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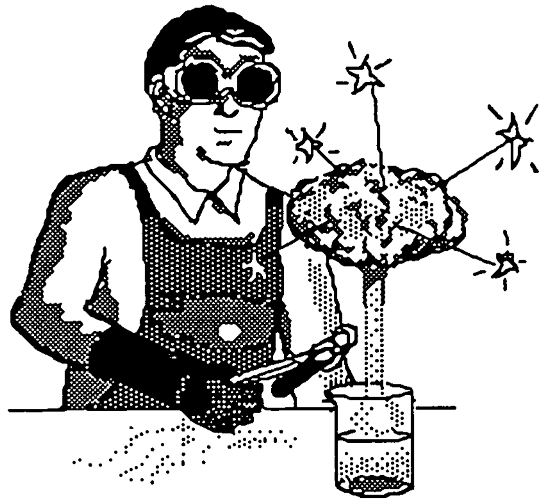
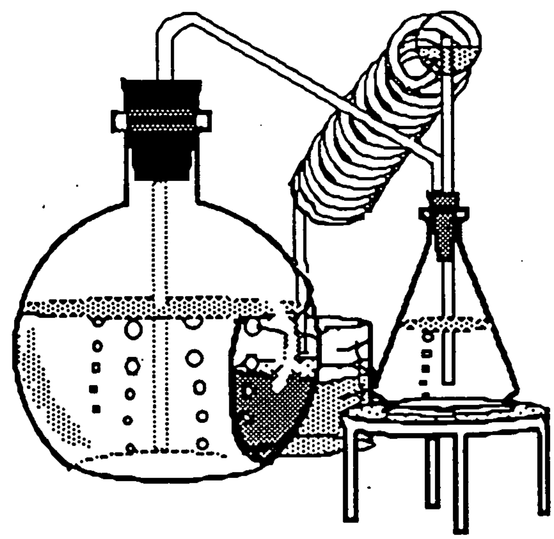
ABSTRACT

This manual is intended for use in presenting a course which provides the content-specific general chemistry education required for the safety awareness and job enhancement of persons employed as waste handlers. The course, which was designed to be delivered to technicians at job sites in a lecture/demonstration format with several hands-on exercises and video and laser disc presentations, is divided into sections on general chemistry and specific applications. Among the topics covered in the general chemistry section are atomic structure, chemical periodicity, and chemical nomenclature and formulas. Carcinogens, poisons, oxidizing/reducing agents, and compatibility determination are among the topics discussed in the section on specific applications. Included in the manual are instructional text and examples, worksheets, and quizzes. (MN)



GENERAL CHEMISTRY FOR WASTE HANDLERS



General Chemistry for Waste Handlers

Revised by Michael E. Sixtus, Mar Vista High School, Imperial Beach, CA

This course, as developed for and presented at Appropriate Technologies II, provided content-specific chemical education required for safety awareness and job enhancement.

The curriculum was tailored to meet the specific needs of the technicians at the job site while allowing the instructor sequence and present the materials according to his professional judgment.

The course was divided into two sections: general chemistry and specific applications. The general chemistry included such topics as atomic structure, chemical periodicity, chemical nomenclature and formulas. The specific application areas included carcinogens, poisons, oxidizing/reducing agents and compatibility determination. The method of presentation was lecture/demonstration, and included several hands-on exercises as well as video and laser disc presentations.

The course was developed in consultation with the Ap. Tech. management to ensure the completeness of the course, and was delivered on site to provide both an effective and accessible program for the technicians enrolled.

GENERAL CHEMISTRY FOR WASTE HANDLERS

Chemistry is the study of what substances are made of and how they react and combine. Chemicals make up all things that have mass; that is, everything that we recognize as matter.

Properties of Matter

General Properties of Matter

Properties are those characteristics that you use to describe something. Matter, which is what the world is made of, has some very specific properties:

Mass: the amount of matter in an object; this remains the same unless the object is changed somehow.

Weight: the response of matter to gravity; on Earth, this is the same as mass.

Volume: the amount of space an object takes up.

Density: mass per unit volume of an object (eg., pounds/cubic foot); this is a very important property in that it is specific for a given object/substance and can be used to tell the difference between substances. As a standard, water has a density of 1.0 (g/cm^3).

Specific Gravity: the comparison, or ratio, of the mass of a substance to the mass of an equal volume of water; the specific gravity of water is also 1.0. Specific gravity has **no** units.

These general properties of matter are physical properties, those that can be observed without changing the identity of the substance.

<u>Phases of Matter</u>

Matter can exist in four different phases, or states, in nature, of which three are very common; these phases are also used to classify matter:

Solids: have a definite shape and definite volume; the particles of matter are packed very closely and show very little movement, and so maintain their original shape

Liquids: have no definite shape but definite volume; the particles are close together but are free to move around, so they assume the shape of whatever container they are in.

Gases: have no definite shape or volume; the particles move around very freely and can spread out to fill whatever volume they are held in. Because of this ability, gases exert pressure on their container, and the pressure is affected by changes in outside conditions:

If the volume of the gas is reduced by a given factor, the pressure will increase by the same factor.

If the temperature of a gas is changed and the volume is kept constant, the pressure of the gas will change.

Plasma: a very high temperature, high energy form of matter found commonly in the sun and inside fusion reactors.

<u>Phase Changes</u>

Matter can change from one phase to another if it goes through a change in energy, mainly heat; as a substance is heated, it goes from solid to liquid to gas, as it is cooled it goes from gas to liquid to solid (under normal conditions). These phase changes are called melting, freezing, vaporization, condensation and sublimation.

Melting: solid to liquid; occurs at the temperature called the **melting point**, which is specific to each type of substance. Melting occurs when a substance absorbs energy.

Freezing: liquid to solid; occurs at the temperature called the **freezing point**, which is also specific to each type of substance. Freezing occurs when a substance loses energy.

Vaporization: liquid to gas; this can occur from the surface of a liquid and is called **evaporation**, and from inside the body of liquid and is called **boiling**. Both of these processes require absorption of energy; however, evaporation requires considerably less energy, and thus less of a temperature change, than does boiling.

Liquids show specific **boiling points** and they also have specific **vapor pressures**, which are related both to temperature and pressure. The vapor pressure of a liquid indicates the amount of the substance in vapor (gas) form at a specific temperature and pressure (usually room temperature, $70^{o}F$, and normal atmospheric pressure at sea level, 14.7 psi). Liquids with high vapor pressures are said to be **volatile**, which means they evaporate rapidly from an open container. Vapor pressure is affected by both the size (small molecules evaporate faster) and the polarity (non-polar molecules evaporate faster) of the liquid.

Condensation: gas to liquid; occurs with a loss of energy, or cooling.

Sublimation: solid to gas; this only occurs in certain substances that cannot exist in the liquid form at normal pressures, such as dry ice.

Classification of Matter

Classes of Matter

Chemists have set up a classification of matter based on the makeup of matter; the categories are elements, compounds, mixtures and solutions. Matter that is the same throughout is called **homogeneous**, matter that has parts with different properties is called **heterogeneous**.

Mixtures:

Mixtures: two or more substances that are mixed together but not combined chemically, a combination of homogeneous substances.

Substances in a mixture keep their separate identities and most/all of their properties; they may, however, change their physical appearance if one is dissolved in another.

Substances in a mixture can be present in any amounts, and can be separated by simple physical means, based on their respective physical properties.

Mixtures can be homogeneous or heterogeneous.

Solution: a homogeneous mixture in which one substance dissolves in another; particles in a solution are not large enough to be seen, and all parts of a solution are identical. Solutions are made up of two parts, **solvent** and **solute**.

A **solute** is the substance dissolved, a **solvent** is the substance doing the dissolving (solutions with water as the solvent are called aqueous solutions, when alcohol is the solvent they are called tinctures).

Most solutions cannot be separated easily by physical means.

Elements:

Homogeneous matter is also called a pure substance; the simplest pure substance, in which all particles are identical and cannot be separated into any simpler substance is called an **element**. The smallest particle of an element is called an **atom**; all atoms of a particular element are identical, while atoms of different elements are different.

Elements are represented by **chemical symbols**, a shorthand notation for the name of the particular element; these symbols can be combined to form chemical formulas, or names of chemical compounds.

Compounds:

Compound: pure substance made up of more than one element; they can be broken down into simpler substances, and their properties are different from those of the elements that make them up.

Molecule: two or more atoms chemically bonded together; most compounds are made up of molecules. A molecule is the smallest particle of a compound that has all of the properties of that compound.

Molecules are represented by chemical formulas, "words" written using chemical symbols that serve to indicate the numbers and kinks of atoms present in a molecule of a given substance. These formulas are then linked into chemical reactions, "sentences" that describe the interactions that occur between molecules resulting in new chemical substances.

Atomic Structure

Subatomic Particles:

All matter is made up of atoms, tiny particles of elements that have all of the properties of that element. Scientists over the years have determined the make-up of atoms; they are all made up of three basic subatomic particles (protons, neutrons and electrons) found in two different areas (the dense center, or nucleus, and a cloud-like area surrounding the center).

Electron: negatively charged particle with a relative mass of 0 found orbiting the nucleus.

Nucleus: center of the atom where all of the mass is concentrated; the protons and neutrons are found only in the nucleus.

Proton: a positively charged particle with a relative mass of 1

Neutron: a neutral particle with a relative mass of very slightly more than 1

All protons, neutrons and electrons are identical; the differences between elements are due to differences in the numbers of protons and neutrons. Since electrons are negative and protons are positive, in a normal atom the numbers of electrons and protons are equal because normal atoms are electrically neutral. The arrangement of electrons around the nucleus is in layers, or energy levels, which resemble the layers of an onion; each level holds a different specific number of electrons. Atoms can gain or lose electrons under certain circumstances, making them either positively or negatively charged particles called **ions**.

The number of protons in an atom determines what element it is; that number is called the **atomic number**.

All chemical reactions take place because of the movement of electrons in the outer cloud of the atom; only nuclear reactions (radioactivity, etc.) involve a change in the number of protons/neutrons.

Interactions of Matter

Given that there are only 92 naturally occurring elements, and millions of different substances and materials in our world around us, elements must combine in many different ways to form these different substances. This combination is called **chemical bonding**.

Chemical bonding takes place mainly through the transferring or sharing of electrons between atoms; atoms want to have or share 8 electrons in their outermost energy levels. When one atom loses an electron(s) to another atom which accepts the electrons, and both atoms wind up with 8 electrons in their outer shells, the **ions** that are formed are attracted together (unlike charges attract) and form an **ionic bond**. The easier an atom gains or loses electrons, the more reactive it is; this tendency can be seen in the periodic table.

Bonding in which electrons are shared between atoms to result in an outer level of 8 is called **covalent bonding**. There are certain ions that are made up of covalently bonded atoms that tend to stay together and act as if they were one atom; they are called **polyatomic ions**, and they will be very important in the writing of chemical formulas and chemical names.

It is possible to predict the type of bond that is likely to be formed between atoms. Compounds formed between atoms that lose electrons easily ant those that gain electrons easily will have ionic bonds; for example, a metal and a nonmetal will form ionic bonds. On the other hand, compounds formed between elements that have similar tendencies to gain electrons will have covalent bonds.

In order to predict this type of behavior, as well as other properties of elements, scientists use a chart called the periodic table.

Periodic Table: (see Appendix 1)

Chemists have organized the known elements (92 natural, currently 15 man-made) into a format called the Periodic Table according to various properties found in common between certain elements. This arrangement is very useful in determining reactive properties of elements and how they are likely to react with other elements. Elements in the first column (family) are called the alkali metals, and group (family) 7 elements are called the halogens.

The elements are arranged in vertical columns (called groups/families) and horizontal rows (called periods), all in order of increasing atomic number. Most of the elements in the periodic table are metals, with the properties of conductivity, malleability, ductility and lustre; they are concentrated on the left-hand side of the table. On the right-hand side are the nonmetals, which lack the metallic properties and are also seen at room temperature as gases and liquids. The dividing line between these two groups are the metalloids, which show combinations of both properties, such as silicon, germanium and arsenic.

The groups of elements share similar properties such as appearance, reactivity and electron structure. The periods of elements are not alike in properties, but there is a pattern going from right to left across the period; for example, each period begins with a very reactive metal and ends with a very inactive gas.

Certain periodic trends are shown while going left to right across the table; for example, elements get less metallic and more nonmetallic. This trend can be linked to the properties called **ionization potential** and **electron affinity**. In simple terms, elements on the far left of the table are very prone to lose electrons (becoming positive ions) and gradually become less and less so until they start to attract electrons instead; this explains the high reactivity of the groups 1 and 7 elements. This trend is also related to the **oxidation number**, which tells you how many electrons an atom wants to gain or lose when ionizing, and thus forming an ionic bond. This number will be very important when we discuss the writing of chemical formulas.

Writing Chemical Formulas/Naming Chemical Compounds (see Appendices 2 and 3)

Now that we know chemical symbols, the "alphabet" of chemistry, we must learn how to "spell" chemical "words". Elements and polyatomic ions all have their electrical charges (oxidation numbers) due to the loss or gain of electrons; that is, how many they would like to lose or gain. Since all chemical compounds or molecules are neutral, the total number of positive and negative charges must add up to 0; when this has been accomplished, you have a correctly written chemical formula. At the same time, you must learn how to read and/or write the correct names of molecules from chemical formulas. These rules apply only to inorganic compounds, especially the naming rules.

Writing Formulas:

Metals have positive oxidation numbers; however, some elements, especially the transition elements, have more than one, some even 4 or 5. It is difficult to keep track of them at first; that is why we use Appendix 2 to find out what they are. Elements that have more than one oxidation number are shown with roman numerals that indicate the particular positive oxidation number of that state of the element. For example, iron (Fe) can be 2+ and 3+, depending on the compound; it is written as Fe (II) or Fe (III).

In simple terms:

a. combining sodium and chlorine

$$\mathbf{Na^{+1} + Cl^{-1} = NaCl}$$

the +1 and -1 charges add up to 0, and so the formula is correct.

b. combining calcium and chlorine

$$\mathbf{Ca^{+2} + 2 \times Cl^{-1} = CaCl_2}$$

here calcium is +2 and thus need two chlorine -1's to add up to 0. The two chlorines are indicated by the **subscript** number 2.

c. combining lithium and nitrogen

$$3 \times Li^{+1} + N^{-3} = Li_3N \;;$$

here three lithium +1's are needed to balance the -3 of nitrogen and add up to 0.

d. combining copper (II) and chlorine

$$Cu^{2+} + 2 \times Cl^{-1} = CuCl_2$$

here copper is in its +2 form and thus two chlorine -1's are needed to add up to 0.

When compounds are made up of more than two elements there will usually be a polyatomic ion involved. The oxidation numbers are read from the table in appendix 2 and the ions are treated as if they were a single ion for balancing. However, if the subscript must be used, the polyatomic ion **must** be surrounded by parentheses and the subscript placed outside:

e. combining copper (II) and nitrate

$$Cu^{2+} + 2 \times NO_3^{-1} = Cu(NO_3)_2$$

where the nitrate ion, NO_3, has a -1 charge and thus two of them must be used to balance the Cu 2+.

Another difficulty arises when one of the charge values is not 1, and thus you must use the lowest common denominator; that is, the smallest number that both numbers can be evenly divided by. For example:

f. combining aluminum and sulfate

$$2 \times Al^{3+} + 3 \times SO_4^{2-} = Al_2(SO_4)_3$$

3 and 2 can each divide 6 evenly (2 x 3 = 6), and thus Al requires 2 and SO_4 requires 3 and all the charges add up to 0.

Naming Compounds:

We will refer to the flowchart and table (Appendix 3) to aid in the naming of compounds. At the top of the chart, **P** and **Q** refer to two elements or polyatomic ions; **x** and **y** refer to the subscripts of the two elements/ions, respectively. The first step identifies a class of compounds known as acids that have hydrogen, **H**, as their first element, and they have a separate style of names. Step two asks for the number of elements in **PQ**; if it is more than two you are dealing with a polyatomic ion and must refer to a table with the ions named, and if it is two elements the next steps make reference to the periodic table. You must first determine if **P** is a metal from its position on the table; then you must determine if it is group **A** or **B** from the group label at the top of the column where the element is found. If it is a group **A** metal then the naming is straightforward: the first element takes its regular name and the second element has the ending of its name changed to **-ide**. If it is a group **B** metal, then its oxidation number must be indicated by using a roman numeral in parentheses following its name.

For example, NaCl: the compound has two elements and the first is not H; the first element is sodium, a group **IA** metal, and the second element is chlorine, a group **VIIA** nonmetal; therefore, the name of the compound is sodium chlor-**ide**.

In the compound $FeCl_3$, we name it as follows: the compound has two elements and the first is not **H**; the first element is iron, a group **VIIIB** metal, and the second element is chlorine, a group **VIIA** nonmetal. Since iron is a **B**-group metal, we must indicate its oxidation number in the name of the compound by using a roman numeral after its element name; its oxidation number in this compound is +3, because it combines with 3 chlorine atoms, each with an oxidation number of -1, and so must be followed by (III). Its name is thus iron (III) chloride.

If the compound has more than two elements, therefore having a polyatomic ion involved, the naming is as above except that the negative ion takes the name of the polyatomic ion rather than changing the ending to **-ide**. For example, NaOH: the compound has more than two elements and the first is not **H**, therefore having a polyatomic ion; the first element is sodium, a group **IA** metal, and the remaining group, OH, is known as the hydroxide ion. Therefore, the name is sodium hydroxide. Another example is $CuNO_3$: the first element is copper, a group **IB** metal thus requiring a roman numeral, and the second group, NO_3, is known as the nitrate ion. As nitrate has a -1 oxidation number and the ratio of copper to nitrate is 1 to 1, copper must have an oxidation number of +1 in this compound; its name is copper (I) nitrate.

If a compound is made up of two elements and the first is not a metal, then the prefixes must be used to indicate the numbers of the two elements used in the formula. The prefixes are as follows:

mono	one
di	two
tri	three
tetra	four
penta	five
hexa	six
hepta	seven
octa	eight
nona	nine
deca	ten

If there is only one atom of the first element, mono is understood and is omitted; even if there is only one atom of the second element, a prefix is always used. The ending of the second element's name is still changed to **ide** as before, because the compound has only two elements. For example, in N_2O_3 there are two elements and the first, nitrogen, is a nonmetal; also, there are two atoms of nitrogen and three atoms of oxygen in the compound. Therefore, the name will be **di**-nitrogen **tri**-oxide.

Finally, in the basic naming of acids there are some unusual rules. First, inorganic acids have **H** as the first element; once the compound has been identified as an acid in this way, the **H** does not enter into the naming. If the compound has only two elements, the normal **-ide** ending is replaced by the prefix **hydro-**, the stem of the element's name, and the ending **-ic acid**. For example, in HCl the chlorine is changed to **hydro**-chlor-**ic acid**. If the compound has more than two elements, that is, it includes a polyatomic ion, then the ending of the ion's name is changed in the following manners: for the ending **-ite**, it is changed to **-ous acid** (eg., H_2SO_3 becomes sulfur-**ous acid** when the ion name is sulf-**ite**); if the ending is **-ate**, it is changed to **-ic acid** (eg., HNO_3 becomes nitr-**ic acid** when the ion name is nitr-**ate**).

Organic Chemistry

Organic compounds are primarily those that contain **carbon** atoms. However, not all carbon-containing compounds are organic. For example, carbonate compounds such as $CaCO_3$ and Na_2CO_3, as well as the oxides of carbon (CO and CO_2) are considered to be inorganic compounds. Therefore, a generic definition of organic compounds is:

Those compounds that contain carbon together with elements such as hydrogen, oxygen, nitrogen, sulfur, and the group VIIA elements.

Carbon is a unique element in that it can combine with itself; this allows carbon atoms to form all kinds of chain-like and ring-like molecules. In fact, there are over 10 million organic compounds known today, with more on the way. This unique ability requires the use of an additional type of formula that indicates the three-dimensional arrangement of the atoms as well as the number and types of the atoms present in the compound; this is known as a structural formula and can be used to show straight and branched-chain as well as ring (cyclic) arrangements of atoms. **Isomers** are molecules with the same molecular formula but different structural formulas.

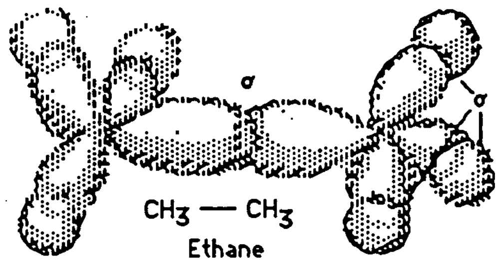
Carbon is a group IVA element, which means it has 4 electrons in its outermost shell and can thus form up to four covalent bonds with other carbon atoms or other elements. When carbon binds to another carbon atom, it can do so in three ways: a single bond, with one electron involved; a double bond, with two electrons; and a triple bond, with three electrons.

This combination of multiple bonds and structural possibilities is taken into account in the classification of organic compounds. Organic compounds have their names based on the largest number of carbons in a straight line (in the case of chain compounds) or the major ring structure (in ring compounds). The basic roots for one to ten carbons are: meth-, 1; eth-, 2; prop-, 3; but-, 4; pent-, 5; hex-, 6; hept-, 7; oct-, 8; non-, 9; and dec-, 10.

Classes of Organic Compounds

1. Alkanes.

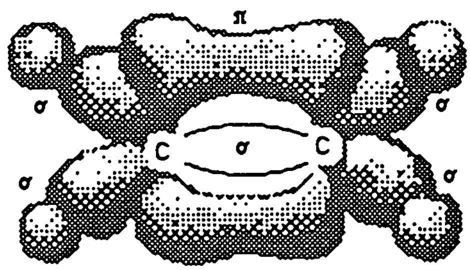
All **alkanes** are hydrocarbons, which means they are made up only of carbon and hydrogen, and the bonds between the carbon atoms are all single (when all carbon-carbon bonds are single, the compound is called **saturated**). The ending of the name is **-ane**. The simplest alkane is methane, followed by ethane, propane, etc. Once you get above three carbons, it is possible to form isomers;the first structure is the straight chain (the normal or *n*-isomer), and the following structures are branched chains.



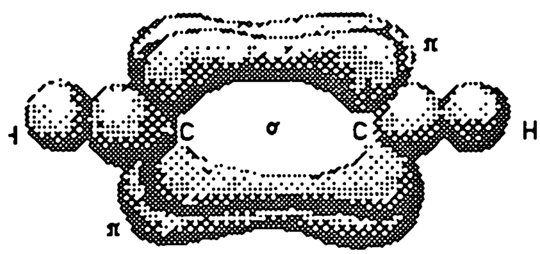
Alkanes are named on the basis of the longest continuous chain of carbon atoms (parent chain). Substituents or branch chains are attached to the main chain. The carbon atoms of the parent chain are numbered from the end that will give the lowest position numbers to the substituents. Alkanes can also be used as branches or substituents on hydrocarbon chains; they are called **radicals** and are named by substituting the ending **-yl** for the normal **-ane** ending and numbered according to their position(s) along the parent chain. If there are two or more substituent groups that are alike, numeric prefixes are used in the name. Examples are:

2. Alkenes and Alkynes.

The **alkenes** and **alkynes** are hydrocarbons, but they have double-bonded (alkenes) or triple-bonded (alkynes) carbons somewhere in the chain (these compounds are called **unsaturated**). Alkenes end in **-ene**; the simplest one is ethylene (ethene), which is used to make polyethylene. Alkynes end in **-yne**; the simplest one is acetylene (ethyne), which is currently used as a fuel.



$CH_2{=}CH_2$
Ethene (Ethylene)



$CH{\equiv}CH$
Ethyne (Acetylene)

The unsaturated hydrocarbons are named by indicating the position at which the multiple bond occurs; for example:

Positional naming systems also make reference to **cis**- and **trans**- structures: cis refers to the substituents being on the same side of the molecule and trans refers to them being on opposite sides.

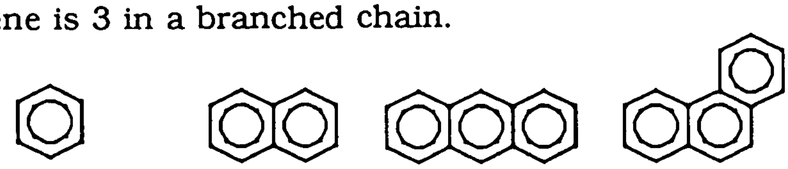
3. Cyclic Hydrocarbons.

These are mostly alkanes that form a closed chain; there are very few double/triple bonds in the cyclic hydrocarbons. They are named by adding the prefix **cyclo-** to the name of the hydrocarbon. For example, cyclopropane is an anesthetic, cyclohexane is a solvent, and cyclohexene is a stabilizer in high-octane gasoline.

All of these hydrocarbons are grouped together as **aliphatic** hydrocarbons.

4. Aromatic Hydrocarbons.

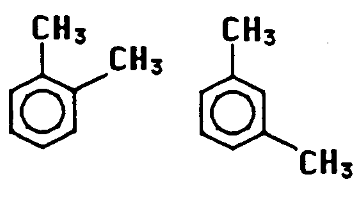
This is a series of cyclic hydrocarbons with alternating single and double bonds. They are called **aromatic** because the early ones smelled good; however, there are others that are very foul smelling. The basic compound in this series is benzene, which is the parent compound for a great number of organic molecules. Other aromatics are made of benzene rings joined together: naphthalene is 2, anthracene is 3 in a straight line, and phenanthrene is 3 in a branched chain.



Benzene Napthalene Anthracene Phenanthrene

Benzene rings can also have side chains attached to them: toluene (methylbenzene) is a major substituted benzene. Substituents on a benzene ring have their positions numbered starting with the 12 o'clock carbon being 1 and progressing clockwise around the structure; multiple ring aromatics are numbered to give the lowest substituent number starting from either the closest 12 or 6 o'clock position.

Older systems of naming positions on a benzene ring include the **ortho**-, **meta**- and **para**- prefixes. If position 1 is at 12 o'clock, ortho would be at #2 and/or #6 clockwise, meta would be at #3 and/or #5, and para would be at #4.



ortho-Xylene meta-Xylene para-Xylene

Benzene can also form a radical, with the loss of one H, and is called the **phenyl** radical.

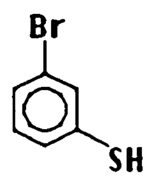
5. Functional Groups.

A functional group is what the **R** group (the basic hydrocarbon chain, also called an **alkyl** group) is attached to; it is the reactive part of the molecule.

The majority of the classes of organic compounds are based on specific functional groups.

A. Halogen Derivatives:

When a halogen (F, Cl, Br, I, At) is substituted for one or more hydrogen atoms in a hydrocarbon, you have a halogen derivative. These are named according to their position of substitution as before. Common aliphatic halogen derivatives are $CHCl_3$, trichloromethane or chloroform; CCl_4, tetrachloromethane or carbon tetrachloride; and 1,2-dichloroethane or ethylene dichloride.



3-Bromothiophenol

B. *Organic Oxygen Compounds:*

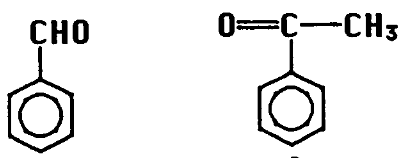
Alcohols and Ethers: The general formula for an **alcohol** is **R-OH** (the -OH being called the hydroxyl group in organic chemistry); the name is given by changing the **-e** of the alkane name to **-ol**. If the R group is short, the alcohol will be polar; if it is long, it will be nonpolar. Some major aliphatic alcohols are methanol (wood alcohol); ethanol (grain alcohol); 2-propanol (isopropanol, rubbing alcohol); 1,2,3-propanetriol (glycerine); 1,2-ethanediol (ethylene glycol); 2,6-di-tert-Butyl-4-methyl-1-phenol (butylated hydroxytoluene, BHT). Aromatic alcohols are based on an -OH attached to a benzene, called **phenol**.

phenol

The general formula for an **ether** is **R-O-R'**, where R and R' can be the same or different hydrocarbon chains. Ethers are named by inserting **-oxy-** between the prefix of the shorter R chain and the alkane name of the longer R chain.

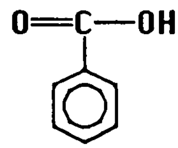
Aldehydes and Ketones: Aldehydes and ketones are characterized by the carbonyl group, which is an oxygen double-bonded to a carbon; aldehydes have the group at the end of the chain and ketones have it in the middle. The general formula for an **aldehyde** is **R-CO-H**; they are named by replacing **-e** with **-al**. The most common aldehyde is methanal, or formaldehyde.

The general formula for a **ketone** is **R-CO-R'**: they are named by replacing **-e** with **-one**. The most common ketone is propanone, or acetone.

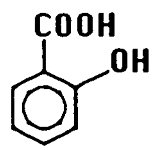


benzaldehyde   Acetophenone

Acids and Esters: Most organic acids are characterized by the carboxylic acid group, -COOH, and are weak acids. The general formula for an organic acid is **R-COOH**; they are named by replacing **-e** with **-oic acid**. A very common organic acid is ethanoic acid, or acetic acid. Just as with inorganic acids, it is possible to have anhydrides of organic acids; for example, **acetic anhydride** is made by removing a water molecule from two acetic acid molecules.



Benzoic acid

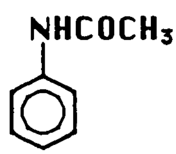


salicylic acid

Esters are made from an organic acid and an alcohol. The general formula for an ester is **R-CO-O-R'**; they are named by combining the radical name of the short R group with the alcohol name whose ending has been changed from **-ol** to **-oate**. Common esters are ethyl ethanoate (ethyl acetate) and ethenyl ethanoate (vinyl acetate).

C. *Organic Nitrogen Compounds:*

Amines: These are organic compounds in which a nitrogen is bound to alkyl groups and hydrogen atoms. They are derivatives of ammonia: if one hydrogen of ammonia is replaced by an alkyl group, the compound is a primary amine; if two are replaced it is a secondary amine, and if all three are replaced, it is a tertiary amine. The general formula for an **amine** is **R-NH$_2$**; they are named by adding -amine as a suffix as well as amino-substituted hydrocarbons. These compounds are not particularly fragrant; examples include putrescine and cadaverine (bad breath) and trimethylamine (rotting fish).

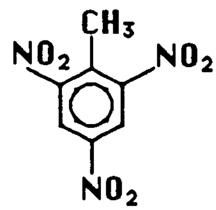


acetanilide

Amides: These are characterized by a carbonyl group and an amine group. An important amide is urea, used in fertilizers and plastics production.

Nitriles: These are characterized by a carbon-nitrogen triple bond. An important nitrile is propenenitrile (acrylonitrile), which is used in polymers.

Nitro compounds: These are characterized by the general formula **R-NO_2**; common examples are nitrobenzene and trinitrotoluene.



2,4,6-trinitrotoluene
(TNT)

ORGANIC WORKSHEET

1. An organic compound always contains a __________ atom.

2. An inorganic compound usually does not contain a ________ atom.

3. If a compound name ends in -ide, -ate, or -ite it is an __________ compound.

4. In organic compounds -ane means __________ bonds are present.

5. -ol means a compound is a _________.

6. An aromatic organic compound contains a ______________.

7. An aliphatic organic compound does not contain a ____________

8. If a compound has cis- or trans- in its name it is probably a ___________ organic compound.

9. If a compound has eth- in its name it is probably a ________ organic compound.

10. If a compound has para- in its name it is probably a ______ organic compound.

11. If a compound has chloro- in its name it could be either a __________ or a ____________ organic compound.

12. Sodium chloride is a _____________ compound.

13. Propanol is a __________ __________ compound.

Acids, Bases and pH

pH is a measure of the acid–base strength of the solution. The pH scale for water-based solutions runs from 0 to 14 with 7 being neutral. 0 to 2 is very acidic, 2 to 5 is moderately acidic, and 5 to7 is slightly acidic. 7 to 9 is slightly basic, 9 to 11 is moderately basic, and 11 to 14 is very basic.. The closer the ph is to 7, the weaker the acid or base. The farther the pH is from 7, the stronger the acid or base.

A straightforward definition of an **acid** is a compound that releases a hydrogen ion in solution and neutralizes bases. Usually this hydrogen ion is written first in an inorganic acid (HCl, HF). In an organic acid the hydrogen ion is usually written last (CH COOH). The inorganic, or mineral, acids are often stronger than the organic acids. Examples of the mineral acids are sulfuric acid (H_2SO_4), nitric acid (HNO_3), hydrochloric acid (HCl, also called muriatic acid), and hydrofluoric acid (HF); these usually have a pH of 0-2 in solution. Examples of organic acids are acetic acid, formic acid, and citric acid; these usually have pH's of 2-4. There are other compounds, called anhydrides, that form acids when they dissolve in water; examples are ferric chloride, ammonium bifluoride and aluminum chloride. The pH of an acid is dependent on several things including:

- **the nature of the acid**
- **the concentration of the acid**

Inorganic **bases** usually have the hydroxide polyatomic ion in them. The strong bases are often inorganic and usually have high pH's (12-14). For example, sodium hydroxide (NaOH) and potassium hydroxide (KOH) are strong bases. The weak bases are often organic compounds, usually amines. Methanolamine and triethanolamine are examples. There are also basic anhydrides, such as calcium oxide, that become basic after being dissolved in water. The pH of a base also depends on the nature of the base and the concentration of the base. **Caustic** is another name that is sometimes used to mean a compound that is basic.

Very strong acids and bases are very corrosive in addition to all the other health and safety problems that may also be present.

Some chemicals that are in their original containers may have Chem Alert labels on them. Attached is an explanation of these labels. Take special note of the following:

1. The large colored bar on the label: These will quickly indicate any special conditions needed for storage.

2. Safety code: This graphic shows special equipment needed for use.

3. NFPA code: These National Fire Protection Association ratings show the severity of the chemical's rating with respect to health hazard, fire hazard, reactivity, and special warnings.

COMMON ACIDS

INORGANIC

HF	hydrofluoric
HBr	hydrobromic
HI	hydroiodic
HCl	hydrochloric
HClO	hypochlorous
$HClO_2$	chlorous
$HClO_3$	perchloric
$HClO_4$	hyperchloric
H_2S	hydrosulfuric
H_2SO_3	sulfurous
H_2SO_4	sulfuric
HNO_2	nitrous
HNO_3	nitric
H_2CO_3	carbonic
H_3PO_3	phosphorous
H_3PO_4	phosphoric

ORGANIC

HCO_2H	formic
CH_3CO_2H	acetic
$CH_3CH_2CO_2H$	propionic
$C_6H_5CO_2H$	benzoic

also butyric, stearic, chloroacetic, etc.

ACIDS, BASES AND pH WORKSHEET

1. What does pH measure?

2. A pH = ______ is neutral.

3. pH = 4 is a ________.

4. pH = 10 is a ________.

5. One substance has a pH = 1. Another has a pH = 4. Which is the stronger acid?

6. One substance has a pH = 8. Another has a pH = 12. Which is the stronger base?

7. What is an acid?

8. What does the pH of an acid or a base depend on?

9. An inorganic base has the name _______ in it.

10. An organic base is an _______.

11. Another name that is sometimes used for a base is ________.

Corrosives

Corrosives are chemicals that react with and break down other materials; some can eat away (**oxidize**) metals, while others can cause severe injury to living tissue resulting in the killing of body cells. From an occupational safety and health point of view, the definition results from its effects on living tissue rather than metal plates. According to an OSHA standard corrosives are compounds that cause "visible destruction of, or irreversible alterations, in living tissue by chemical action at the site of contact" during a 4-hour test period.

A name or structure alone is insufficient to identify a substance as a corrosive, since "corrosive" refers to the action of the chemical. For example, strong acids are corrosives but not all acids are corrosives. Boric acid, for example, is an eye wash. Information on whether a compound is a corrosive or not is based on experimental evidence and will be found on the MSDS for the substance.

The degree of danger posed by a compound depends on its reactivity; i.e, how fast and how vigorously the compound reacts with other compounds. The amount of damage that results depends on

- **reactivity**
- **concentration of the chemical**
- **length of exposure**

It should be noted that some "corrosives" can pose multiple threats; some pose inhalation risks while others are readily absorbed through the skin and can cause poisoning. Corrosives are especially reactive chemicals and they can react with other chemicals to result in a worsened hazard situation. Others are not only corrosives but also flammable liquids or oxidizing materials; for example, chlorine gas and nitric acid. Information on these added dangers should be obtained from a MSDS.

Because corrosives are so reactive, it is often necessary to take special measures in designing containers for them; otherwise they may eat through the container. They should be stored away from materials with which they could react violently. An acid that may decompose in contact with water will probably react even more violently with a strong alkali.

In case of an spill emergency, generally recommended actions usually include flooding the involved area with large quantities of water. Too little water can worsen the situation by leading to strong local heating or spattering. Particular circumstances may require changes in these procedures. Some substances react dangerously with water. Remember these are reactive substances that can react with other chemicals and may release toxic vapors or cause fires and explosions (check for compatibility). Quick action is a must, because the longer the contact, the greater the damage.

EXAMPLES

EXTREMELY DANGEROUS: (a) these will cause skin destruction in test animals in less than 3 minutes or (b) cause skin destruction in between 3 and 60 minutes but are particularly dangerous because the vapor is toxic.

bromine
chromosulfuric acid
nitric acid

MEDIUM DANGER: will cause skin destruction in from 3 to 60 minutes but have no particular additional hazard.

acetic acid
formic acid
fumaryl chloride

MINOR DAMAGE: still cause skin destruction in a 4-hour test.

crotonic acid
triethylenediamine
phosphoric acid

CORROSIVES WORKSHEET

1. ______________ are substances that react vigorously to destroy other materials.

2. Corrosives can cause severe injury to living tissue resulting in:

3. T/F All acids are corrosives.

4. Information on whether a compound is a corrosive will be found on:

5. The amount of damage caused by a corrosive depends on
   (a)

   (b)

   (c)

6. T/F Corrosives pose no other dangers.

7. Corrosives are reactive chemicals and they can react with other chemicals to result in a ____________ hazard situation.

8. Corrosives may __________ their containers.

9. Corrosives should be stored away from __________________.

10. In case of an emergency, general recommended actions include flooding with ______________________________.

11. Too little water may lead to _____________ or_______________.

12. T/F Always flood spilled corrosives with water.

13. Why is quick action necessary?

Oxidizers

Oxidation is the reaction of a material with oxygen. Oxygen can come from the air which contains 20% oxygen. Common oxidation reactions are respiration, burning, and rusting (a slow process). The rate that oxidation occurs depends on the concentration of oxygen present and temperature. Oxygen in air is diluted with the 80% nitrogen so that the rate of oxidation is much less than in pure oxygen.

In the past, oxidation was defined as the combination of a substance with oxygen. For example, glucose (sugar) in our cells reacts with oxygen to produce carbon dioxide and water in the reaction:

$$C_6H_{12}O_6 + 6\ O_2 \dashrightarrow 6\ CO_2 + 6\ H_2O.$$

Another example is the rusting of an iron pipe, in which the reaction is:

$$4\ Fe + 3\ O_2 \dashrightarrow 2\ Fe_2O_3$$

However, even though this is a useful definition, the concept of oxidation has been expanded to include reactions where oxygen is not involved. As presently defined,

Oxidation is the transfer of electrons between species or the loss of electrons by an atom undergoing a chemical reaction. It is the change in oxidation number of an atom from a lower to a higher value.

In the reaction between iron and oxygen, for example, the oxidation number of iron changes from 0 to +3, because each iron atom gives up three electrons in the reaction. Iron starts out with an oxidation number of 0 because an element in its uncombined state is defined as having an oxidation number of 0. By our definition, this means that iron is oxidized, but what happens to the oxygen? We say that the oxygen is reduced.

Reduction is the transfer of electrons between species or the gain of electrons by an atom undergoing a chemical reaction. It is the change in oxidation number of an atom from a higher to a lower value.

In this reaction, the oxidation number of oxygen changes from 0 to -2, because each oxygen atom gains two electrons from the iron. In the overall reaction, the iron is oxidized and the oxygen is reduced; the two go hand in hand, because you cannot have oxidation without reduction and vice versa.

Oxidizers (oxidizing agents) are substances that cause other substances to be oxidized; Reducing agents are substances that cause other substances to be reduced. You are probably familiar with several oxidizing and reducing agents. Calcium hypochlorite, $Ca(OCl)_2$, is used as an oxidizing agent in bleach and as a swimming pool disinfectant; Sodium hypochlorite, NaOCl, is commonly found in household laundry bleach; Hydrogen peroxide, H_2O_2, serves as an antiseptic and disinfectant. Hydrogen is a common reducing agent in many reactions.

Many oxidizing agents release oxygen when they react, in the process providing a self-contained source of energy to fuel a reaction. Oxidizers are very reactive compounds; the types of reactions that occur depend on the other reactants that they come into contact with and the reaction conditions. When combining with combustible materials, oxidizers will burn fiercely. In contact with other substances spontaneous combustion may occur; that is, a slow oxidation reaction will cause heat to build up and ultimately result in combustion. With other substances, explosive mixtures may form that may be sensitive to friction. Finally, with extremely reactive substances, oxidizers may cause immediate combustion or explosion. It is likely that a lot of heat in all these reactions and perhaps toxic gases will be released.

Oxidizers as a class are not defined as a health hazard. They are more of a safety hazard, with the danger coming from fire and explosion from the compound itself in reaction with another material. Because of the high reactivity of oxidizers, it is important to make sure that containers will not leak and that they are stored away from materials with which they could react violently - which are almost anything.

INORGANIC EXAMPLES:

nitrates, nitrites, chlorates, chlorites, hypochlorites, peroxides, perchlorates, permanganates

ammonium nitrate
sodium chlorate
hydrogen peroxide
calcium perchlorate
potassium permanganate

ORGANIC EXAMPLES:

organic peroxides: They can react explosively when involved in a fire; they can also form highly unstable, explosive crystals as they get older. Transportation hazard label will say: "organic peroxides".

acetyl peroxide
benzoyl peroxide
tert-butyl peroxyacetate

OXIDIZERS WORKSHEET

1. Oxidation is a reaction of a material with ____________.

2. Oxygen can come from the _________.

3. A common oxidation reaction is _________________.

4. The rate of an oxidation reaction depends on ______________ and _____________.

5. Chemicals that release oxygen when they react are called ______________.

6. ____________ provide a self-contained source of energy to fuel a reaction.

7. An example of an oxidizer that contains no oxygen is _______

8. The kinds of reactions that occur with oxidizers depend on ________________ and ______________.

9. Oxidizers may burn fiercely when combined with ______________

10. A slow oxidation reaction which causes heat to build up and ultimately results in combustion is called _________________

11. Explosive mixtures may form that may be sensitive to _______

12. With extremely reactive substances, oxidizers may cause immediate _____________ or _____________.

13. Reactions with oxidizers may result in a lot of ___________ and perhaps _____________.

14. Oxidizers are not defined as a _________ hazard, but as a __________ hazard.

15. Because of the high reactivity of oxidizers it is important to make sure that the containers do not ______.

16. Oxidizers should not be stored near _______.

17. An example of a class of inorganic oxidizer is ____________

18. A specific example of an inorganic oxidizer is ____________

19. An example of a class of organic oxidizer is ______________

20. A specific example of an inorganic oxidizer is ____________

Solvents

A **solvent** is defined as a liquid capable of dissolving other materials (solids, liquids or gases) to form a solution. The solvent is generally the major component of the solution. Solvents can be divided into classes, the most important being **polar** and **nonpolar**. A polar molecule is one in which the individual chemical bonds are not symmetrically arranged and therefore are not "in balance". Thus, the charge separation in the bonds gives rise to an overall charge separation in the molecule. Nonpolar molecules are those in which the chemical bonds are symmetrically arranged and thus there is no charge separation in the molecule. Typically, polar solvents will dissolve polar and ionic substances such as sodium chloride or potassium nitrate; the most common polar solvent is water. Nonpolar solvents, on the other hand, are used to dissolve nonpolar and organic substances such as iodine and paraffin; common nonpolar solvents are benzene and carbon tetrachloride.

Solvents, although divided into two major classes, are considered together because of their common characteristics in handling, use, and storage. Solvents are used to dissolve other materials; they could be cleaning fluids or degreasers. Solvents are used in chemical processing because more controlled behavior is obtained with chemicals uniformly present in solution. Many different solvents are used depending on the reaction conditions required.

Many organic (nonpolar) solvents are flammable liquids; thus they present more of a safety hazard than a health hazard. However, any type of health hazard may be present - solvents may be toxic, corrosive, or an irritant. Information on these hazards should be on a MSDS for the substance.

Flammability is measured by a **flashpoint** test. The flashpoint is the lowest temperature at which the vapor of a combustible liquid can be made to ignite. Therefore the lower the flashpoint the greater the danger of fire. The Department of Transportation classifies a "flammable liquid" as those having a flashpoint below 100°F and a "combustible liquid" as those having a flashpoint greater than/equal to100°F but less than 200°F. If a liquid has a flashpoint greater than 200°F it can still burn. Be careful not to use nonflammable or noncombustible solvents on vehicles. According to the EPA and the DHS an ignitable liquid in one with a flashpoint less than 140°F. Thus the same liquid can have different classifications depending on who is handling it.

The flashpoint is not the only measure of the level of hazard. Some substances may evaporate to form a combustible atmosphere so that the hazard is higher. Substances with high viscosity do not flow easily so the hazard is lower.

Solvents should be handled with adequate ventilation because almost all organic solvents, if inhaled, will have an anesthetic effect, leading to sleepiness. Skin exposure should be avoided. Solvents can remove protective oils from the skin and some can even penetrate the skin. Some solvents can even cause damage to internal organs(particularly the liver and blood forming organs).

The principle danger from organic solvents is the fire hazard. Vapors form combustible and explosive atmospheres. Precautions should be taken against electrical sparks or other accidental source of ignition; grounding of containers while pouring "ignitables" is recommended.

The storage area for solvents should be constructed to be fireproof or to contain a fire. Solvents should be stored separately from substances that could react with them, especially oxidizers.

EXAMPLES

Great Danger; flashpoint below 0°F

acetone
diethyl ether
tetrahydrofuran

Medium Danger; flashpoint between 0°F and 73°F

benzene
ethanol
methanol

Minor Danger; flashpoint between 73°F and 141°F

bromobenzene
hydrazine
turpentine

Toxic Solvents

chloroform
carbon tetrachloride
tetrachloroethylene

Corrosive Solvents

acetic acid
ethanolamine
benzyl bromide
methylene chloride

SOLVENT WORKSHEET

1. T/F Solvents are a single class of compounds.

2. Solvents are similar to each other in the ways in which they are ___________, ___________, and __________________________.

3. Solvents are used to ____________________.

4. One very important solvent for inorganic compounds is _____.

5. _________ liquids are also used as solvents.

6. Many solvents are ___________ liquids.

7. Solvents present more of a _________ hazard than a _________ hazard.

8. T/F With solvents there are no health hazards.

9. Solvents may be _________, _____________ or an _________.

10. Flammability is measured by a _________________________.

11. The ____________ is measured by a flashpoint test.

12. The flashpoint is the lowest temperature at which the vapor of a combustible liquid can ______________________.

13. According to the DOT a _______________ liquid is one that has a flashpoint below 100°F.

14. According to the DOT a ___________ liquid is one that has a flashpoint between ________ and ___________.

15. Solvents should be handled with adequate _____________.

16. Organic solvents, if inhaled, can lead to _______________.

17. Some solvents can cause damage to ______________.

18. The principle danger from organic solvents is _________.

19. With solvents precautions should be taken against _________.

20. Solvents should not be stored near _________.

Carcinogens

Carcinogens are substances that cause cancer. In cancer, modified body cells start reproducing and continue to do so out of control. This leads to tumor formation.

It had long been known that exposure to some substances is related to the development of cancer. With regard to dose levels and the duration of exposure, the range of effects seem to be broad. Some authorities hold that there is no safe exposure level and this conservative view is certainly the safest one to take. From an occupational and health point of view the definition of carcinogen results from its effects in animal testing. Specific exposure tests have been prescribed to be performed on test animals. The tests take about 2 years to run and analyze, so they are expensive and information does not accumulate rapidly. There is an argument about the applicability of test data obtained with animals to humans.

According to OSHA, a chemical is considered to be a carcinogen if it has been:

1. Evaluated by the International Agency for Research on Cancer and found to be a carcinogen or potential carcinogen.
2. Listed in the "Annual Report on Carcinogens" published by the National Toxicology Program as a carcinogen or potential carcinogen.
3. Regulated by OSHA as a carcinogen. OSHA specifically regulates the 18 substances listed in the examples. According to OSHA information on whether the compound is a carcinogen must be included in the MSDS for that substance.

The problem of cancer initiation is extremely complex. Not only are the causes uncertain and possibly a combination of factors, including individual susceptibility, but the effects are not immediate. Some cancers may not become active for many years so that it is difficult to trace back from the effect to the cause. Further complications arise because of the existence of promoters. These are substances which are not themselves carcinogenic but which allow other substances to have a carcinogenic effect.

A very stringent mandatory system of controls had been established for regulated substances. Some of the provisions are:

1. Establishment of a controlled area where carcinogens are processed, used, handled, or stored.
2. Access by authorized employees only.
3. Use of closed vessel operations.
4. Requirements that employees wash hands, forearms, face, and neck on each exit from the area.
5. Requirement that employees shower after the last exit of the day.
6. No drinking fountains in the controlled area.
7. No food, beverages, cosmetics, smoking materials, or chewing gum in the controlled area.
8. Maintenance or reduced air pressure in controlled areas, so that air flow is always in.
9. Prohibition of dry sweeping or mopping in the area.
10. Use of proper labels and warning placards.
11. Establishment of proper training programs.

Although the measures are required by rule only for regulated substances, they form a comprehensive safety program that could be applied to advantage for any cancer-suspect material. This program is based on elimination of contact with the material. Further measures may be required; for instance, the use of protective clothing and equipment may be required. Carcinogens should be stored away from other materials and access to them should be strictly controlled.

SUBSTANCES CLASSIFIED BY OSHA AS CARCINOGENS

2-acetylaminofluorene
acrylonitrile
4-aminodiphenyl
arsenic, inorganic
benzidine
bis-chloromethyl ether
coke oven emissions
1,2-dibromo-3-chloropropane
3,3'-dichlorobenzidine
4-dimethylaminoazobenzene
ethyleneimine
methyl chloromethyl ether
alpha-naphthylamine
beta-naphthylamine
4-nitrobiphenyl
N-nitrosodimethylamine
beta-propiolactone
vinyl chloride

CARCINOGENS WORKSHEET

1. A _______________ is a substance that causes cancer.

2. Cancer leads to _______________.

3. ______________________________ is related to development of cancer.

4. The safest view to take is that ______ exposure to carcinogens is safe.

5. T/F It is easy and fast to test a chemical to see if it is a carcinogen.

6. The problem of cancer initiation is _____________.

7. The causes of cancer are _______________.

8. T/F A person will get cancer as soon as he is exposed to a carcinogen.

9. T/F Any cancer-suspect material should be handled as carefully as a carcinogen.

10. The mandatory system of controls is based on _____________.

11. Carcinogens should be stored _______________.

Poisons

Poisons are substances that can cause death or serious injury if they are swallowed, inhaled, or come in contact with the skin. Different poisons may act very differently. Poisons interfere with the proper functioning of the body. For example they might affect oxygen distribution in the bloodstream or block nerve impulses. From OSHA's point of view the definition of a toxic substance results from its effect on test animals. Substances may be listed as either toxic or highly toxic depending on how lethal they are.

Toxicology

Toxicity in humans is determined by the interaction of several factors such as Dose, the Inherent Toxicity of the Chemical, the Route of Exposure, and Pharmacokinetics. The dose is the quantity of bioactive substance received by an organism from its environment, and the magnitude of the response of an organism is proportional to the magnitude of the dose; the Dose–Response relationship. The most common toxicological measurement of this relationship is the **LD_{50}** (lethal dose 50), the dose at which half of a given test population, most often mice or rats, will be killed. Other measurements of the dose–response relationship are: **NOEL**, no observed effect level; **TD_{50}**, median toxic dose; **NOAEL**, no observed adverse effect level; **LC_{50}**, lethal concentration 50; **TD_{lo}**, the lowest toxic dose; and **ED_{50}**, median pharmacologically effective dose.

The inherent toxicity of the compound is based upon its chemical and physical properties, its interactions with other chemicals, any sort of environmental transformation that might occur, and any particular specificity exhibited by the chemical. The route of exposure involves the route of entry and absorption of the chemical, which can include dermal, inhalation and ingestion exposures. Finally, pharmacokinetics refers to the action of chemicals in the body over a period of time, including the processes of absorption, distribution, localization in tissues, biotransformation, and excretion.

There are several types of effects to poisons that have been categorized: **Acute**, rapid onset and relatively rapid recovery, occurring after a single exposure or multiple exposures in a short period of time (eg., Cyanide); **Chronic**, delayed onset or following multiple exposures over time (eg., arsenic); **Subclinical**, not revealed by signs or symptoms (eg., lead). Tolerance to various poisons can develop over time and/or repeated low exposures to the substance. Also, some people may demonstrate idiosyncratic responses, abnormal reactivities in the form of extreme sensitivities to low doses or insensitivity to high doses.

Irritants and Sensitizers

Other classes of substances that are defined as health hazards are **irritants** and **sensitizers**. According to OSHA irritants are chemicals that are not corrosive but cause a reversible inflammatory effect on the skin. Eye irritants are included. Note that this definition of an irritant is different from the shipping regulations of the Department of Transportation. According to the DOT an irritant is defined as a substance that in contact with fire or air gives off dangerous or intensely irritating fumes. Because this is a more severe hazard care should be taken to distinguish between shipping labels and health effects labels. Sensitizers are chemicals that cause a large proportion of exposed people to develop an allergic reaction after repeated exposure.

Symptoms of poisoning have a wide range - convulsions to cessation of breathing to no noticeable symptoms. It is possible for a poison to enter the system with no noticeable effect and then result in symptoms at a later time.

Safe handling of toxic materials clearly should be based on no contact whenever possible. Because of the personal threat of poisons it is important that poisons are in containers that do not leak and are stored away from materials that could attack the containers and release the chemicals.

Planning for an emergency should be carried out before the emergency occurs. General recommendations include removal of the source of contamination and diluting or neutralizing the contamination. Get the victim to a source of fresh air. Rinse spills on the skin with large quantities of water (Know the location of the safety shower and eyewash!) Quick action is essential, because the longer the contact the greater the damage. Proper emergency response procedures should be given on the MSDS.

EXAMPLES

HIGHLY TOXIC SUBSTANCES

hydrocyanic acid
lead tetraethyl
phenyl mercaptan

TOXIC SUBSTANCES

aniline
chloral
phenol

SMALL HAZARDS

resorcinol
bromoform
dichlorobenzenes

TOXIC GASES WHICH POSE AN INHALATION HAZARD

ammonia, anhydrous
chlorine
sulfur dioxide

Remember the above information is based only on toxicity data. When a compound is handled, other factors such as flammability must be considered. All this information should be found on the Material Safety Data Sheet for the chemical.

POISON WORKSHEET

1. __________ can cause death or serious injury.

2. Poisons are dangerous if they are ____________, __________, or come in contact with the skin.

3. Poisons interfere with ______________________________.

4. ___________ are chemicals that cause a reversible inflammatory effect on the skin.

5. The DOT defines an ______________ as a substance that in contact with fire or air gives off dangerous or intensely irritating fumes.

6. ____________ are chemicals that cause a large proportion of exposed people to develop an allergic reaction after repeated exposure.

7. The amount of danger from a poison depends on:
   (a)
   (b)
   (c)
   (d)

8. T/F Poisons can act immediately.

9. T/F Poisons can take days to react.

10. T/F When someone is poisoned he will always appear very sick.

11. T/F If at all possible poisons should not come into contact with a person.

12. Poisons should be stored in containers that do not _______.

13. Poisons should be stored away from materials that could ------------------------------------.

14. You should plan for an emergency ____________________.

15. A poisoning victim needs a source of ______ air.

16. The safety shower is located ____________________.

17. The eyewash is located ______________________.

18. __________ action is necessary in case of poisoning.

19. Proper emergency procedures should be given on the --------.

ORGANIC QUIZ

1. T/F Inorganic compounds always contain a carbon atom.

2. T/F If a compound ends in -ate it is an inorganic compound.

3. T/F If a compound ends in -ene it is an organic compound.

4. T/F An aliphatic compound's name may end in -ol.

5. T/F An aromatic compound's name may end in -ol.

6. An aromatic compound always contains a ________________.

7. T/F Cis- is usually found in an aromatic compound.

8. T/F Meth- is usually found in an aliphatic compound.

9. T/F Meta- is usually found in an aromatic compound.

10. T/F Chloro- is found only in aliphatic compounds.

ACIDS, BASES AND pH QUIZ

1. ________ is a measure of the strength of an acid or base.

2. pH = 7 is ____________.

3. pH = 0 to pH = 7 is a __________.

4. pH = 7 to pH = 14 is a __________.

5. List the pH of a strong acid._______

6. List the pH of a weak base. ________

7. An acid releases a _____________ ion.

8. What does the pH of an acid or a base depend on?

9. An inorganic base contains the name ___________.

CORROSIVES QUIZ

1. What is a corrosive?

2. T/F All acids are corrosives.

3. The amount of damage caused by a corrosive depends on:
   (a)

   (b)

   (c)

4. Corrosives pose other dangers. One of these is ___________.

5. Corrosives may _____________ their containers.

6. In case of an emergency, general recommended actions include:
   --.

7. T/F Always flood spilled corrosives with water.

8. Why is quick action necessary?

OXIDIZERS QUIZ

1. What is oxidation?

2. A common oxidation reaction is ___________________.

3. What are oxidizers?

4. T/F Oxidizers provide a self-contained source of energy to fuel a reaction.

5. Oxidizers may burn fiercely when combined with ______________

6. What is spontaneous combustion?

7. T/F Oxidizers can cause an explosion with extremely reactive substances.

8. T/F Oxidizers are always a health hazard.

9. Oxidizers should not be stored near ____________.

10. Give several examples of oxidizers.

SOLVENTS QUIZ

1. Solvents are used to ________________________________.

2. One very important solvent for inorganic compounds is ______.

3. ___________ liquids are also used as solvents.

4. T/F Many solvents are flammable liquids.

5. T/F Solvents are never organic liquids.

6. T/F With solvents there are no health hazards.

7. What is a flashpoint?

8. With DOT standards a flammable liquid has a flashpoint below __________.

9. With DOT standards a combustible liquid has a flashpoint between _______ and _______.

10. Solvents should be handled with adequate ______________.

11. Organic solvents, if inhaled, can lead to _____________.

12. The principle danger from organic solvents is _________.

13. Solvents should not be stored near ________.

CARCINOGENS QUIZ

1. What is a carcinogen?

2. Tumors are caused by _______________.

3. The safest view to take is that _____ exposure to carcinogens is safe.

4. The problem of cancer initiation is _______________.

5. T/F The causes of cancer are well known.

6. T/F A person will get cancer as soon as he is exposed to a carcinogen.

7. T/F Any cancer suspect material should be handled as carefully as a carcinogen.

8. The mandatory system of controls is based on _____________.

POISON QUIZ

1. What is a poison?

2. Three ways a person can be effected by a poison are
   (a)

   (b)

   (c)

3. ______________ are chemicals that cause a reversible inflammatory effect on the skin.

4. _____________ are chemicals that cause a large proportion of exposed people to develop an allergic reaction after repeated exposure.

5. The amount of danger from a poison depends on:
   (a)

   (b)

   (c)

   (d)

6. T/F Poisons can either act immediately or take days to react.

7. Poisons should be stored in containers that do not _______.

8. Where are the safety shower and eyewash?

9. __________ action is necessary in case of poisoning.

NOTICE

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