honest and careful work is required from students. They should therefore perform only those experiments that are selected for them by teacher. Such experiments are safe and the students do not have to worry. Nevertheless even a very simple error can produce dangerous conditions for the work. Sometimes, even a slight change of concentration of one reagent is sufficient to change the safe conditions of a chemical reaction (and to cause an explosion). The reaction then might occur in a different way, perhaps at a highly accelerated rate. Therefore students are asked not to deviate from the procedure in the manual.

b) Accidents:

The most common accidents occur when students try to insert tubing, a thermometer, or a glass rod into a hole in a rubber stopper. Other frequent sources of danger are volatile organic liquids that might ignite if students bring open flame close to them. We should know what to do if somebody spills a caustic reagent on oneself or if some chemicals got into one's eye. The chemical substance in the eye has to be handled with water from the nearest sink, at least 10 minutes, and we call the doctor immediately. We should also know what to do if the fire breaks out in the lab, which means to use an extinguisher or sand, blanket, or anything appropriate at the time. Every student must always know where water, shower, first-aid kit, fire extinguishers and other things are so that he / she will not have to look for them long if they are needed quickly.

c) Chemical glassware:





Vocabulary 1:

alteration
 adapter
 beaker
 blanket
 blender
 bottle
 bottom
 burette
 burner
 calcine
 calcining circle
 ceramic
 clamp (holder)
 combustion spoon
 condenser
 conical
 container
 cork
 crucible
 crucible tongs
 desiccator
 dish
 distillation
 dropping
 evolve
 extinguisher
 filtration
 fire extinguisher
 flask
 fluid
 fume chamber
 funnel
 gauze
 glass rod
 glass stopper
 glassware
 graduation
 heating
 ignite
 insert
 layer
 lid
 liquid
 melt
 mixer
 mortar
 neck
 opening

změna
 rozdvojka, nástavec, adapter, redukce
 kádinka
 deka, přikrývka; plášť; povlak
 kuchyňský mixer
 láhev
 dno
 byreta
 hořák
 žíhat, pražit
 žhací kruh
 keramický
 držák
 spalovací lžice
 chladič
 kuželovitý, kónický
 nádoba, bedna, kontejner
 korek
 tavicí kelímek
 kleště na kelímek
 sušička, exsikátor
 miska
 destilace
 kapací
 vyvjet
 hasicí přístroj
 filtrace
 hasicí přístroj
 baňka, láhev
 tekutina
 digestoř
 trychtýř, nálevka
 síťka
 skleněná tyčinka
 skleněná zátka
 laboratorní sklo
 dílkování, stupnice
 zahřívání
 zapálit, zahřívát
 vložka; vložit, vsunout
 vrstva
 víko, víčko
 kapalina
 tavit, rozpouštět
 míchačka
 třecí miska
 krk; hrdlo láhve
 otvor

is' najit

pestle
 pinchcock
 pipette
 pour
 powder
 powder funnel
 reagent
 round
 rubber stopper
 secure
 separation
 separatory
 septum inlet
 solvent
 spirit burner
 stopcock
 straight
 sublimation
 sulphur *Brit.*, sulfur *Am.*
 support stand
 test tube
 thermometer
 throw out
 tip

 tongs
 transferring
 trap
 tripod stand
 tube
 vessel
 volumetric
 volumetric flask
 volumetric cylinder
 wash bottle
 watch glass

tlouček
 tlačka
 pipeta
 nalévat, lit
 prášek
 násypka
 činidlo
 kulatý
 gumová zátka
 zajistit
 dělení
 dělicí
 přívod s přepážkou
 rozpouštědlo
 lihový kahan
 kohout
 přímý
 sublimace
 síra
 stojan
 zkumavka
 teploměr
 vyhodit
 převrhnout (se); dávat spropitné; špička
 pipety
 kleště
 přenášení
 sifon, lapač; past
 trojnožka
 trubice
 nádoba; plavidlo
 odměrný
 odměrná baňka
 odměrný válec
 stříčka
 hodinové sklíčko

Exercise 1:

a) Complete the sentences with the help of the table below (All words necessary to complete the table can be found in the vocabulary of this chapter – some of them, however, must be changed in the appropriate way.):

- A is a common container in a chemical laboratory.
- This vessel has a round
- That big is used as a mixing
- There are some new in our lab.
- You can see fine at these
- are used to measure accurate volumes.
- There is a new in this small beaker.
- are used for liquids into containers with small openings.
- Sulphur in is in that
- Crucible are necessary to hold crucibles used for and calcining materials at high temperatures.

1.			S			U					
2.			N		C						
2.		O		T							
3.	B		A			R					
3.			S			L					
4.		O		T			N		R		
5.	G		A		U			I			S
5.		U				T					
6.			P		T				S		
7.	S			V							
8.			N						S		
8.				R					G		
9.	P		W								
9.				C		B			E		
10.			N								
10.	M			T					G		

CHAPTER 2

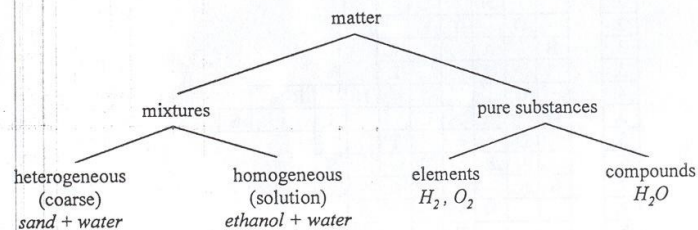
Types of Matter

a) Classification of Matter:

Matter is anything that has mass and occupies space. It exists in three phases: *solid*, *liquid*, and *gas*. A *solid* has a rigid shape and a fixed volume. A *liquid* has a fixed volume but is not rigid in shape; it takes on the shape of the container. A *gas* has neither a fixed volume nor a rigid shape; it takes on both the volume and the shape of the container.

Matter can be classified into two categories - *pure substances* and *mixtures*. *Pure substances* (e.g.: water) have a fixed composition (they cannot be divided into simpler parts by physical methods) and a unique set of properties; they are either elements or compounds. *Mixtures* are composed of two or more substances; they can be either homogeneous (e.g.: ethanol in water) or heterogeneous (sand in water).

The composition of the mixture is the same throughout in a homogeneous mixture whereas in heterogeneous mixtures the composition varies throughout (most rocks fall into this category). An element is a type of matter that cannot be broken down into two or more pure substances. A compound is a pure substance that contains more than one element.



b) Separation Methods:

Many different methods can be used to separate the components of a mixture from one another. A couple of methods that are usually carried out in the laboratory are filtration and distillation. The filtration is used to separate a heterogeneous solid-liquid mixture. The mixture is passed through a barrier with fine pores such as filter paper. The distillation is used to resolve a homogeneous solid-liquid, or liquid-liquid, mixture. The more volatile liquid vaporizes, leaving the residue of the solid, or the less volatile liquid, in the distilling flask. Almost pure liquid is obtained by condensing the vapour.

c) Solutions and Their Properties:

Another name for a homogeneous mixture is a *solution*. A solution is made up of *solvent*, the substance present in largest amount, and one or more *solutes*. Most commonly, the solvent is a liquid, while solutes may be solids, liquids, or gases.

Nearly every chemical reaction takes place in homogeneous solutions. Therefore, it is important to understand the properties of solutions before we can begin to understand those reactions. The most distinct characteristic of a solution is its concentration (a measure of the relative amounts of solute and solvent in a solution).

We know various units of concentration like mass percent, mole fraction, molarity, and molality.

Molarity, the number of moles of solute per liter of solution, has the units moles / L which can be abbreviated *M* or *c*. Meanings of the abbreviations are *c* - molar concentration, *n* - molar quantum, *V* - volume of the solution. This is the most commonly used measure of concentration.

$$c = \frac{n}{V}$$

Molality is the number of moles of solute per kilogram of solvent and is abbreviated *c_m*. Meanings of the abbreviations are *c_m* - molal concentration, *n* - molar quantum, *m_R* - weight of the pure solvent. The major advantage of using molality *c_m* (instead of molarity *M*) as a measure of concentration is that molality is temperature independent because it, unlike molarity, includes no volume term.

$$c_m = \frac{n}{m_R}$$

Another temperature independent measure of concentration is *mass percent*. Mass percent *P_w* is defined as the mass of solute *m* divided by the mass of the solution *m_s* multiplied by 100 %.

$$P_w = \frac{m}{m_s} \cdot 100 \%$$

The last measure of concentration we will discuss is called *mole fraction*. Mole fraction *x* is the ratio of the number of moles of solute *n* to the total number of moles of solution *n_s*.

$$x = \frac{n}{n_s}$$

There are two common ways to prepare a liquid solution. The first is to weigh out a known mass of solute and mix it with the amount of solvent just needed to achieve the desired concentration. The solvent can be weighed (in the case of *c_m*, *P_w*, *x*) or added to the solute into a volumetric flask to receive total volume needed for the desired concentration (in the case of *c*). The other method involves the dilution of a concentrated stock solution with more solvent to achieve a solution with a lower concentration than the original solution.

What factors affect the solubility of solutes in different solvents? A rule was observed that *similar dissolves similar*. Non-polar solvents dissolve non-polar solutes better than polar solvents and polar solvents dissolve polar solutes better than non-polar solvents.

Raising the temperature of a solution will increase the solubility of most solid solutes. Likewise, increasing the pressure above a solution will increase the solubility of gaseous solutes.

sublimation
substance
system
take on
vapour

sublimace
hmota, látka
soustava, systém
nabýt, nabývat; vzít na sebe co
pára, výpary, opar, mlha

Vocabulary 2:

atomic mass unit
atomic relative mass
boiling
coarse
composition
compound
condensation
crystallization
density
desublimation
dilute a)
distillation
distinct
electric field
element
evaporate
evaporation
evenly
extraction
filtration
float
freezing
gaseous state
gravitational field
heterogenous u
homogeneous, homogenous
involve
link
liquid state
magnetic field
mass percent
matter
melting
mixture
mol
molecular relative mass
molarity
mole fraction .
pure substance
saturated
separation
solid state
solubility
solute
solution
solvent
stir (pt., pp. stirred)
stock solution

atomová hmotnostní jednotka
atomová relativní hmotnost
var
hrubý, drsný
složení
sloučenina
kondenzace
krystalizace
hustota
desublimace
zředit, rozředit
destilace
jasný, nesporný, zřetelný
elektrické pole
prvek
vypařit
vypařování, odpařování
rovnoměrně, pravidelně, ustáleně
extrakce
filtrace
plout, vznášet se
tuhnout
skupenství plynné
gravitační pole
heterogenní
homogenní
zahmovat
spojit
skupenství kapalné
magnetické pole
hmotnostní zlomek, procenta
látka, hmota
~~směs látek~~, směs látek
látkové množství, mol
molekulová relativní hmotnost
látková (dříve molární) koncentrace
molární koncentrace
chemicky čistá látka
nasycený
dělení
skupenství pevné
rozpustnost
rozpuštěná látka
roztok
rozpuštědlo
zamíchat, rozmíchat
zásobní roztok

Aerosol	aerosol
Aqueous solution	vodný roztok
Compound	sloučenina
Consist of	skládat se z...
Chemical substance	chemická látka
Detergent	detergent
Dissolved	rozpuštěný
Emulsion	emulze
Foam	pěna
Fog	mlha
Gas	plyn
Immiscible	nemísitelný
Insoluble	nerozpustný
Liquid	kapalina
Miscible	mísitelný
Mix	mísit
Mixture	směs
Particle	částice
Saturated solution	nasycený roztok
Sediment	sediment
Shake	třást, třepat
Smoke	kouřit, kouř, dým
Solid	pevná látka
Solubility	rozpustnost
Solubility curve	křivka rozpustnosti
Soluble	rozpustný
Solute	rozpouštěná látka
Solution	roztok
Solvent	rozpouštědlo
Stir	míchat
Suspension	suspenze
To form	tvořit
Volatile	těkavý
boiling point	bod varu
centrifugate	centrifugovat
centrifugation	centrifugace
centrifuge	centrifuga
centrifuging	centrifugování

constituent	složka
crystallization	krystalizace
crystals	krystaly
decantation	dekantace
dissociate	disociovat
distil	destilovat
distillate	destilát
distillation	destilace
distilled water	destilovaná voda
embedded	pevně do něčeho vložený
evaporate	vypařovat se
evaporation	vypařování
filter cake	filtrační koláč
filter paper	filtrační papír
filtering	filtrování
filtrate	filtrát
filtration	filtrace
force	síla
fractional distillation	frakční destilace
homogenate	homogenizát
chromatogram	chromatogram
chromatography	chromatografie
identify	identifikovat
impure	nečistý
impurity	nečistota
microscope slide	mikroskopické sklíčko
porous	porézní, prostupný
precipitate	precipitát, sraženina
reagent	činidlo
residue	zbytek (např. opak filtrátu při filtraci)
scales, balance	váhy
sedimentation	sedimentace
separate	separovat, oddělovat
separating funnel	dělicí nálevka
settle	usadit se, klesnout
sublimation	sublimace
vapour (brit.), vapor (am.)	pára
water bath	vodní lázeň
weigh	vážít (určit váhu)

Names and Symbols of Some of the More Familiar Elements

● Aluminum Al	Chlorine Cl	Lithium Li	Rubidium Rb
● Antimony Sb	Chromium Cr	● Magnesium Mg	Selenium Se
Argon Ar	Cobalt Co	● Manganese Mn	● Silicon Si
Barium Ba	● Copper Cu	● Mercury Hg	● Silver Ag
Beryllium Be	Fluorine F	Neon Ne	● Sodium Na
Bismuth Bi	● Gold Au	Nickel Ni	Strontium Sr
● Boron B	Helium He	● Nitrogen N	Sulfur S
Bromine Br	Hydrogen H	● Oxygen O	● Tin Sn
Cadmium Cd	Iodine I	Phosphorus P	● Uranium U
● Calcium Ca	● Iron Fe	Platinum Pt	Xenon Xe
● Carbon C	Krypton Kr	Plutonium Pu	● Zinc Zn
Cesium Cs	● Lead Pb	● Potassium K	

Names of Compounds

A compound can be identified either by its formula (e.g., NaCl) or its name (sodium chloride). In this section, you will learn the rules used to name ionic and simple molecular compounds. To start with, it will be helpful to show how individual ions within ionic compounds are named.

Ions

Monatomic cations take the name of the metal from which they are derived. Examples include

Na⁺ sodium K⁺ potassium

There is one complication: Certain metals, notably those in the transition series, form more than one type of cation. An example is iron, which forms both Fe²⁺ and Fe³⁺. To distinguish between these cations, the charge must be indicated in the name. This is done by putting the charge as a Roman numeral in parentheses after the name of the metal:

Fe²⁺ iron(II) Fe³⁺ iron(III)

(An older system used the suffixes *-ic* for the ion of higher charge and *-ous* for the ion of lower charge. These were added to the stem of the Latin name of the metal, so that the Fe³⁺ ion was referred to as ferric and the Fe²⁺ ion as ferrous.)

Monatomic anions are named by adding the suffix *-ide* to the stem of the name of the nonmetal from which they are derived.

N ³⁻ nitride	O ²⁻ oxide	H ⁻ hydride
	S ²⁻ sulfide	F ⁻ fluoride
	Se ²⁻ selenide	Cl ⁻ chloride
	Te ²⁻ telluride	Br ⁻ bromide
		I ⁻ iodide

Polyatomic ions are given special names:

NH ₄ ⁺	ammonium
OH ⁻	hydroxide

NO ₃ ⁻	nitrate		
ClO ₃ ⁻	chlorate	ClO ₄ ⁻	perchlorate
CN ⁻	cyanide		
CH ₃ COO ⁻	acetate		
MnO ₄ ⁻	permanganate		
CO ₃ ²⁻	carbonate	HCO ₃ ²⁻	hydrogen carbonate
PO ₄ ³⁻	phosphate	HPO ₄ ²⁻	hydrogen phosphate
SO ₄ ²⁻	sulfate		H ₂ PO ₄ ⁻ dihydrogen phosphate
CrO ₄ ²⁻	chromate	Cr ₂ O ₇ ²⁻	dichromate

Certain nonmetals in Groups 15-17 of the periodic table form more than one polyatomic ion containing oxygen (oxoanions). The names of several such oxoanions are shown in below. From the entries in the table, you should be able to deduce the following rules.

- When a nonmetal forms two oxoanions, the suffix *-ate* is used for the anion with the larger number of oxygen atoms. The suffix *-ite* is used for the anion containing fewer oxygen atoms.
- When a nonmetal forms more than two oxoanions, the prefixes *per-* (largest number of oxygen atoms) and *hypo-* (fewest oxygen atoms) are used as well.

Oxoanions of Nitrogen, Sulfur and Chlorine

Nitrogen	Sulfur	Chlorine
NO ₃ ⁻ nitrate	SO ₄ ²⁻ sulfate	ClO ₄ ⁻ perchlorate
NO ₂ ⁻ nitrite	SO ₃ ²⁻ sulfite	ClO ₃ ⁻ chlorate
		ClO ₂ ⁻ chlorite
		ClO ⁻ hypochlorite

Ionic Compounds

The name of an ionic compound consists of two words. The first word names the cation and the second names the anion. This is, of course, the same order in which the ions appear in the formula.

Example:

CaS	calcium sulfide
Al(NO ₃) ₃	aluminum nitrate
FeCl ₂	iron(II) chloride

Binary Molecular Compounds

When a metal combines with a nonmetal, the product is ordinarily an ionic compound. As you have just seen, the formulas and names of these compounds can be deduced in a straightforward way. When two nonmetals combine with each other, the product is most often a binary molecular compound. There is no simple way to deduce the formulas of such compounds. There is, however, a systematic way of naming molecular compounds that differs considerably from that used with ionic compounds.

The systematic name of a binary molecular compound, which contains two different nonmetals, consists of two words.

- The first word gives the name of the element that appears first in the formula; a Greek prefix (see below) is used to show the number of atoms of that element in the formula.
- The second word consists of
 - the appropriate Greek prefix designating the number of atoms of the second element
 - the stem of the name of the second element
 - the suffix *-ide*

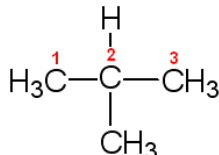
Nomenclature of Organic Compounds

General rules

Nomenclature of Alkanes

Straight-Chain Alkanes			Alkyl Groups		
English name	Czech name		English name	Czech name	
methane	methan	CH ₄	methyl	methyl	CH ₃ -
ethane	ethan	CH ₃ CH ₃	ethyl	ethyl	CH ₃ -CH ₂ -
propane	propan	CH ₃ CH ₂ CH ₃	propyl	propyl	CH ₃ -CH ₂ -CH ₂ -
butane	butan	CH ₃ (CH ₂) ₂ CH ₃	isopropyl	isopropyl	(CH ₃) ₂ CH-
pentane	pentan	CH ₃ (CH ₂) ₃ CH ₃	butyl	butyl	CH ₃ -CH ₂ -CH ₂ -CH ₂ -
hexane	hexan	CH ₃ (CH ₂) ₄ CH ₃			
heptane	heptan	CH ₃ (CH ₂) ₅ CH ₃			
octane	oktan	CH ₃ (CH ₂) ₆ CH ₃			

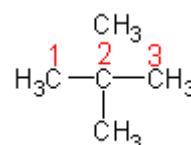
With alkanes containing a *branched chain*, such as

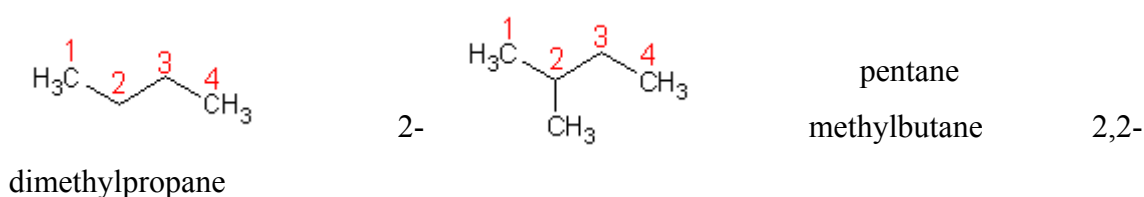


2-methylpropane

the name is more complex. A branched-chain alkane such as 2-methylpropane can be considered to be derived from a *straight-chain* alkane by replacing one or more hydrogen atoms by alkyl groups. The name consists of two parts:

- a suffix that identifies the parent straight-chain alkane. To find the suffix count the number of carbon atoms in the longest continuous chain. For a three-carbon chain, the suffix is propane; for a four-carbon chain it is butane, and so on.
- a prefix that identifies the branching alkyl group and indicates by a number the carbon atom where branching occurs. In 2-methylpropane, referred to above, the methyl group is located at the second carbon from the end of the chain:





Notice that

- if the same alkyl group is at two branches, the prefix **di-** is used (2,2-dimethylpropane). If there were three methyl branches, we would write trimethyl, and so on.
- the number in the name is made as small as possible. Thus, we refer to 2-methylbutane, numbering the chain from the left, rather than from the right.

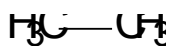
[branched chain](#) – rozvětvený řetězec

[straight chain](#) – přímý (rovný) řetězec

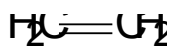
Nomenclature of Alkenes

The systematic names of alkenes are derived from those of the corresponding alkanes with the same number of carbon atoms per molecule. There are two modifications.

- the ending **-ane** is replaced by **-ene**

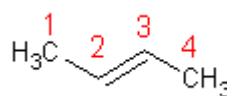
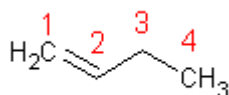


ethane



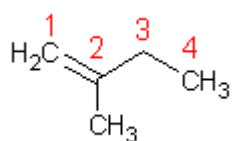
ethene

- where necessary, a number is used to designate the *double-bonded carbon*; the number is made as small as possible.

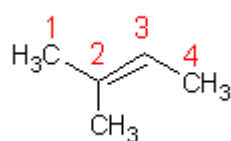


but-1-ene

but-2-ene

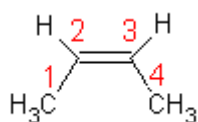


2-methylbut-1-ene

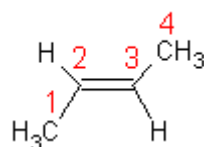


2-methylbut-2-ene

You may be surprised to learn that there are actually two different 2-butenes, differing from each other in molecular geometry.



cis-but-2-ene

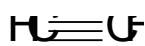


trans-but-2-ene

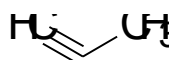
[double-bonded carbon](#) – uhlík se dvěma vazbami

Nomenclature of Alkynes

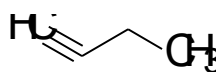
The IUPAC names of alkynes are derived from those of the corresponding alkenes by replacing the suffix **–ene** with **–yne**.



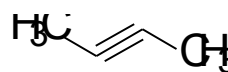
ethyne



propyne



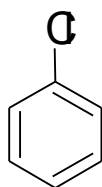
but-1-yne



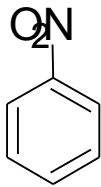
but-2-yne

Derivatives of Benzene

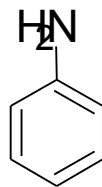
Monosubstituted benzenes are ordinarily named as derivatives of benzene.



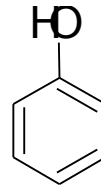
chlorobenzene



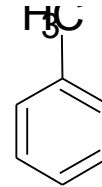
nitrobenzene



aminobenzene
(aniline)



hydroxybenzene
(phenol)



methylbenzene
(toluene)

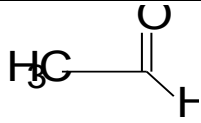
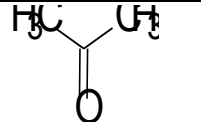
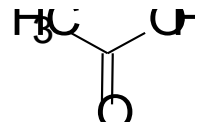
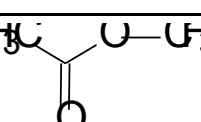
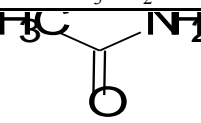
The last three compounds listed are always referred to by their common names, shown in red.

common – běžný (triviální)

referred – uváděný

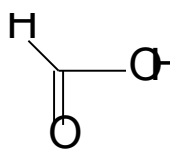
Functional Groups

Many organic molecules can be considered to be derived from hydrocarbons by substituting a functional group for a hydrogen atom. The functional group can be a nonmetal atom or small group of atoms that is bonded to carbon.

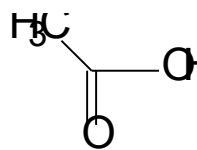
Common Functional Groups			
Czech name	Class	Example	Name
halogeny	halides	C_2H_5Cl	chloroethane
alkoholy	alcohols	C_2H_5OH	ethanol
ethery	ethers	CH_3-O-CH_3	dimethyl ether
aldehydy	aldehydes		ethanal
ketony	ketones		propanone
karboxylové kyseliny	carboxylic acids		ethanoic acid
estery	esters		methyl methanoate
aminy	amines	CH_3NH_2	aminomethane
amidy	amides		ethanamide

Carboxylic Acids

The systematic names of these compounds are obtained by adding the suffix –oic to the stem of the name of the corresponding alkanes. In practice, these names are seldom used for the first two members of the series, which are commonly referred to as formic acid and acetic acid.



methanoic acid
(formic acid)



ethanoic acid
(acetic acid)

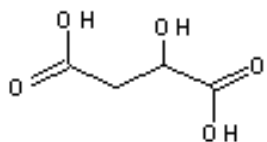
A wide variety of carboxylic acids occur in nature, giving a sour or tart taste to foods.

Some naturally Occurring Organic Acids		
Name		Source
acetic acid		vinegar
citric acid		citrus fruits
malic acid		apples, grape juice
oxalic acid	HOOC-COOH	tomatoes, spinach

Self-tests

Write the name

Write the correct names of these compounds:



malic acid



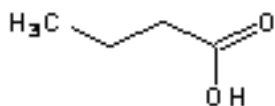
but-2-ene



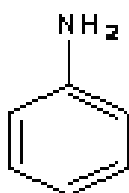
pentane



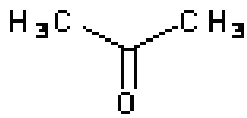
pent-1, 3-diene



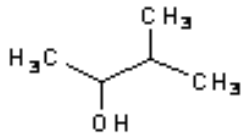
butanoic acid



aminobenzene



propanone

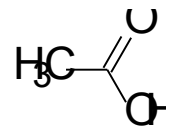


3-methylbutan-2-ol

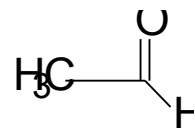
Draw the formula

Draw the right formulas of these compounds

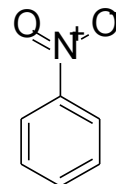
ethanoic acid



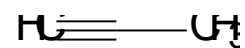
ethanal



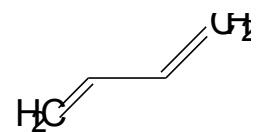
nitrobenzene



propyne



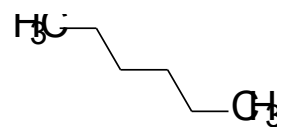
trans-but-2-ene



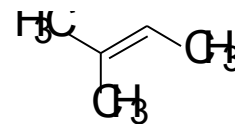
pent-2,3-diene



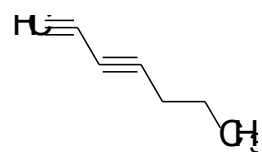
hexane



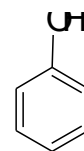
2-methylbut-2-ene



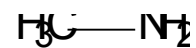
hept-1,3-diyne



phenol



aminomethane



but-2-ene-1-ol

