III. Ward's Science Chemicals

Ward's Science provides various grades of chemicals for use by chemistry teachers. Chemicals are graded based on various industry standards to identify quality and/or purpose of use. Selection of a chemical is based on the intended use of the chemical. Typical Secondary Chemistry chemicals are reagent or lab grades.

The following organizations have set grading systems that are recognized industry standards for classification of chemical purities:

A.C.S - The American Chemical Society Committee
F.C.C - Food Chemical Codex
N.F. - National Formulary
U.S.P. - US Pharmacopeia

Chemical Grades

Chemical grades of purity have been adapted to indicate a chemical's quality and primary uses. The grades listed below, in order of purity (with •••• being the purest, and • being least pure), are available through Ward's Science. The higher the purity, the higher the relative cost of the chemical.

Purity/Grade

••• **ACS** are chemicals that meet the requirements of the American Chemical Society Committee on Analytical Reagents.

••• **Reagent Analyzed or Reagent Grade** are chemicals of an analytical grade acceptable for all general laboratory use, certified to have impurities below specific levels set by the Committee on Analytical Reagents of the American Chemical Society. Analytical methods used for these determinations are based on standard chemical industry test procedures.

•• **Lab Grade** are chemicals meeting a minimum purity standard suitable for histology methods, general laboratory applications, and demonstrations that do not require qualitative results.

Acids and Bases

Ward's Science provides a full line of acids and bases for laboratory use. Getting a better understanding of what an acid and a base is, and how they work, will give you a better understanding of what acids you should use in your classroom.

Acids

Acids are solutions that donate protons and have a pH less than 7 in a water solution. The lower the pH, the stronger the acidity and corrosiveness. The word acid comes from the Latin word *acere*, which means "sour." All acids taste sour. Well known acids include vinegar (5% acetic acid), lactic acid (in buttermilk), citric acid (from certain fruits and vegetables, notably citrus fruits), ascorbic acid (vitamin C, as from certain fruits) and carbonic acid (for carbonation of soft drinks). Aspirin (acetosalicylic acid) tastes sour if you don't swallow it fast enough.[1]

Properties of Acids

- Acids change litmus (a blue vegetable dye) from blue to red.
- Their aqueous (water) solutions conduct electric current (are electrolytes).
- React with bases to form salts and water.

[1] Source – The ChemTeam

- Acids neutralize the chemical properties of bases.
- Evolve hydrogen gas (H_2) upon reaction with an active metal (such as alkali metals, alkaline earth metals, zinc, aluminum).

Strong Acids

Strong acids react completely with water, leaving no undissociated molecules in solution. As solutions become more concentrated, dissociation progresses toward 100%. Typically, once the acid is 100% dissociated in solutions of 1.0-molar or less, it is called strong. The most common strong acid used by chemistry teachers is hydrochloric acid (HCl).

Strong acids include the following:

HCl	Hydrochloric acid
HNO_3	Nitric acid
H_2SO_4	Sulfuric acid
HBr	Hydrobromic acid
HI	Hydroiodic acid
$HClO_4$	Perchloric acid
H_3PO_4	Phosphoic acid

Weak Acids

With the exception of those listed above, nearly all other acids are weak.

Bases

Bases are solutions that can accept protons. Basic solutions have a pH greater than 7. Concentrated bases (alkalis) are more corrosive to tissue than most concentrated inorganic acids and dissolve the fatty acids and oils in your skin. They feel slippery or soapy to the touch and are actually a primary ingredient in the production of soap. Some bases, such as lye (NaOH) and household ammonia (aqueous), are detergents. All bases taste bitter, and many foods and medicines are bases, including mustard and cough syrup.

Properties of Bases

- They don't change the color of untreated litmus, but can turn red (acidified) litmus back to blue.
- They neutralize the chemical properties of acids.
- Their aqueous (water) solutions conduct and electric current (are electrolytes).
- They react with acids to form salts and water

Strong Bases

Strong bases dissociate almost completely in water. In aqueous solution, they are the only significant source of OH^-. The most common soluble strong bases are the hydroxides of group 1A (the *alkali metals*) and group 2A (the *alkaline earth metals*).

Strong bases include the following:

LiOH	Lithium hydroxide
NaOH	Sodium hydroxide
KOH	Potassium hydroxide
RbOH	Rubidium hydroxide
CsOH	Cesium hydroxide
*$Ca(OH)_2$	Calcium hydroxide
*$Sr(OH)_2$	Strontium hydroxide
*$Ba(OH)_2$	Barium hydroxide

** Completely dissociated in solutions of 0.01 M or less.*
These are insoluble bases that ionize 100%.

The most commonly used bases in teaching are NaOH and KOH. There are other strong bases, such as Na_2O or CaO, and the amides. However, these substances are seldom used in Secondary Chemistry classes. With the exception of those listed above, nearly all other bases are considered weak.

Most metal oxides are basic oxides. One example is: NA_2O (S) + $H_2O \Rightarrow$ 2 NAOH (aq).

Acid and Base Chart

Ward's Science supplies several common acids and bases as concentrated solutions in water. The table below gives approximate molarities for these materials.

Chemical	Formula	Molecular weight	Molarity	Specific gravity	Weight %
Acetic acid (ethanoic acid)	CH_3COOH	60.05	17.5	1.05	99-100
Ammonium hydroxide	NH_4OH	35	14.8	0.88	28-30
Formic acid	HCOOH	46	23	1.22	88
Hydrochloric acid	HCl	36.5	12	1.18	36-38
Nitric acid	HNO_3	63	15.6	1.42	69
Phosphoric acid	H_3PO_4	98	14.7	1.7	85
Sulfuric acid	H_2SO_4	98	18	1.84	95-98

Chemical Quality and Characteristic Changes

As expressed throughout the Ward's Science Laboratory Manual, proper handling and storage of your Ward's chemicals is essential to keep them fresh and potent. Conditions such as exposure to sunlight or air, and improper handing resulting in exposure to impurities, will have an effect on many chemicals. Frequently these exposures change or deteriorate a chemical's qualities and shelf life. Some chemicals, such as hypochlorite, will crystallize over time if improperly stored. And contact with organic material, such as paper or oil, may cause some acids to change color in the bottle (though the acid is probably still usable).

There are also a few chemicals that have melting points near room temperature and may change from liquid to solid (or the reverse) depending on the temperature of the room. Examples include t-Butyl alcohol with a melting point of 25 °C and glacial acetic acid with a melting point of 16 °C. Both t-Butyl alcohol and Glacial acetic acid could be a solid in some instances, or a liquid in others, depending on your storage area or the temperature of the room. It is important that you have a full understanding of the chemicals you will be purchasing, handling, and using. Much of this information is found on the Safety Data Sheets (SDS's). You can find a detailed breakdown and description of SDS's in *Section IV*.

Safer Chemical Substitutions

You can reduce waste and improve classroom safety by substituting environmentally safer materials and chemicals when preparing for your chemistry demonstrations and experiments. The following substitutions are recommended by Ward's Science:

Hazardous Chemical	Substitute	Practice
Benzene	Cyclohexane, alcohols	
2 – Butanol	n-Butyl alcohol	
Carbon tetrachloride	Cyclohexane	Non-polar solvent
Carbon tetrachloride	Isopropyl alcohol	Vapor pressure-temperature
Chlorinated solvents	Non-chlorinated solvents	
Chloroform	1,1,1 – Trichloroethane	
Chromate ion	Hypochlorite ion	Organic synthesis
Chromic-sulfuric acid, alcoholic potassium hydroxide	Enzymatic cleaners, aqueous solvents, and biodegradable detergents	Glassware cleaning
Conventional acids Conventional bases	Vinegar Ammonia	Acid-base experiments
1,4 – Dioxane	Tetrahydrofuran or 1, 2Dimethoxyethane	
Ethanol-base baths.	Biodegradable detergents	
Ethyl ether	Methyl t-butyl ether	Organic synthesis
Formaldehyde	Ethanol or other preservatives	Specimen storage
Halogenated hydrocarbons	Trichloroethylene, methylene chloride & perchloroethylene	Heavier-than-water, non-polar solvents,
Heavy metals	Iron, cobalt, copper, etc.	Qualitative test for heavy metals
Methanol solution	Sugar water	Density determination
Mercury thermometers	Accurate non-mercury or digital thermometer.	Temperature
P - dichlorobenzene	Napthalene	
Potassium	Calcium	
Sulfide ion	Hydroxide ion	Qualitative test for heavy metals
Xylene or toluene-based mixtures.	Biodegradable liquid scintillation mixtures. Limonene based extracts	

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