Laboratory Solution Preparation

- **Basic concepts of preparing solutions**
- **Over 300 recipes of common laboratory solutions**
- **Solution preparation tips**

Many of the reagents used in science are in the form of solutions which need to be purchased or prepared. For many purposes, the exact value of concentration is not critical; in other cases, the concentration of the solution and its method of preparation must be as accurate as possible. The Flinn Laboratory Solution Preparation reference section is designed for both the novice and experienced solution maker. It provides valuable information on the basic concepts of preparing solutions and instructions for preparing most solutions required in the high school science laboratory. Professional quality solutions are possible when high quality and fresh chemicals and solvents are used, and meticulous procedures are followed. Many of the solutions described in this section are available ready-made from Flinn Scientific to save valuable laboratory prep time.

The section is divided into several parts for your convenience.

▶ Basic concepts of preparing solutions

▶ Preparation of simple inorganic salt solutions

▶ Preparations of acid and base solutions

▶ Recipes for Biological, Histological, and Chemical solutions

Basic Concepts of Preparing Solutions

Molarity

The most common unit of solution concentration is **molarity (M)**. The molarity of a solution is defined as the number of moles of solute per one liter of solution. Note that the unit of volume for molarity is *liters,* not milliliters or some other unit. Also note that one liter of solution contains both the solute and the solvent. Molarity, therefore, is a ratio between moles of solute and liters of solution. To prepare laboratory solutions, usually a given volume and molarity are required. To determine molarity, the formula weight or molar mass of the solute is needed. The following examples illustrate the calculations for preparing solutions.

If starting with a solid, use the following procedure:

- Determine the mass in grams of one mole of solute, the molar mass, MM_s.
- Decide volume of solution required, in liters, V.
- Decide molarity of solution required, M.
- Calculate grams of solute (g_s) required using equation 1.

  eq. 1. $g_s = MM_s \times M \times V$

- Example: Prepare 800 mL of 2 M sodium chloride.

  $(MM_{NaCl} = 58.45\ g/mol)$

  $g_{NaCl} = 58.45\ g/mol \times 2\ mol/L \times 0.8\ L$

  $g_{NaCl} = 93.52\ g\ NaCl$

  Dissolve 93.52 g of NaCl in about 400 mL of distilled water, then add more water until final volume is 800 mL.

If starting with a solution or liquid reagent:

- When diluting more concentrated solutions, decide what volume (V_2) and molarity (M_2) the final solution should be. Volume can be expressed in liters or milliliters.
- Determine molarity (M_1) of starting, more concentrated solution.
- Calculate volume of starting solution (V_1) required using equation 2. Note: V_1 must be in the same units as V_2.

  eq. 2. $M_1V_1 = M_2V_2$

- Example: Prepare 100 mL of 1.0 M hydrochloric acid from concentrated (12.1 M) hydrochloric acid.

  $M_1V_1 = M_2V_2$

  $(12.1\ M)(V_1) = (1.0\ M)(100\ mL)$

  $V_1 = 8.26\ mL$ conc. HCl

  Add 8.26 mL of concentrated HCl to about 50 mL of distilled water, stir, then add water up to 100 mL.

Percent Solutions

Mass percent solutions are defined based on the grams of solute per 100 grams of solution.

Example: 20 g of sodium chloride in 100 g of solution is a 20% by mass solution.

Volume percent solutions are defined as milliliters of solute per 100 mL of solution.

Example: 10 mL of ethyl alcohol plus 90 mL of H_2O (making approx. 100 mL of solution) is a 10% by volume solution.

Mass-volume percent solutions are also very common. These solutions are indicated by w/v% and are defined as the grams of solute per 100 milliliters of solution.

Example: 1 g of phenolphthalein in 100 mL of 95% ethyl alcohol is a 1 w/v% solution.

BASIC CONCEPTS OF PREPARING SOLUTIONS continued on next page.

Conversion Between Percent Solutions

You may wish to convert mass percent to volume percent or vice versa. If so, follow this procedure:

A 10% by mass solution of ethyl alcohol in water contains 10 g of ethyl alcohol and 90 g of water.

1. The formula for determining the volume of the component (ethyl alcohol in our example) is:

$$\text{Volume} = \frac{\text{mass of ethyl alcohol}}{\text{density of ethyl alcohol}}$$

2. Determine the volume of the total solution by dividing the mass of the solution by the density of the solution.
3. Determine the percent by volume by dividing the volume of the component by the volume of the solution.

Let's solve 1, 2, and 3 above as follows:

1. Mass of ethyl alcohol = 10 g (given)

   Density of ethyl alcohol = 0.794 g/mL (from handbook)

$$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

$$\text{Volume of ethyl alcohol} = \frac{10\text{ g}}{0.794\text{ g/mL}} = 12.6\text{ mL}$$

2. Mass of solution = 100 g (given)

   Density of solution (10% ethyl alcohol) = 0.983 g/mL (from handbook)

$$\text{Volume of solution} = \frac{100\text{ g}}{0.983\text{ g/mL}} = 101.8\text{ mL}^*$$

3. Volume percent of solution

$$\text{Percent} = \frac{\text{volume of ethyl alcohol}}{\text{total volume of solution}} = \frac{12.6}{101.8} = 12.4\%$$

Reverse the procedure to convert volume percent to mass percent.

*** The volume percent statement generally is accurate but the volume percent is not always calculated directly from the volumes of the mixed ingredients because the final volume may not equal the sum of the separate volumes. In our solution (No. 2 above) note that if the alcohol volume (12.6 mL) is added to the water volume (90 mL), the final volume is less than 102.6 mL.**

Calculating Molarity from Percent Solutions

To determine the molarity of a mass percent solution, the density of the solution is required. Use the following procedure:

1. Determine the mass of solution by multiplying the volume of the solution by the density of the solution.

$$\text{mass} = \text{volume} \times \text{density}$$

2. Determine concentration in percent by mass of the solute in solution. *Change to the decimal equivalent.*
3. Calculate the molar mass of the compound, MM.
4. Multiply mass (step 1) by mass % (step 2) and divide by molecular mass (step 3) to find the number of moles present in the whole solution.
5. Divide the number of moles (step 4) by the volume in liters of the solution to find the molarity of the solution.

Example: Determine molarity of 37.2% hydrochloric acid (density 1.19 g/mL).

1. Mass of solution = 1,000 mL × 1.19 g/mL = 1,190 g
2. Mass % = 37.2 % = 0.372
3. Molar mass of hydrochloric acid = 36.4 g/mol
4. $\dfrac{\text{mass} \times \text{mass \%}}{MM_{HCl}} = \dfrac{1{,}190\text{ g} \times 0.372}{36.4\text{ g/mol}} = 12.1\text{ moles}$
5. Molarity = moles/liters = 12.1 moles/1 liter = 12.1 M

Definitions

Buffer: A solution which tends to maintain a constant pH when excess acid or base is added.

Concentrated: For some commonly used acids and bases, the maximum solubility (at room temperature) in an aqueous solution or as a pure liquid.

Concentration: The relative amount of solute and solvent in a solution.

Hydrates: Compounds containing water chemically combined in a definite ratio. Computations using formula weight must take the water molecules into account.

Miscible: The ability of two liquids to be completely soluble in one another.

Molality: A concentration unit (m); defined as the number of moles of solute divided by the number of kilograms of solvent.

Molar Mass: The mass of a mole of any element or compound.

Molarity: A concentration unit (M); defined as the number of moles of solute divided by liters of solution.

Preparation of Simple Inorganic Salt Solutions

Name / Formula / F.W.	Concentration	g/L
Aluminum chloride $AlCl_3 \cdot 6H_2O$ 241.43	0.2 M 0.05 M	48.3 g 12.1 g
Aluminum nitrate $Al(NO_3)_3 \cdot 9H_2O$ 375.13	0.1 M	37.5 g
Aluminum sulfate $Al_2(SO_4)_3 \cdot 18H_2O$ 666.42	0.1 M	66.6 g
Ammonium acetate $NH_4C_2H_3O_2$ 77.08	1.0 M 0.1 M	77.1 g 7.7 g
Ammonium chloride NH_4Cl 53.49	1.0 M 0.5 M	53.5 g 26.7 g
Ammonium nitrate NH_4NO_3 80.04	1.0 M 0.5 M 0.1 M	80.0 g 40.0 g 8.0 g
Ammonium sulfate $(NH_4)_2SO_4$ 132.1	0.1 M	13.2 g
Barium chloride $BaCl_2 \cdot 2H_2O$ 244.28	0.1 M	24.4 g
Barium hydroxide $Ba(OH)_2 \cdot 8H_2O$ 315.50	0.1 M	31.5 g
Barium nitrate $Ba(NO_3)_2$ 261.35	0.5 M 0.1 M	130.7 g 26.1 g
Bismuth nitrate $Bi(NO_3)_3 \cdot 5H_2O$ 485.1	0.1 M	48.5 g in 500 mL 6M HNO_3*
Bismuth trichloride $BiCl_3$ 315.34	0.2 M	63.1 g in 500 mL 3M HCl*
Cadmium chloride $CdCl_2 \cdot 2½H_2O$ 228.34	0.1 M	22.8 g
Cadmium nitrate $Cd(NO_3)_2 \cdot 4H_2O$ 308.49	0.1 M	30.8 g
Calcium acetate $Ca(C_2H_3O_2)_2 \cdot H_2O$ 176.19	0.5 M 0.1 M	88.1 g 17.6 g
Calcium chloride $CaCl_2 \cdot 2H_2O$ 147.02	1.0 M 0.1 M	147.0 g 14.7 g
Calcium hydroxide $Ca(OH)_2$ 74.10	saturated	2 g†
Calcium nitrate $Ca(NO_3)_2 \cdot 4H_2O$ 236.16	0.5 M 0.1 M	118.1 g 23.6 g
Chromium(III) chloride $CrCl_3 \cdot 6H_2O$ 266.48	0.1 M	26.6 g
Chromium(III) nitrate $Cr(NO_3)_3 \cdot 9H_2O$ 400.18	0.1 M	40.0 g
Cobalt(II) chloride $CoCl_2 \cdot 6H_2O$ 237.95	0.1 M	23.8 g
Cobalt(II) nitrate $Co(NO_3)_2 \cdot 6H_2O$ 291.05	0.1 M	29.1 g
Copper(II) chloride $CuCl_2 \cdot 2H_2O$ 170.49	0.5 M 0.1 M	85.2 g 17.0 g
Copper(II) nitrate $Cu(NO_3)_2 \cdot 3H_2O$ 241.6	0.5 M 0.1 M	120.8 g 24.2 g
Copper(II) sulfate $CuSO_4 \cdot 5H_2O$ 249.69	1.0 M 0.5 M	249.7 g 124.8 g
Iron(II) sulfate $FeSO_4 \cdot 7H_2O$ 278.03	0.01 M	2.8 g and 1 mL conc. H_2SO_4*
Iron(III) chloride $FeCl_3 \cdot 6H_2O$ 270.32	1.0 M 0.1 M	270.3 g 27.0 g
Iron(III) nitrate $Fe(NO_3)_3 \cdot 9H_2O$ 404.00	0.1 M	40.4 g

*Add solid to acid solution, stir, then add to water. Dilute to 1 L. Remember, always add acid to water.

†Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

Normality: A concentration unit (N); defined as the number of equivalents of solute per liter of solution. (e.g., 1 M H_2SO_4 = 2 N H_2SO_4)

Saturated Solution: A solution that contains the maximum amount of a particular solute that will dissolve at that temperature.

Solute: The substance which is dissolved, or has gone into solution (typically a solid).

Solution: A uniform homogeneous mixture of two or more substances. The individual substances may be present in varying amounts.

Solvent: The substance which does the dissolving (typically a liquid, such as water or alcohol). Must be greater than 50% of the solution.

Standard Solution: A very precise solution, usually to 3–4 significant figures, used in quantitative analysis or an analytical procedure.

Supersaturated Solution: A solution that contains more solute than equilibrium conditions allow; it is unstable and the solute may precipitate upon slight agitation or addition of a single crystal.

continued on next page.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Lead acetate $Pb(C_2H_3O_2)_2 \cdot 3H_2O$ 379.34	0.1 M	38.0 g
Lead chloride $PbCl_2$ 278.12	saturated	12.0 g†
Lead nitrate $Pb(NO_3)_2$ 331.2	1 M 0.5 M 0.1 M	331.2 g§ 165.6 g 33.1 g
Lithium carbonate Li_2CO_3 73.89	0.1 M	7.4 g
Lithium chloride LiCl 42.40	1.0 M 0.1 M	42.4 g 4.2 g
Lithium nitrate $LiNO_3$ 68.95	1.0 M 0.5 M	69.0 g 34.5 g
Magnesium bromide $MgBr_2 \cdot 6H_2O$ 292.25	0.1 M	29.2 g
Magnesium chloride $MgCl_2 \cdot 6H_2O$ 203.33	1.0 M 0.1 M	203.3 g 20.3 g
Magnesium hydroxide $Mg(OH)_2$ 58.34	saturated	300 g†
Magnesium nitrate $Mg(NO_3)_2 \cdot 6H_2O$ 256.43	0.1 M	25.6 g
Magnesium sulfate $MgSO_4 \cdot 7H_2O$ 246.50	0.5 M 0.1 M	123.3 g 24.7 g
Manganese chloride $MnCl_2 \cdot 4H_2O$ 197.91	0.5 M 0.1 M	99.0 g 19.8 g
Manganese sulfate $MnSO_4 \cdot H_2O$ 169.01	0.2 M 0.1 M	33.8 g 16.9 g
Mercury(II) chloride $HgCl_2$ 271.50	0.25 M 0.10 M	67.9 g 27.2 g
Mercury(II) nitrate $Hg(NO_3)_2 \cdot H_2O$ 342.63	0.1 M	34.2 g in 50 mL conc. HNO_3*
Mercury(I) nitrate $Hg_2(NO_3)_2 \cdot 2H_2O$ 561.22	0.1 M	56.2 g in 100 mL conc. HNO_3*
Mercury(I) sulfate Hg_2SO_4 497.24	0.1 M	49.7 g in 30 mL 1 M HNO_3*
Nickel chloride $NiCl_2 \cdot 6H_2O$ 237.72	0.25 M 0.1 M	59.4 g 23.8 g
Nickel nitrate $Ni(NO_3)_2 \cdot 6H_2O$ 290.82	1 M 0.2 M	290.8 g 58.2 g
Nickel sulfate $NiSO_4 \cdot 6H_2O$ 262.87	1.0 M 0.5 M	262.9 g 131.4 g
Potassium bromide KBr 119.02	0.5 M 0.1 M	59.5 g 11.9 g
Potassium carbonate K_2CO_3 138.21	0.5 M 0.1 M	69.1 g 13.8 g
Potassium chloride KCl 74.56	0.5 M 0.1 M	37.3 g 7.5 g

*Add solid to acid solution, stir, then add to water. Dilute to 1 L. Remember, always add acid to water.

†Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

§Use 7.5 mL conc. HNO_3 to help dissolve.

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

How To

Make a Solution

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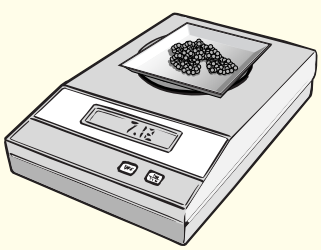
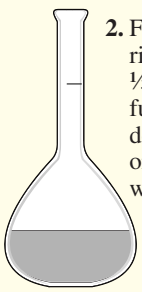
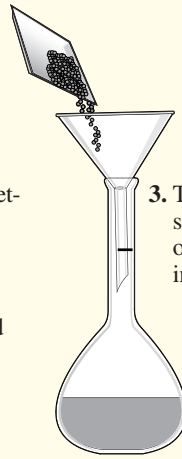


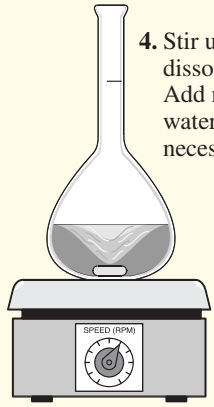
1. Weigh solid.



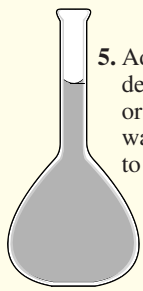
2. Fill volumetric flask ⅓–½ full with deionized or distilled water.



3. Transfer solid, wash out weighing dish.



4. Stir until dissolved. Add more water if necessary.



5. Add deionized or distilled water up to mark.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Potassium chromate K_2CrO_4 194.21	1.0 M 0.5 M 0.1 M	194.2 g 97.1 g 19.4 g
Potassium dichromate $K_2Cr_2O_7$ 294.22	0.1 M	29.4 g
Potassium ferricyanide $K_3Fe(CN)_6$ 329.26	0.5 M 0.1 M	164.6 g 32.9 g
Potassium ferrocyanide $K_4Fe(CN)_6 \cdot 3H_2O$ 422.41	0.1 M	42.2 g
Potassium hydrogen phthalate $KHC_8H_4O_4$ 204.23	0.1 M	20.4 g
Potassium hydroxide see page 123		
Potassium iodate KIO_3 214.01	saturated 0.2 M 0.1 M	214.0 g† 42.8 g 21.4 g
Potassium iodide KI 166.01	1 M 0.5 M 0.2 M	166.0 g 83.0 g 33.2 g
Potassium nitrate KNO_3 101.11	0.5 M 0.1 M	50.6 g 10.1 g
Potassium permanganate $KMnO_4$ 158.04	0.2 M 0.1 M 0.01 M	31.6 g 15.8 g 1.6 g
Potassium phosphate, monobasic KH_2PO_4 136.09	0.1 M	13.6 g
Potassium phosphate, dibasic K_2HPO_4 174.18	0.1 M	17.4 g
Potassium phosphate, tribasic K_3PO_4 212.27	0.1 M	21.2 g
Potassium sulfate K_2SO_4 174.27	0.5 M 0.1 M	87.1 g 17.4 g
Potassium thiocyanate KSCN 97.18	1.0 M 0.5 M 0.1 M	97.2 g 48.6 g 9.7 g
Silver nitrate $AgNO_3$ 169.87	0.5 M 0.1 M	84.9 g 17.0 g
Sodium acetate $NaC_2H_3O_2 \cdot 3H_2O$ 136.08	1 M 0.5 M	136.1 g 68.0 g
Sodium bicarbonate $NaHCO_3$ 84.01	0.5 M 0.1 M	42.0 g 8.4 g
Sodium borate $Na_2B_4O_7 \cdot 10H_2O$ 381.42	4 %	40.0 g
Sodium bromide NaBr 102.90	1.0 M 0.1 M	102.9 g 10.3 g
Sodium carbonate Na_2CO_3 105.99	saturated 1.0 M 0.1 M	214.0 g† 106.0 g 10.6 g
Sodium carbonate $Na_2CO_3 \cdot H_2O$ 124.00	1.0 M 0.1 M	124.0 g 12.4 g

***Add solid to acid solution, stir, then add to water. Dilute to 1 L. Remember, always add acid to water.**

†Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

General Solubility Rules for Inorganic Compounds

Nitrates (NO_3^-): All nitrates are soluble.

Acetates ($C_2H_3O_2^-$): All acetates are soluble; silver acetate is moderately soluble.

Bromides (Br^-) **Chlorides** (Cl^-) and **Iodides** (I^-): Most are soluble except for salts containing silver, lead, and mercury.

Sulfates (SO_4^{2-}): All sulfates are soluble except barium and lead. Silver, mercury(I), and calcium are slightly soluble.

Hydrogen sulfates (HSO_4^-) : The hydrogen sulfates (aka bisulfates) are more soluble than the sulfates.

Carbonates (CO_3^{2-}), **phosphates** (PO_4^{3-}), **chromates** (CrO_4^{2-}), **silicates** (SiO_4^{2-}): All carbonates, phosphates, chromates, and silicates are insoluble, except those of sodium, potassium, and ammonium. An exception is $MgCrO_4$, which is soluble.

Hydroxides (OH^-): All hydroxides (except lithium, sodium, potassium, cesium, rubidium, and ammonium) are insoluble; $Ba(OH)_2$, $Ca(OH)_2$ and $Sr(OH)_2$ are slightly soluble.

Sulfides (S^{2-}): All sulfides (except sodium, potassium, ammonium, magnesium, calcium and barium) are insoluble. Aluminum and chromium sulfides are hydrolyzed and precipitate as hydroxides.

Sodium (Na^+), **potassium** (K^+), **ammonium** (NH_4^+): All sodium, potassium, and ammonium salts are soluble. (Except some transition metal compounds.)

Silver (Ag^+): All silver salts are insoluble. Exceptions: $AgNO_3$ and $AgClO_4$; $AgC_2H_3O_2$ and Ag_2SO_4 are moderately soluble.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Sodium chloride	saturated	390.0 g†
NaCl	1.0 M	58.5 g
58.45	0.1 M	5.8 g
Sodium dichromate	0.1 M	29.8 g
$Na_2Cr_2O_7 \cdot 2H_2O$		
298.03		
Sodium fluoride	0.1 M	4.2 g
NaF		
41.99		

Increase the Rate of Dissolving Solids

A solvent will only dissolve a limited quantity of solute at a definite temperature. However, the rate at which the solute dissolves can be accelerated by the following methods:

1. Pulverize or grind up the solid to increase the surface area of the solid in contact with the liquid.
2. Heat the solvent. This will increase the rate of solution because the molecules of both the solvent and the solute move faster.
3. Stir vigorously.

Combinations of all three methods, when practical, will dissolve solids more quickly.

Sodium hydroxide see page 1250

Sodium iodide	0.5 M	75.0 g
NaI	0.1 M	15.0 g
149.92		
Sodium nitrate	0.5 M	43.0 g
$NaNO_3$	0.1 M	8.5 g
84.99		
Sodium oxalate	0.1 M	13.4 g
$Na_2C_2O_4$		
134.00		
Sodium phosphate, monobasic	0.1 M	13.8 g
$NaH_2PO_4 \cdot H_2O$		
137.99		
Sodium phosphate, dibasic	0.5 M	134.0 g
$Na_2HPO_4 \cdot 7H_2O$	0.1 M	26.8 g
268.07		
Sodium phosphate, dibasic	0.5 M	71.0 g
Na_2HPO_4	0.1 M	14.2 g
141.96		
Sodium phosphate, tribasic	0.1 M	38.0 g
$Na_3PO_4 \cdot 12H_2O$		
380.12		
Sodium sulfate	saturated	600 g†
$Na_2SO_4 \cdot 10H_2O$	1.0 M	322.2 g
322.19	0.5 M	161.1 g

Name / Formula / F.W.	Concentration	g/L
Sodium sulfate	saturated*	260 g†
Na_2SO_4	1.0 M	142.0 g
142.02	0.5 M	71.0 g
Sodium sulfide	2.0 M	48.0 g§
$Na_2S \cdot 9H_2O$	1.0 M	24.0 g
240.18		
Sodium sulfite	1.0 M	126.1 g
Na_2SO_3		
126.05		
Sodium thiosulfate	0.5 M	124.1 g
$Na_2S_2O_3 \cdot 5H_2O$	0.1 M	24.8 g
248.19		
Strontium chloride	0.5 M	133.3 g
$SrCl_2 \cdot 6H_2O$	0.1 M	26.7 g
266.64		
Strontium hydroxide	saturated	220 g†
$Sr(OH)_2 \cdot 8H_2O$		
266.82		
Strontium nitrate	1.0 M	211.6 g
$Sr(NO_3)_2$	0.5 M	105.8 g
211.63		
Tin(II) chloride	0.1 M	22.6 g in 1 M HCl*
$SnCl_2 \cdot 2H_2O$		
225.65		
Tin(IV) chloride	0.1 M	35.1 g in 3 M HCl*
$SnCl_4 \cdot 5H_2O$		
350.61		
Zinc chloride	0.5 M	68.1 g and 1 mL 12 M HCl*
$ZnCl_2$		
136.29	0.1 M	13.6 g
Zinc nitrate	0.5 M	149.7 g
$Zn(NO_3)_2 \cdot 6H_2O$	0.1 M	29.7 g
297.49		
Zinc sulfate	1.0 M	287.6 g
$ZnSO_4 \cdot 7H_2O$	0.1 M	28.8 g
287.56		

*** Add solid to acid solution, stir, then dilute to 1 L. Remember, always add acid to water.**

† Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

§ Use hot water, stir vigorously.

Distilled or Deionized Water—Which Do I Need?

Distilled water is free of inorganic materials, suspended impurities, and most organic contaminants. To make or buy distilled water is expensive. While there may be school laboratory applications where distilled water is required, in many applications, deionized (aka demineralized) water will do just as well. Deionized water, like distilled water, is free of inorganic materials and most suspended contaminants. If you need organic-free water, buy a still or buy distilled water.

Preparation of Acid Solutions

Name / Formula / F.W.	Concentration	Amount/Liter§
Acetic Acid*	6 M	345 mL
CH_3CO_2H	3 M	173
F.W. 60.05	1 M	58
99.7%, 17.4 M	0.5 M	29
sp. gr. 1.05	0.1 M	5.8
Hydrochloric Acid*	6 M	500 mL
HCl	3 M	250
F.W. 36.4	1 M	83
37.2%, 12.1 M	0.5 M	41
sp. gr. 1.19	0.1 M	8.3
Nitric Acid*	6 M	380 mL
HNO_3	3 M	190
F.W. 63.01	1 M	63
70.0%, 15.8 M	0.5 M	32
sp. gr. 1.42	0.1 M	6.3
Phosphoric Acid*	6 M	405 mL
H_3PO_4	3 M	203
F.W. 98.00	1 M	68
85.5%, 14.8 M	0.5 M	34
sp. gr. 1.70	0.1 M	6.8
Sulfuric Acid*	9 M	500 mL†
H_2SO_4	6 M	333†
F.W. 98.08	3 M	167†
96.0%, 18.0 M	1 M	56
sp. gr. 1.84	0.5 M	28
	0.1 M	5.6

*Always add acid to water. The addition of acid to water is an exothermic reaction. Use high temperature (e.g., Pyrex®) glassware.

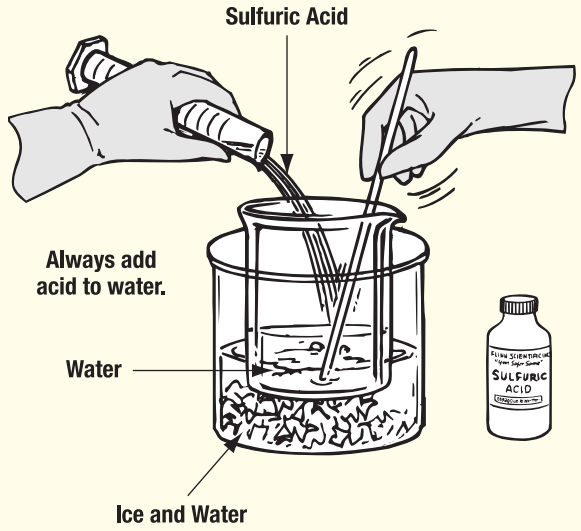
†Extremely exothermic, submerge mixing vessel in an ice bath. See adjacent box.

§The amount of solute required to prepare one liter of solution.

Preparing Sulfuric Acid Solution?

Always **ADD ACID (AA)** to water! A great amount of heat is liberated when sulfuric acid is added to water. The temperature of the solution will rise rapidly. In fact, the temperature may rise so fast that the solution will boil and possibly spatter a strongly acidic solution. Consider immersing your mixing vessel in a bucket of ice to control the solution temperature. Always add the acid to water ***very*** slowly while stirring continuously.

▶ See free How To video at flinnsci.com!



Safe Storage of Acids

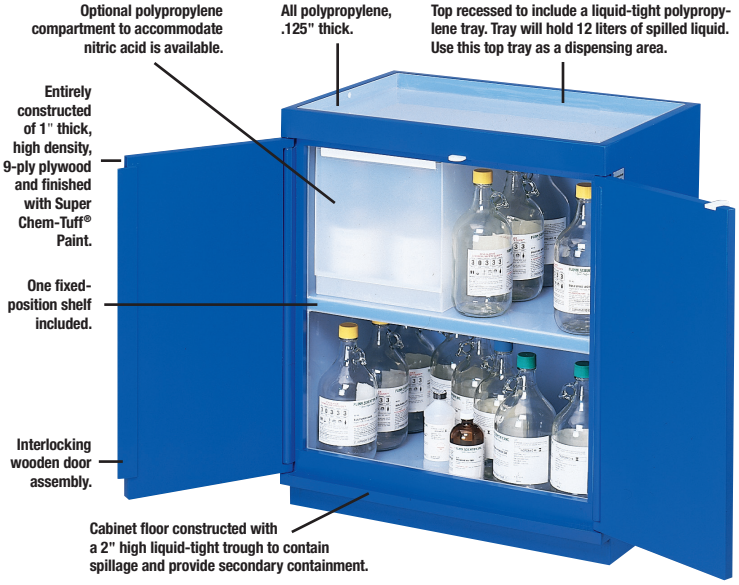
Flinn/SciMatCo® Wooden Acid Cabinets are Ideal for School Storerooms

Corrosive chemicals, such as strong acids and bases, must be isolated from other chemicals to prevent accidental contact and hazardous reaction conditions. The best way to isolate your corrosive chemicals is to store them in an approved corrosive storage cabinet like the Flinn wooden acid cabinet. Locked storage cabinets also provide security against theft and vandalism.

Flinn wood acid cabinets are designed specifically for high school chemical storerooms. Made from nine-ply, high-density plywood, Flinn acid cabinets are guaranteed never to rust or corrode.

Flinn acid cabinets will provide long life and safe, secure storage for all your corrosives.

▶ See free video at flinnsci.com!



Flinn Acid Cabinets

- **Wooden acid cabinets are safer and more durable than metal cabinets.**
- **Acid attacks ALL metal cabinets.**
- **No metal is used anywhere in the interior construction of Flinn/SciMatCo acid cabinets.**

Preparation of Base Solutions

Name / Formula / F.W.	Concentration	Amount/Liter§
Ammonium Hydroxide*	6 M	405 mL
NH_4OH	3 M	203
F.W. 35.05	1 M	68
	0.5 M	34
	0.1 M	6.8
Potassium Hydroxide	6 M	337 g
KOH	3 M	168
F.W. 56.11	1 M	56
	0.5 M	28
	0.1 M	5.6
Sodium Hydroxide†	6 M	240 g
NaOH	3 M	120
F.W. 40.00	1 M	40
	0.5 M	20
	0.1 M	4.0

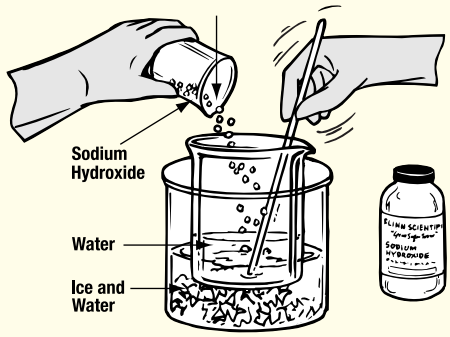
*Use concentrated (14.8 M) ammonium hydroxide.

†Exothermic reaction. Use high temperature (borosilicate) glassware.

§The amount of solute required to prepare one liter of solution.

Preparing Sodium Hydroxide Solution?

A great amount of heat is liberated when sodium hydroxide and water are mixed. The temperature of the solution may rise very rapidly. In fact, the temperature may rise so fast that the solution may boil and possibly spatter a hot, caustic solution. Immerse the flask or beaker in an ice–water bath to control the solution temperature. In addition, pay special attention to the condition of the beaker or flask, you use to prepare these solutions. If you use a glass vessel it must be borosilicate glass and it must be free of any scratches, chips or breaks. Inspect the vessel carefully before use. Add ingredients slowly with continuous stirring.



FLINN CHEMICALS make teaching science safer!

Many science teachers spend too much time and energy complying with regulations concerning the use, storage, and handling of laboratory chemicals. Flinn Scientific's unique chemical packaging and labeling meet or exceed these regulations, allowing you more time to do what you do best…teach science! Depend on Flinn Scientific to fulfill all of your chemical needs.

A Concentrated acids are packaged in Flinn *Saf-Cubes*® for safe shipping and storage.

B Innovative packaging like the H_2O_2 accordion bottle and the *E-Z Drop*® bottle allow for safe storage and easy dispensing.

C Reactive metals are packaged in plastic bottles inside plastic bags and placed in special metal cans for safe storage.

D Flinn *Chem-Saf*® bags, and desiccant packets are standard on many Flinn chemicals.

E A CD with up-to-date and specifically designed SDS for science teachers is included with your first chemical order each year.

F A free Flinn Exclusive lab safety poster is also included with your first chemical order of each year!

Recipes for Biological, Histological, and Chemical Solutions

Aceto-Carmine (Schneider)
Place 0.5 g of carmine and 55 mL of DI water in a 200-mL flask, bring to a boil, and add 45 mL of glacial acetic acid. Plug flask with cotton wool, boil again, cool and filter. (stain and fixative, good for protozoa and nuclei)

Aceto-Orcein Staining Solution
Heat 31.5 mL of glacial acetic acid and 13.5 mL of DI water almost to boiling. When acid is hot, add 2 g of synthetic orcein and allow to cool. Dilute by adding 55 mL of DI water; stir and filter. (connective tissue stain)

Adrenaline Hydrochloride
Dissolve 0.1 g of adrenaline hydrochloride in 100 mL of Ringer's solution.

Adipoyl Chloride/Hexane Solution
Dissolve 4.6 g of adipoyl chloride in approximately 50 mL of hexane, stir, then dilute to 100 mL with hexane. (nylon demonstration)

Agar (Non-nutrient)
Suspend 15 g of agar in 1 L of DI water. Heat to a boil and stir until completely dissolved. Let cool to 50–55 °C and then dispense into desired containers. Agar will firm as it cools. Must add a nutrient if using for culture growth.

Agarose Gel
The standard concentration of agarose in the gel is 0.8%—a concentration that offers a compromise between band resolution and running time. The following directions are for 100-mL of an 0.8% agarose solution. Stir 0.8 g of agarose into 100 mL of working strength (1X) electrophoresis buffer (TBE or TAE) in a glass Erlenmeyer flask. Stopper with non-absorbent cotton, or foam plug. Dissolve agarose by heating in a microwave (30–40 seconds, stir, repeat) or on a hot plate. Heat until solution is clear and agarose appears to be fully dissolved. Stir frequently and do not allow solution to boil for more than a few seconds. Prepare the casting tray, place the well comb, and pour the gel(s) when the agarose solution has cooled to approximately 60 °C. Allow the gel to fully solidify on a flat, level surface for 20 to 30 minutes. Gel should be opaque and firm to the touch.

Alizarin
0.1% methanol solution: Dissolve 0.1 g of alizarin in 50 mL of methyl alcohol, then dilute to 100 mL with methyl alcohol. (pH indicator)

Alizarin Red S
1% aqueous: Dissolve 1 g of alizarin red S in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Alizarin Yellow R
0.1% aqueous: Dissolve 0.1 g of alizarin yellow R in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Aluminon
Dissolve 0.1 g of aurin tricarboxylic acid in 100 mL of DI water. (qualitative reagent for aluminum)

Amylase
0.5% aqueous: Dissolve 0.5 g of amylase in 50 mL of DI water, then dilute to 100 mL. Prepare fresh. (starch digestion)

Aniline Blue Alcohol Stain
1% alcohol: Dissolve 1 g of aniline blue in 100 mL 85% ethyl alcohol. (stain for cellulose)

Aniline Blue Aqueous Stain
0.5% aqueous: Dissolve 0.5 g aniline blue in 50 mL DI water, then dilute to 100 mL. Filter if necessary. (stain for algae and fungi)

Aniline Blue Indicator
0.1% aqueous: Dissolve 0.1 g aniline blue in 50 mL DI water, then dilute to 100 mL. (pH indicator)

Baker's Softening Fluid
Mix 10 mL of glycerol, 54 mL of 95% ethanol and 35 mL DI water. (softening of animal structures)

Barfoed's Reagent
Add 10 mL of glacial acetic acid to 1 L of DI water and stir. Add 66.5 g of cupric acetate monohydrate. Heat and stir until solid is completely dissolved. (test for glucose)

Benedict's Qualitative Solution
Dissolve 173 g of sodium citrate dihydrate and 100 g sodium carbonate anhydrous in 800 mL DI water. Warm and stir to aid dissolution. Filter if necessary. In a separate container, dissolve 17.3 g copper (II) sulfate pentahydrate in 100 mL DI water. Slowly, while stirring constantly, add the copper sulfate solution to the first solution. Let cool and dilute to 1 L with DI water. (test for the presence of simple sugars)

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

Safety Tip

Become a Label Fanatic!

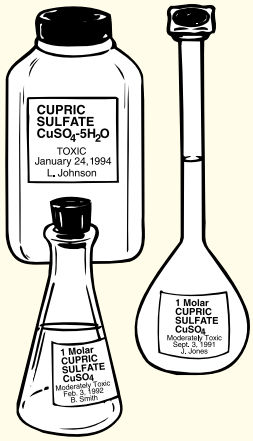
- Do not use chemicals from unlabeled containers.
- Do not place labels on top of one another.
- Label chemicals clearly and permanently.

An unlabeled container will become tomorrow's "Mystery Substance." A grease pencil or label can help eliminate a future problem and a lot of expense.

You Make It—You Label It!

Minimum label requirements:

1. Identity of contents
2. Concentration
3. Your name
4. Date of preparation (if applicable)
5. Hazard alert (if applicable)



Benedict's Quantitative Solution
Dissolve 18.0 g of copper (II) sulfate pentahydrate in 100 mL of DI water and set aside. Dissolve 100.0 g of sodium carbonate anhydrous, 200.0 g of sodium citrate dihydrate, and 125 g of potassium thiocyanate in 800 mL DI water. Heat, if necessary to aid dissolution of the solids. Allow the solution to cool, then transfer to a 1-L volumetric flask. Slowly, while stirring constantly, add the copper sulfate solution to the 1-L flask. Prepare a 0.1 M potassium ferrocyanide solution by dissolving 0.25 g of potassium ferrocyanide trihydrate in 5 mL of DI water. Add to the 1-L volumetric flask, stir, then dilute to 1 L with DI water. Filter if necessary. (25 mL of this solution is reduced by 50 mg of glucose)

Bial's Reagent (Sumner)
Add 4 drops of 10% iron(III) chloride solution to 100 mL of 6 M hydrochloric acid. Add .03 g of orcinol and stir. (test for pentoses and glycuronic acids)

Bile Salts
5% aqueous: Dissolve 5 g of bile salts in 50 mL of DI water, dilute to 100 mL. Mix gently to avoid foam. (digestive studies)

Bismark Brown Y
0.5% aqueous: Dissolve 0.5 g of bismark brown Y in 50 mL of DI water, dilute to 100 mL, stir, and filter if necessary. (stain for protozoa)

Biuret Test Solution
Dissolve 2.3 g of copper (II) sulfate pentahydrate in 230 mL of DI water. Set aside. Dissolve 308 g sodium hydroxide in 770 mL of DI water (very exothermic; cool vessel in an ice water bath) and cool to room temperature. Add all the copper sulfate solution to the sodium hydroxide solution. Solution should be blue. (test for proteins)

Blood Agar Base Infusion
Suspend 40 g of blood agar base infusion in 1 L of DI water. Heat to a boil while stirring vigorously. Boil for one minute. Sterilize for 15 min at 121 °C (15 lbs. of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and pour into sterilized culture dishes. (culture medium)

Borax
Add 4 g Borax (sodium borate, $Na_2B_4O_7 \cdot 10H_2O$) to 100 mL of DI water. Stir. (preparation of slime)

Borax Carmine
Dissolve 2 g of borax (aka sodium tetraborate) in 50 mL of DI water, add 1.5 g of carmine and boil for 30 minutes. Let cool, make up to 50 mL with DI water, then add 50 mL of 70% ethyl alcohol. Let stand for a few days, then filter. (good general stain for plant and animal tissue)

Borax Methylene Blue
Heat 100 mL of DI water to 60 °C and stir in 2 g methylene blue and 5 g borax. Allow to cool slowly. Solution improves with age. (connective tissue stain, Negri bodies)

Bouin's Fixative
Mix together 75 mL of saturated aqueous picric acid solution, 25 mL of commercial formalin (10% formaldehyde solution), and 5 mL of glacial acetic acid. (plant and animal tissue fixative)

Brilliant Blue R-250
Dissolve 0.25 g of Coomassie brilliant blue R-250 in 40 mL methyl alcohol. Add 40 mL DI water, then 7 mL concentrated acetic acid. Dilute to 100 mL with DI water. (staining proteins in polyacrylamide and agarose gels for electrophoresis)

Brilliant Blue G-250
Dissolve 0.1 g of Coomassie brilliant blue G-250 in 25 mL methyl alcohol. Add 40 mL DI water, then 5 mL acetic acid. Dilute to 100 mL with DI water. (staining proteins in polyacrylamide and agarose gels for electrophoresis)

Brilliant Cresyl Blue
Dissolve 0.85 g sodium chloride in 75 mL of DI water. Add 1 g brilliant cresyl blue and stir to dissolve. Dilute to 100 mL with DI water. (vital stain, general stain for protozoa and plant cells)

Brilliant Green
1% aqueous: Dissolve 1 g of brilliant green in 50 mL of DI water, dilute to 100 mL, stir, and filter if necessary. (stain for plant cytoplasm, and pH indicator)

Bristol's Solution
Dissolve 1 g of potassium dihydrogen phosphate, 1 g sodium nitrate, 0.3 g of magnesium sulfate, 0.1 g calcium chloride, 0.1 g sodium chloride and a trace of ferric chloride in 1 L of DI water. (culture of algae)

Bromcresol Green
0.1% alcoholic: Dissolve 0.1 g of bromcresol green in 75 mL of ethyl alcohol, then dilute to 100 mL. (pH indicator)

Bromcresol Green
0.04% aqueous: Dissolve 0.04 g of bromcresol green in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Bromcresol Purple
0.04% aqueous: Dissolve 0.04 g of bromcresol purple in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Note: DI water denotes either distilled or deionized water.

How To Prepare Buffer Solutions

Buffer solutions are available from Flinn as premade solutions and ready-to-mix capsules and envelopes. Buffers are typically mixtures of a weak acid and the salt of the acid or a weak base and its salt. This combination is called a conjugate acid-base pair and it will resist changes in pH upon addition of small amounts of acid or base. Recipes for three common buffer solutions are provided.

pH 4: Dissolve 5.10 g of potassium hydrogen phthalate ($KHC_8H_4O_4$) in 250 mL of DI water, add 0.50 mL of 0.10 M hydrochloric acid, then dilute to 500 mL.

pH 7: Prepare 0.10 M potassium phosphate monobasic (KH_2PO_4) solution by dissolving 3.40 g in 250 mL DI water. Prepare 0.20 M sodium hydroxide solution by dissolving 0.8 g in 100 mL DI water. Mix 250 mL of the 0.10 M potassium phosphate solution and 73 mL of 0.2 M sodium hydroxide solution, then dilute to 500 mL.

pH 10: Prepare 0.025 M sodium borate solution ($Na_2B_4O_7 \cdot 10H_2O$) by dissolving 2.38 g in 250 mL of DI water. Prepare 0.20 M sodium hydroxide solution by dissolving 0.8 g in 100 mL DI water. Mix 250 mL of the 0.025 M sodium borate solution and 27 mL of the 0.2 M sodium hydroxide solution, then dilute to 500 mL.

RECIPES continued on next page.

Recipes for Biological, Histological, and Chemical Solutions, continued

Bromine Water
Add 1 mL of bromine to 200 mL of DI water and stir. Keep in a tightly sealed bottle. The shelf life is poor due to evaporation of bromine. (polar/nonpolar solubility studies)

Bromphenol Blue
0.04% aqueous: Dissolve 0.04 g of bromphenol blue in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Bromthymol Blue
0.04% aqueous: Dissolve 0.04 g of bromthymol blue in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Carbol Fuchsin (Ziehl-Nielson)
Dissolve 1 g of basic fuchsin in 10 mL of 100% ethyl alcohol (absolute); set aside. Dissolve 5 g of phenol in 100 mL of DI water. Add the two solutions together and stir. (bacterial stain, bacterial spores, and various cytoplasmic inclusions)

Carnoy's Fluid
Mix together 10 mL glacial acetic acid, 30 mL of chloroform, and 60 mL of 100% ethyl alcohol. (fixative for tissue used in chromosome studies)

Chlorophenol Red
0.04% aqueous: Add 23.5 mL of 0.01 M sodium hydroxide to 226.5 mL of DI water. Dissolve 0.1 g of chlorophenol red in this solution. (pH indicator)

Clayton Yellow
1% aqueous: Dissolve 1 g of Clayton yellow in 50 mL of DI water, then dilute to 100 mL. (pH indicator and fluorescent dye for microscopy)

Congo Red Indicator
0.1% aqueous: Dissolve 0.1 g of Congo red in 50 mL of DI water, then dilute to 100 mL. (pH indicator)

Congo Red Stain
1% aqueous: Dissolve 1 g of Congo red in 100 mL of DI to which a few drops of ammonium hydroxide solution have been added. (plant tissue stain)

m-Cresol Purple
Add 26.2 mL of 0.01 M sodium hydroxide to 200 mL of DI water. Dissolve 0.1 g of m-cresol purple in this solution, dilute to 250 mL. Can omit NaOH if using Na salt. (pH indicator)

Cresol Red
Add 26.2 mL of 0.01 M sodium hydroxide to 200 mL of DI water. Dissolve 0.1 g of cresol red in this solution, dilute to 250 mL. Can omit NaOH if using Na salt. (pH indicator)

Crystal Violet Indicator
0.02% aqueous: Dissolve 0.02 g of crystal violet in 80 mL of DI water, then dilute to 100 mL. (pH indicator)

Crystal Violet Stain (Gram)
Dissolve 2 g of crystal violet in 20 mL of 95% ethyl alcohol. Dissolve 0.8 g of ammonium oxalate monohydrate in 80 mL of DI water and then mix with the crystal violet solution. Filter if necessary. (used in Gram staining procedure for bacteria)

Destaining Solution
Add 70 mL glacial acetic acid to 400 mL methanol. Dilute to 1 L with DI water. (removes stains from polyacrylamide gels)

Dichloroindophenol
Dissolve 0.025 g of 2,6-dichloroindophenol, sodium salt in 80 mL DI water, then dilute to 100 mL. Prepare fresh. (indicator for Vitamin C)

Diphenylamine Reagent
Mix 1 g of diphenylamine in 100 mL glacial acetic acid and 2.75 mL of conc. sulfuric acid. Store in an amber bottle at 2 °C. Warm to room temperature before using. (DNA/RNA extractions)

EMB Agar
Suspend 36 g of EMB agar in 1 L of DI water and heat to boiling to dissolve the solid. Sterilize for 15 min at 121 °C (15 lbs. of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and swirl to disperse the precipitate just prior to pouring into sterilized culture dishes. (culture medium)

Note: DI water denotes either distilled or deionized water.

Eosin Y Indicator
1% alcoholic: Dissolve 1 g eosin Y in 80 mL 95% ethyl alcohol, then dilute to 100 mL. Stir and filter if necessary. (fluorescent pH indicator)

Eosin Y Stain
0.5% aqueous: Dissolve 0.5 g of eosin Y in approximately 80 mL DI water, then dilute to 100 mL. Stir and filter if necessary. Add a few drops of chloroform as preservative. (good cytoplasmic stain)

Eriochrome Black T Indicator
1% alcoholic: Dissolve 1 g of eriochrome black T in 80 mL of 95% ethyl alcohol, dilute to 100 mL with 95% ethyl alcohol. (indicator for EDTA titrations)

Erythrosin B Indicator
1% alcoholic: Dissolve 1 g of erythrosin B in 80 mL of 95% ethyl alcohol, dilute to 100 mL with 95% ethyl alcohol. (indicator for EDTA titrations)

Erythrosin B Stain
1% aqueous: Dissolve 0.1 g of erythrosin B in 100 mL of DI water. Stir and filter if necessary. Add chloroform as a preservative. (biological stain)

Fast Green
Dissolve 2 g of fast green in 100 mL of DI water containing 2 mL of glacial acetic acid. (tissue cell staining)

Fehlings Solution A

RECIPES continued on next page.

How To
Set up a Prep Room

Equipment
- Electronic Balance
- Magnetic Stirrers
- Volumetric Flasks
- Graduated Cylinders
- Water Purification System
- Bottles
- Labels

Safety Essentials
- Eyewash/Body Drench
- Spill Control and Clean-up Materials
- Fire Extinguisher
- Chemical-resistant Gloves and Aprons
- Chemical Splash Goggles
- Telephone Available for Emergency Use
- Chemical First Aid Kit
- Good Ventilation

Dissolve 34.6 g of copper(II) sulfate pentahydrate in 500 mL DI water. Combine solution A and B (1:1) just before use. (test for reducing sugars and aldehydes)

Fehlings Solution B
Dissolve 125 g of potassium hydroxide and 173 g of potassium sodium tartrate tetrahydrate in 500 mL of DI water. Combine solution A and B (1:1) just before use. (test for reducing sugars and aldehydes)

Ferroin Solution
Dissolve 0.23 g of iron(II) sulfate heptahydrate in 100 mL of DI water. Add 0.46-g of 1,10-phenanthroline monohydrate and stir until dissolved. (redox indicator)

Fluorescein
0.1% alcoholic: Dissolve 0.1 g of fluorescein in 80 mL of 95% ethyl alcohol, then dilute to 100 mL. (fluorescent pH indicator)

Formalin-Aceto-Alcohol (FAA)
Mix together 50 mL of 95% ethyl alcohol, 2 mL of glacial acetic acid, 10 mL of 40% formaldehyde and 40 mL of DI water. (preservative for algae, also a fixative)

Fuchsin, Acid, Indicator
1% aqueous: Dissolve 1 g of acid fuchsin in 80 mL of DI water, then dilute up to 100 mL. (pH indicator)

Fuchsin, Acid, Stain
1% aqueous: Dissolve 1 g of acid fuchsin in 100 mL of DI water and 1 mL of glacial acetic acid. Filter if necessary. (staining marine algae and small crustaceans)

Fuchsin, Basic
1% aqueous: Dissolve 1 g of basic fuchsin in 80 mL of DI water, then dilute to 100 mL. Filter if necessary. (pH indicator and biological stain)

Fuchsin, New
1% aqueous: Dissolve 1 g of new fuchsin in 80 mL of DI water, then dilute to 100 mL. Filter if necessary. (biological stain)

Gastric Juice
Dissolve 5 g pepsin, 8.75 g conc. hydrochloric acid, and 2.5 g of lactic acid in 500 mL of DI water. Dilute to 1 L and stir gently to avoid foaming. (digestive studies)

Gibberellic Acid
Dissolve 100 mg of gibberellic acid in 5.0 mL of ethyl alcohol. Dilute to 1 L with DI water. (plant growth hormone)

Guar Gum
Dissolve 0.5 to 1.0 g of guar gum in 100 mL DI water. Make fresh. (preparation of "slime")

Hayem's Solution
Dissolve 0.25 g of mercury (II) chloride, 2.5 g of sodium sulfate, and 0.5 g of sodium chloride in 100 mL of DI water. (diluting solution for red cell counts)

Hematoxylin, Delafield's
Dissolve 4 g of hematoxylin in 25 mL of 100% ethyl alcohol. Add 400 mL of saturated aqueous aluminum ammonium sulfate solution. Expose to light for a few days in a cotton stoppered bottle, then filter. Add 100 mL of methyl alcohol and 100 mL of glycerin. The stain must be ripened at room temperature for 2 months before use. Store in a well stoppered flask. (good general stain for non-woody plant tissue and animal tissue)

Hexamethylenediamine/Sodium Hydroxide
Dissolve 60 g of 1,6-hexamethylenediamine in 500 mL of DI water; add 20 g of sodium hydroxide; stir to dissolve; dilute to 1 L. (nylon demonstration)

Indigo Carmine
Dissolve 0.25 g of indigo carmine in 80 mL of 50% ethyl alcohol solution. Stir, dilute to 100 mL with 50% ethyl alcohol solution. Prepare fresh; shelf life is poor. (pH indicator)

Iodine, Tincture of
Dissolve 50 g of potassium iodide in 50 mL of DI water; add 70 g iodine; stir to dissolve then dilute to 1 L with 95% ethyl alcohol. Store in a dark bottle.

Iodine–Potassium Iodide
Dissolve 15 g of potassium iodide in 125 mL of DI water; add 3 g of iodine; stir to dissolve, then dilute to 1 L. Store in a dark bottle. (starch test)

Always store iodine solutions in PVC-coated amber, glass bottles.

Iodine Solution (0.05 M)
Dissolve 20 g of potassium iodide in 400 mL of DI water; add 13 g of iodine; stir to dissolve, then dilute to 1 L. Store in a dark bottle.

Iodine Solution, Gram's
Dissolve 6.7 g of potassium iodide in 100 mL of DI water; add 3.3 g of iodine; stir to dissolve, then dilute to 1 L. Store in a dark bottle. (used in Gram staining procedure for bacteria)

Iodine Solution, Lugol's
Dissolve 20 g of potassium iodide in 200 mL of DI water; add 10 g of iodine; stir to dissolve then dilute to 1 L. Store in a dark bottle. (General biological stain and vital stain stock solution, dilute 5:1 before use.)

Knop's Solution
Add 1 g of potassium nitrate, 1 g of magnesium sulfate heptahydrate, 1 g of potassium phosphate dibasic, and 3 g of calcium nitrate tetrahydrate to 500 mL distilled water; stir then dilute to 1 L with distilled water. Shake solution before use to redissolve the calcium nitrate. Add 10 g of agar and 10 g of glucose to 500 mL of this solution for culturing algae. Only use distilled water when making this solution. (culturing algae)

Limewater
Add 25 g of calcium hydroxide to 1 liter of DI water; shake; allow the solid to settle before use. Keep container tightly closed. (detecting carbon dioxide gas)

Litmus
0.5% aqueous: dissolve 0.5 g of litmus in 80 mL of boiling DI water. Allow solution to cool to room temperature, dilute to 100 mL. Stir, filter if necessary. (pH indicator)

Note: DI water denotes either distilled or deionized water.

Preparing an Iodine Solution?

Iodine crystals are not directly soluble in water, which is why most water-based iodine solutions call for potassium iodide as an ingredient. Iodine is soluble in potassium iodide solutions.

As a general rule, start with approximately one-fourth of the final volume of water and add the required amount of potassium iodide. Once the potassium iodide has dissolved, add the iodine crystals. Stir until completely dissolved and bring the solution up to its final volume.

Generally, the more concentrated the potassium iodide solution, the more readily the iodine crystals will dissolve. Iodine solutions should be prepared in a fume hood.

RECIPES continued on next page.

Malachite Green
1% aqueous: Dissolve 1 g of malachite green oxalate in 50 mL of DI water; stir gently to prevent foaming; dilute to 100 mL. Filter if necessary. (pH indicator, stain for plant cytoplasm)

Methyl Cellulose
3% aqueous: Heat 100 mL of DI water to 85 °C (not boiling), shake 3.0 g of methyl cellulose powder into hot water, and stir rapidly while cooling the solution to 5 °C in an ice water bath. Solution is stable at room temperature but store in tightly closed containers. (slowing down protozoa for microscopy)

Methylene Blue
1% aqueous: Dissolve 1 g of methylene blue in 75 mL of DI water, then dilute to 100 mL. (pH indicator and stain)

Methylene Blue, Loeffler's
Dissolve 0.3 g of methylene blue in 30 mL of 95% ethyl alcohol; add 0.01 g of potassium hydroxide and 100 mL of DI water; stir, and filter. (bacterial stain)

Methyl Green
1% aqueous, acidified: Dissolve 1 g of methyl green in 75 mL of DI water, add 1 mL of glacial acetic acid, then dilute to 100 mL with DI water. Stir, filter if necessary. Use 1% acidified aqueous solution as a general nuclear stain, plant stain or cytoplasm stain.

Methyl Orange
0.1% aqueous: Dissolve 0.1 g of methyl orange in 75 mL of DI water, then dilute to 100 mL. (pH indicator)

Methyl Red
0.1% alcoholic: Dissolve 0.1 g of methyl red in 75 mL 95% ethyl alcohol, then dilute to 100 mL. (pH indicator)

Methyl Red
0.04% aqueous: Dissolve 0.1 g of methyl red in 11.8 mL of 0.02 M sodium hydroxide solution; dilute to 250 mL with DI water. If using Na salt, omit NaOH. (pH indicator)

Methyl Violet 2B, Indicator
0.04% aqueous: Dissolve 0.1 g of methyl violet 2B in 200 mL of DI water, then dilute to 250 mL. (pH indicator)

Methyl Violet 2B, Stain
Dissolve 0.05 g of methyl violet 2B in 100 mL of 0.7% sodium chloride solution and 1 mL of 1 M acetic acid; stir, and filter if necessary. Use 0.9% sodium chloride solution if staining human blood cells. (staining amphibian and human blood cells)

Methyl Violet 6B, Indicator
1% aqueous: Dissolve 1 g of methyl violet 6B in 75 mL of DI water, then dilute to 100 mL. Stir and filter if necessary. (biological stain)

Millon Reagent
Dissolve 1 part by weight mercury in 2 parts concentrated nitric acid; when mercury has dissolved, add to 2 parts water; stir. Note: always add acid to water. (test for proteins)

Molisch Reagent
Dissolve 5 g 1-naphthol in 100 mL of 95% ethyl alcohol. (test for aldehydes, sugars, and carbohydrates)

Neutral Red
Dissolve 0.1 g of neutral red in 60 mL of 95% ethyl alcohol, then dilute to 100 mL with DI water. Stir and filter if necessary. (pH indicator and vital stain stock solution)

Nigrosin
Saturated: Dissolve 3 g of nigrosin (water soluble) in 100 mL of DI water. Stir and filter if necessary. (biological stain for protozoa)

Ninhydrin
Add 2.5 g of ninhydrin to 50 mL of n-butyl alcohol in a 600-mL beaker. Gently heat and stir the solution using a magnetic stirrer/hot plate in a fume hood until all the solid is dissolved. Dilute to 500 mL with n-butyl alcohol. Use extreme caution when heating n-butyl alcohol, extreme fire risk. (test for proteins)

m-Nitrophenol
0.3% aqueous: dissolve 0.3 g of m-nitrophenol in 75 mL DI water, then dilute to 100 mL. (pH indicator)

p-Nitrophenol
0.1% aqueous: dissolve 0.1 g of p-nitrophenol in 75 mL DI water, then dilute to 100 mL. (pH indicator)

4-(p-Nitrophenylazo) Resorcinol
Dissolve 0.01 g of 4–(p-nitrophenylazo) resorcinol in 100 mL of 1 M sodium hydroxide solution, stir. (indicator solution for magnesium and molybdenum)

Nutrient Agar
Mix together 23 g of nutrient agar with 1 L of DI water. Sterilize for 15 minutes at 121 °C (15 lbs of pressure) in an autoclave or pressure cooker. Nutrient agar should be sterilized if it is being used as culture media. Cool to 50–55 °C and pour into sterilized culture dishes. (culture medium)

Nutrient Agar (using plain agar)
Dissolve 5 g peptone, 3 g meat extract, and 15 g of plain agar in 850 mL of distilled water. Adjust pH to 7.0. Bring to 1 L with distilled water. Autoclave or filter sterilize.

Orange G
1% aqueous: Dissolve 1 g of orange G in 75 mL of DI water, then dilute to 100 mL. Stir and filter if necessary. (staining plant sections)

Orange IV
0.1% aqueous: Dissolve 0.1 g of orange IV in 75 mL of DI water, then dilute to 100 mL. Stir and filter if necessary. (pH indicator and biological stain)

Orcein
Mix together 1 g of orcein, 1 mL of conc. hydrochloric acid, and 100 mL of 100% ethyl alcohol. Shake to dissolve, let sit over night, and filter. (stain for elastic fibers)

Pancreatin
Dissolve 5.0 g of pancreatin in 500 mL of DI water, then dilute to 1 L. Add 0.5 M sodium bicarbonate solution dropwise until solution is neutral. (digestive studies)

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

How To

Slow Microorganisms

Solutions of methyl cellulose are commonly used in microscopy to slow the movements of microorganisms—making them more readily observable. Generally offered as a 2–3% solution in water, its high viscosity physically inhibits the organism. In use, the resulting dilution will depend on the amount of water present on the slide when the slowing agent is added. Some experimentation may be required to find the optimal dilution for a particular organism. One technique involves dropping the methyl cellulose onto a clean slide in the form of a ring. A drop of the culture being studied is then placed into the center of the ring and a cover glass applied. As an alternative, see the listing for polyvinyl alcohol solution.

Phenantholine
See Ferroin Solution, page 1254.

Phenolphthalein
1% alcoholic: Dissolve 1 g of phenolphthalein in 50 mL of 95% ethyl alcohol, then dilute to 100 mL with 95% ethyl alcohol. For a 0.5% solution, only use 0.5 g of phenolphthalein. (pH indicator)

Phenol Red
0.02% alcoholic: Dissolve 0.1 g of phenol red in 400 mL of 95% ethyl alcohol, then dilute to 500 mL with 95% ethyl alcohol. (pH indicator)

Phenol Red, Sodium Salt
0.02% aqueous: Dissolve 0.1 g of phenol red, sodium salt in 400 mL of DI water, then dilute to 500 mL. (pH indicator)

Phloroglucinol
Mix 0.5 g phloroglucinol and 50 mL of DI water. Add 50 mL of conc. hydrochloric acid and stir. Use within 5–7 days. Always add acid to water. (test for pentose or galactose)

Polyvinyl Alcohol
4% aqueous: Add 40 g of polyvinyl alcohol to 1 L of hot tap water. Microwave on high for about 2 minutes; stir, and heat for additional 1–2 minute increments until dissolved. Allow solution to cool before use. (preparation of "slime")

Potato Dextrose Agar
Suspend 39 g of potato dextrose agar in 1 L of DI water. Heat to a boil while stirring constantly. Boil for 1 minute. Sterilize for 15 minutes at 121 °C (15 lbs of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and pour into sterilized culture dishes. If using for plate counts of yeasts and molds, adjust the pH to 3.5 with sterile 10% tartaric acid. (culture medium for plate counts of yeasts and molds)

Pyrogallol
Dissolve 80 g of potassium hydroxide in 65 mL of DI water, add 5 g of pyrogallol, stir, then dilute to 100 mL. Poor shelf life, make fresh. (determining oxygen content)

Resazurin
1% aqueous: Dissolve 1 g of resazurin in 50 mL DI water, then dilute to 100 mL. Stir and filter if necessary. (biological stain and pH indicator)

Richard's Solution
Dissolve 6.6 g of potassium nitrate, 3.3 g of potassium dihydrogen phosphate, 33.3 g sucrose, and 1.7 g of magnesium sulfate in 1 L of DI water. (culture of molds)

Rhodamine B
1% aqueous: Dissolve 1 g of rhodamine B in 50 mL DI water, then dilute to 100 mL. Stir and filter if necessary. (biological stain)

Ringer's Solution for Frogs
Dissolve 0.14 g of potassium chloride, 6.5 g of sodium chloride, 0.12 g calcium chloride, and 0.2 g sodium bicarbonate in 1 L of DI water. (mounting fluid and examination of blood cells)

Ringer's Solution for Mammals
Dissolve 0.42 g of potassium chloride, 9.0 g of sodium chloride, 0.24 g calcium chloride, and 0.2 g sodium bicarbonate in 1 L of DI water. (mounting fluid and examination of blood cells)

Rose Bengal
1% aqueous: Dissolve 1 g of rose bengal in 50 mL DI water, then dilute to 100 mL with distilled water. Stir and filter if necessary. (biological stain)

Sabouraud Dextrose Agar
Suspend 65 g of sabouraud dextrose agar in 1 L of DI water. Heat to boiling while stirring. Boil for 1 minute. Sterilize for 15 minutes at 121 °C (15 lbs of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and pour into sterilized culture dishes. (microbiological culture medium)

Safranin O
Dissolve 0.1 g safranin in 75 mL of DI water, then dilute to 100 mL. Filter before use. (Gram counter stain)

Saline Solution
0.75% aqueous: Dissolve 7.5 g of sodium chloride in 750 mL of DI water, then dilute to 1 L. (Saline solution for birds and invertebrates, use 0.8% for frogs and 0.9% for mammals)

Seawater (Hale's)
Dissolve 23.991 g sodium chloride, 0.742 g potassium chloride, 2.240 g calcium chloride dihydrate, 10.893 g magnesium chloride hexahydrate, 9.10 g sodium sulfate decahydrate, 0.197 g sodium bicarbonate, 0.085 g sodium bromide, 0.018 g strontium chloride hexahydrate, and 0.027 g boric acid in 800 mL DI water. Dilute up to 1 L. Final solution has a salinity of 34.33 0/00 (ppt) and a chlorinity of 19 0/00. Not for aquaria, only for technical purposes.

Seawater
Dissolve 29.42 g of sodium chloride, 0.5 g of potassium chloride, 3.22 g magnesium chloride, 0.56 g sodium bromide, 1.36 g calcium sulfate, 2.4 g magnesium sulfate, 0.11 g calcium carbonate, 0.003 g ferric oxide in 1 L DI water. Not for aquaria, only for technical purposes.

Schiff's Reagent
Dissolve 0.5 g of fuchsin in 500 mL of DI water. Decolorize solution by passing sulfur dioxide gas through the solution, or add 9 g of sodium bisulfite and 20 mL of 2 M hydrochloric acid to the fuchsin solution. (test for aldehydes)

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

Schweitzer's Reagent
Boil a solution of 5 g of copper (II) sulfate pentahydrate in 100 mL of DI water and slowly add 2 M sodium hydroxide solution until precipitation is complete. Filter the copper oxide precipitate, wash with water then dissolve in the minimum volume of 4 M ammonium hydroxide. Also called ammoniacal copper oxide solution. (reagent for dissolving cellulose)

Sebacoyl Chloride/Hexane Solution
Mix 4 mL of sebacoyl chloride with 96 mL of hexanes. (nylon demonstration)

Starch Solution
1% aqueous: Make a smooth paste with 10 g of soluble starch and DI water. Pour the starch paste into 1 L of boiling water while stirring. Cool to room temperature before use. Poor shelf life, always prepare fresh solution. An easier way to make a starch solution is to generously spray ordinary spray starch (the type used for ironing) into DI water. Make fresh. (indicator for iodine)

Sudan III
Warm 73.5 mL of 95% ethyl alcohol in a warm water bath. Add 0.5 g of sudan III and stir. Add 75 °C DI water to just below the 100 mL mark. Stir and cool to room temperature then dilute to 100 mL with DI water. Filter if necessary. (biological stain for fats and lipids)

Sudan IV
Warm 75 mL of 95% ethyl alcohol in a warm water bath. Add 0.5 g sudan IV and stir. Cool to room temperature then dilute to 100 mL with DI water. Filter if necessary. (biological stain for fats and lipids)

10X TBE Electrophoresis Buffer
Dissolve 108 g of Tris base [tris(hydroxymethyl)aminomethane], 55 g of boric acid, and 7.5 g of EDTA, disodium salt in 800 mL of DI water, then dilute to 1 L. There is no need to sterilize the solution. If white clumps begin to precipitate in the solution, place the bottle in hot water until the clumps dissolve. Stored at room temperature. To use as a buffer, dilute 100-mL of 10X stock to 1 L with DI water.

10X TAE Electrophoresis Buffer
Dissolve 48.4 g of Tris base [tris(hydroxymethyl)aminomethane], 11.4 mL of glacial acetic acid (17.4 M), and 3.7 g of EDTA, disodium salt in 800 mL of DI water, then dilute to 1 L. There is no need to sterilize the solution. Stored at room temperature. To use as a buffer, dilute 100-mL of 10X stock to 1 L with DI water.

Thymol Blue
0.04% aqueous: Mix together 0.04 g of thymol blue and 50 mL of DI water. Add 5 mL of 0.01 M sodium hydroxide solution; stir until all the solid has dissolved. Dilute to 100 mL with DI water. (pH indicator)

Thymol Blue
0.04% aqueous: Dissolve 0.04 g of thymol blue, sodium salt in 75 mL of DI water, then dilute to 100 mL. (pH indicator)

Thymolphthalein
0.04% alcoholic: Dissolve 0.04 g of thymolphthalein in 75 mL of anhydrous ethyl alcohol, then dilute to 100 mL with anhydrous ethyl alcohol. (pH indicator)

Tollen's Reagent
Add 2–3 drops of 2 M sodium hydroxide solution to 5 mL of 0.2 M silver nitrate solution; add 2 M ammonium hydroxide solution dropwise until precipitate dissolves. Prepare and use this solution immediately; explosive fulminating silver will form if solution is allowed to stand for any period of time. (test for aldehydes and reducing sugars)

Toluidine Blue O
Mix 1 g of toluidine blue O and 0.5 mL of conc. hydrochloric acid into a homogeneous paste. While stirring, gradually add the paste to 50 mL of DI water, then dilute to 100 mL of DI water. (biological stain for bacteria)

Universal Indicator
Add 0.18 grams of methyl red and 0.36 grams of phenolphthalein to 550 mL of 95% ethyl alcohol (C_2H_5OH); stir to dissolve. In a separate container, add 0.43 grams of bromthymol blue to 200 mL of distilled water; stir to dissolve. Mix together the two solutions; dilute to 1 liter with distilled water. Add 1 M sodium hydroxide solution dropwise until the solution's color is dark green; stir. (Use: pH indicator, pH 4 = red, pH 5 = orange, pH 6 = yellow, pH 7 = light green, pH 8 = green-blue, pH 9 = dark blue-green, pH 10 = purple)

Winkler's Solution #1
Dissolve 480 g of manganese (II) sulfate tetrahydrate in 500 mL of DI water, then dilute to 1 L. (determining dissolved oxygen)

Winkler's Solution #2
Dissolve 500 g of sodium hydroxide and 135 g of sodium iodide in 700 mL of DI water, then dilute to 1 L. A large amount of heat is generated, place the mixing container in an ice water bath. Store in a plastic container. (determining dissolved oxygen)

Wright's Stain
Dissolve 2.5 g of Wright's stain in 75 mL of absolute methyl alcohol, then dilute to 100 mL with absolute methyl alcohol. Stir and filter if necessary. (biological stain for blood)

Note: DI water denotes either distilled or deionized water.