CHAPTER 1

Safety in the laboratory classes

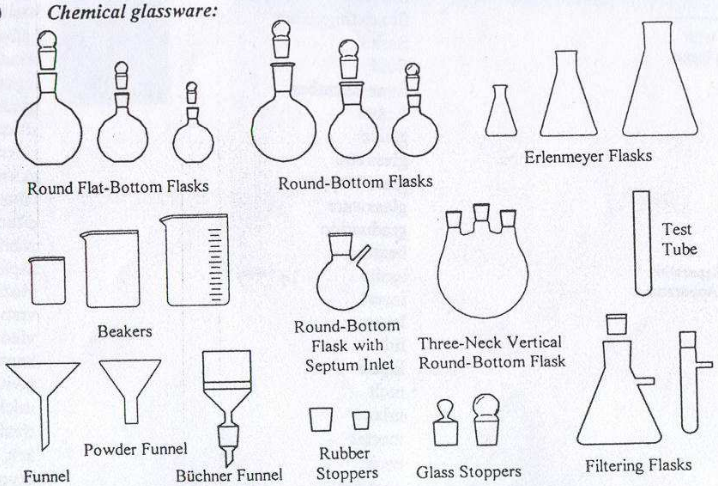
a) ***General Instructions:***

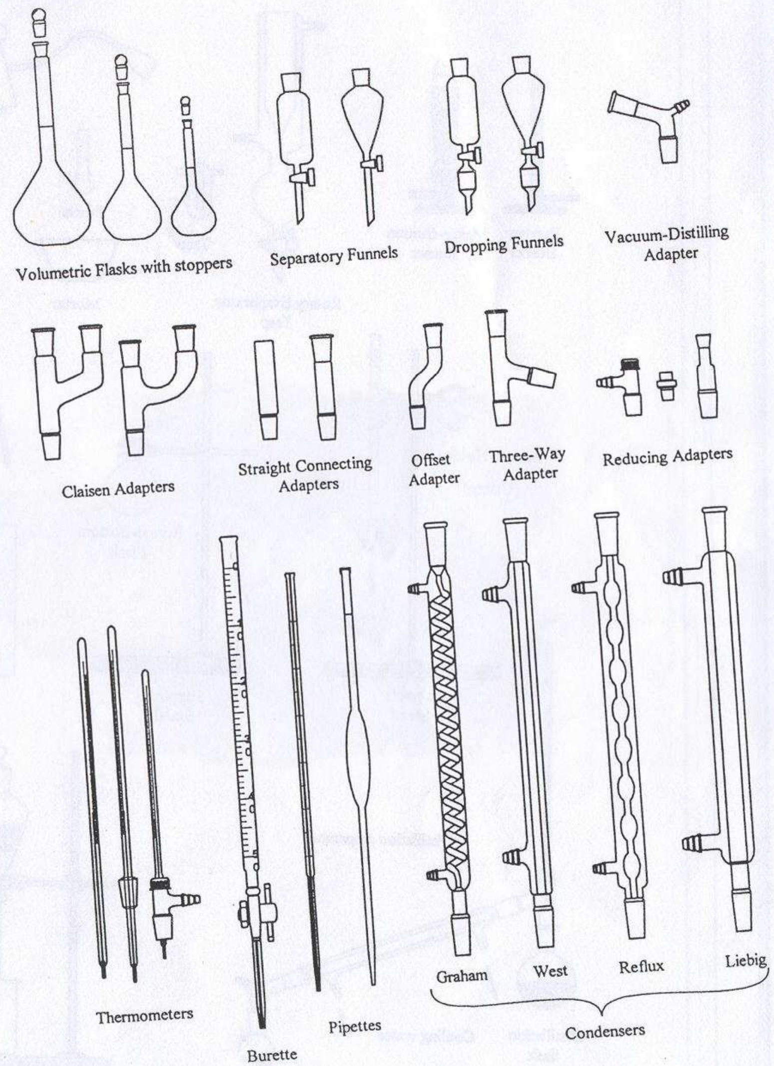
There are some general instructions in safety precautions in the laboratory work. Most accidents could be prevented if proper precautions are taken. The attention, honest and careful work is required from students. They should therefore perform only those experiments that are selected for them by teacher. 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.

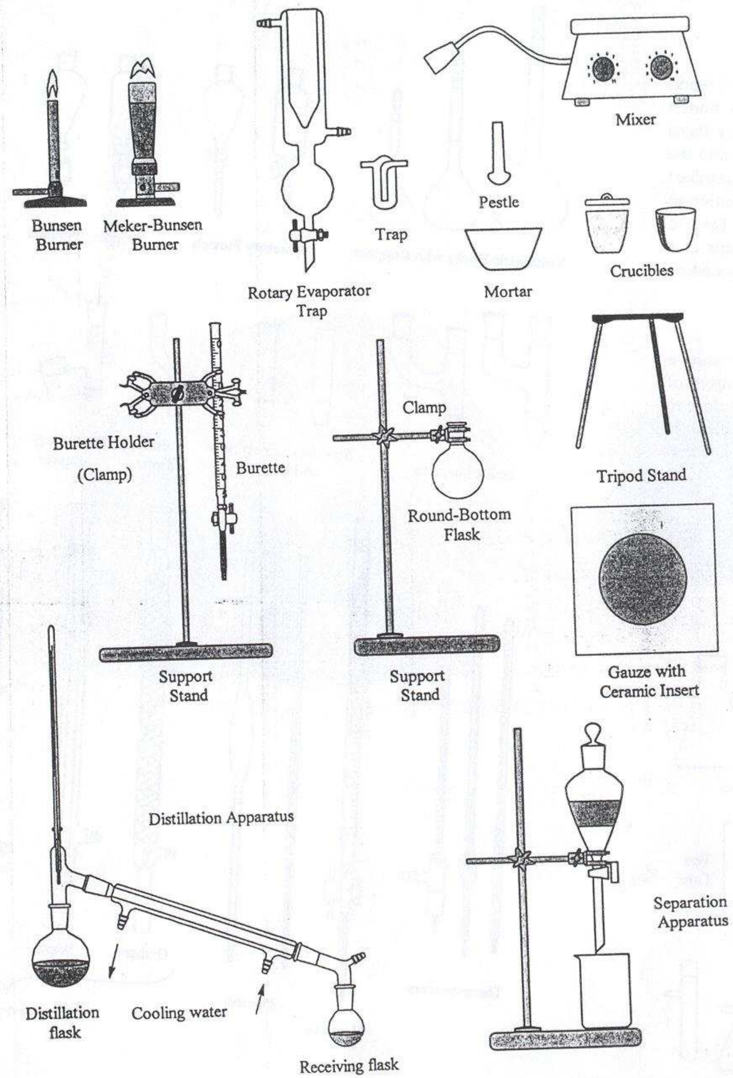
b) ***Accidents:***

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	změna
adapter	rozdvojka, nástavec, adapter, redukce
beaker	kádinka
blanket	deka, přikrývka; plášť; povlak
blender	kuchyňský mixer
bottle	láhev
bottom	dno
burette	byreta
burner	hořák
calcine	žíhat, pražit
calcining circle	žíhací kruh
ceramic	keramický
clamp (holder)	držák
combustion spoon	spalovací lžíce
condenser	chladič
conical	kuželovitý, kónický
container	nádoba, bedna, kontejner
cork	korek
crucible	tavicí kelímek
crucible tongs	kleště na kelímek
desiccator	sušička, exsikátor
dish	miska
distillation	destilace
dropping	kapací
evolve	vyvíjet
extinguisher	hasicí přístroj
filtration	filtrace
fire extinguisher	hasicí přístroj
flask	baňka, láhev
fluid	tekutina
fume chamber	digestoř
funnel	trychtýř, nálevka
gauze	síťka
glass rod	skleněná tyčinka
glass stopper	skleněná zátka
glassware	laboratorní sklo
graduation	dílkování, stupnice
heating	zahřívání
ignite iz'najt	zapálit, zahřívat
insert	vložka; vložit, vsunout
layer	vrstva
lid	víko, víčko
liquid	kapalina
melt	tavit, rozpouštět
mixer	míchačka
mortar	třecí miska
neck	krk; hrdlo láhve
opening	otvor

pestle	tlouček
pinchcock	tlačka
pipette	pipeta
pour	nalévat, lít
powder	prášek
powder funnel	násypka
reagent	činidlo
round	kulatý
rubber stopper	gumová zátka
secure	zajistit
separation	dělení
separatory	dělicí
septum inlet	přívod s přepážkou
solvent	rozpouštědlo
spirit burner	lihový kahan
stopcock	kohout
straight	přímý
sublimation	sublimace
sulphur *Brit.*, sulfur *Am.*	síra
support stand	stojan
test tube	zkumavka
thermometer	teploměr
throw out	vyhodit
tip	převrhnout (se); dávat spropitné; špička pipety
tongs	kleště
transferring	přenášení
trap	sifon, lapač; past
tripod stand	trojnožka
tube	trubice
vessel	nádoba; plavidlo
volumetric	odměrný
volumetric flask	odměrná baňka
volumetric cylinder	odměrný válec
wash bottle	střička
watch glass	hodinové sklíčko

Exercise 1:

a) ***Complete the sentences*** *with the help of the table bellow (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.):*

1. A ....….. is a common container in a chemical laboratory.
2. This ....….. vessel has a round ....…..
3. That big ....….. is used as a mixing ....…..
4. There are some new ....….. in our lab.
5. You can see fine ....….. at these ....…..
6. ....….. are used to measure accurate volumes.
7. There is a new ....….. in this small beaker.
8. ....….. are used for ....….. liquids into containers with small openings.
9. Sulphur in ....….. is in that ....…..
10. 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				

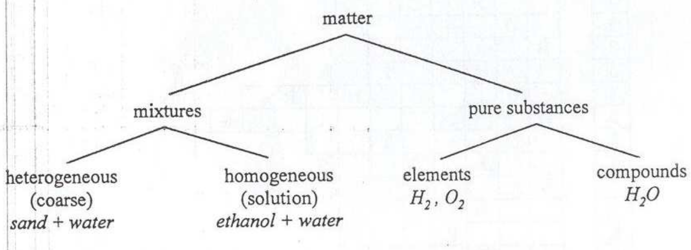
CHAPTER 2
Types of Matter

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 lutes. Likewise, increasing the pressure above a solution will increase the solubility of ost gaseous solutes.

sublimation	sublimace
substance	hmota, látka
system	soustava, systém
take on	nabýt, nabývat; vzít na sebe *co*
vapour	pára, výpary, opar, mlha

Vocabulary 2:

atomic mass unit	atomová hmotnostní jednotka
atomic relative mass	atomová relativní hmotnost
boiling	var
coarse	hrubý, drsný
composition	složení
compound	sloučenina
condensation	kondenzace
crystallization	krystalizace
density	hustota
desublimation	desublimace
dilute	zředit, rozředit
distillation	destilace
distinct	jasný, nesporný, zřetelný
electric field	elektrické pole
element	prvek
evaporate	vypařit
evaporation	vypařování, odpařování
evenly	rovnoměrně, pravidelně, ustáleně
extraction	extrakce
filtration	filtrace
float	plout, vznášet se
freezing	tuhnutí
gaseous state	skupenství plynné
gravitational field	gravitační pole
heterogenous	heterogenní
homogeneous, homogenous	homogenní
involve	zahrnovat
link	spojit
liquid state	skupenství kapalné
magnetic field	magnetické pole
mass percent	hmotnostní zlomek, procenta
matter	látka, hmota
melting	[redacted]ní, tání
mixture	směs látek
mol	látkové množství, mol
molecular relative mass	molekulová relativní hmotnost
molarity	látková (dříve molární) koncentrace
mole fraction	molární koncentrace
pure substance	chemicky čistá látka
saturated	nasycený
separation	dělení
solid state	skupenství pevné
solubility	rozpustnost
solute	rozpuštěná látka
solution	roztok
solvent	rozpouštědlo
stir (*pt., pp.* stirred)	zamíchat, rozmíchat
stock solution	zásobní roztok

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 Fe^{2+} and Fe^{3+}. 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:

Fe^{2+} iron(II)　　　Fe^{3+} 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 Fe^{3+} ion was referred to as ferric and the Fe^{2+} 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.

				H^-	hydride
N^{3-}	nitride	O^{2-}	oxide	F^-	fluoride
		S^{2-}	sulfide	Cl^-	chloride
		Se^{2-}	selenide	Br^-	bromide
		Te^{2-}	telluride	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_3COO^-	acetate						
MnO_4^-	permanganate						
CO_3^{2-}	carbonate	HCO_3^{2-}	hydrogen carbonate				
PO_4^{3-}	phosphate	HPO_4^{2-}	hydrogen phosphate	$H_2PO_4^-$	dihydrogen phosphate		
SO_4^{2-}	sulfate						
CrO_4^{2-}	chromate	$Cr_2O_7^{2-}$	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.

1. 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.
2. 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	
				ClO_4^-	*per*chlorate
NO_3^-	nitrate	SO_4^{2-}	sulfate	ClO_3^-	chlorate
NO_2^-	nitrite	SO_3^{2-}	sulfite	ClO_2^-	chlorite
				ClO^-	*hypo*chlorite

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.

1. **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.
2. **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*

To illustrate these rules, consider the names of the several oxides of nitrogen:

Example:

N_2O_5 dinitrogen pentaoxide	N_2O_4 dinitrogen tetraoxide
NO_2 nitrogen dioxide	N_2O_3 dinitrogen trioxide
NO nitrogen oxide	N_2O dinitrogen oxide

Greek Prefixes Used in Nomenclature

Number	Prefix	Number	Prefix	Number	Prefix
2	di	5	penta	8	octo
3	tri	6	hexa	9	nona
4	tetra	7	hepta	10	deca

Example:

SO_2	sulfur dioxide	PCl_3	phosphorus trichloride
SO_3	sulfur trioxide	Cl_2O_7	dichlorine heptaoxide

Many of the best-known binary compounds of the nonmetals have acquired common names. These are widely and, in some cases, exclusively used.

Example:

H_2O	water	PH_3	phosphine
H_2O_2	hydrogen peroxide	AsH_3	arsine
NH_3	ammonia	NO	nitric oxide
N_2H_4	hydrazine	N_2O	nitrous oxide
C_2H_2	acetylene	CH_4	methane

Acids

A few binary molecular compounds containing H atoms ionize in water to form H^+ ions. These are called **acids**. One such compound is hydrogen chloride, HCl; in water solution it exists as aqueous H^+ and Cl^- ions. The water solution of hydrogen chloride is given a special name; it is referred to as hydrochloric acid. A similar situation applies with HBr and HI:

Pure Substance	Water Solution	
HCl(g) hydrogen chloride	$H^+(aq)$, $Cl^-(aq)$	hydrochloric acid
HBr(g) hydrogen bromide	$H^+(aq)$, $Br^-(aq)$	hydrobromic acid
HI(g) hydrogen iodide	$H^+(aq)$, $I^-(aq)$	hydriodic acid

Most acids contain oxygen in addition to hydrogen atoms. Such species are referred to as **oxoacids**. Two oxoacids that you are likely to encounter in the general chemistry laboratory are:

HNO_3 nitric acid H_2SO_4 sulfuric acid

The names of oxoacids are simply related to those of the corresponding oxoanions. The *-ate* suffix of the anion is replaced by *-ic* in the acid. Similarly, the suffix *-ite* is replaced by the suffix *-ous*. The prefixes *per-* and *hypo-* found in the name of the anion are retained in the name of the acid.

Example:

ClO_4^-	perchlorate ion	$HClO_4$	perchloric acid
ClO_3^-	chlorate ion	$HClO_3$	chloric acid
ClO_2^-	chlorite ion	$HClO_2$	chlorous acid
ClO^-	hypochlorite ion	$HClO$	hypochlorous acid