HAND HEART HEAD

Laboratory Manual

Preparation and Maintenance of Stock Solution

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DEPARTMENT OF BOTANY

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Preparation and Maintenance of Stock Solution

Stock solution

A **stock solution** is a large volume of common reagent, such as hydrochloric acid or sodium hydroxide, at a standardized concentration. This term is commonly used in analytical chemistry for procedures such as titrations, where it is important that exact concentrations of solutions are used. Stock solutions do not necessarily come in concentrations of simple numbers; for example a solution could be 0.1 M HCl. In biochemistry, the term is often used to refer to a concentrated solution, from which one can dilute into a working concentration of solution. Stock solutions are used to save preparation time, conserve materials, reduce storage space, and improve the accuracy with which working lower concentration solutions are prepared.

Solutions are commonly made up in the laboratory from solid materials, from liquids or from other solutions. The descriptions below assume knowledge of the calculations required to determine solution concentrations, the ability to accurately weigh solids and to pipette liquids.

From solid material

(1) Determine the concentration and amount of solution required for the experiment.

(2) Calculate the amount of solute required to prepare the desired solution.

(3) Weigh out the amount of solute calculated in step (2) and obtain a volumetric flask of appropriate volume.

(4) Add the solute to the volumetric flask.

(5) Fill the volumetric flask approximately two thirds full, stopper and mix. Do this by inverting the flask, shaking and returning the flask to upright. Do this ten times. Make sure to hold the stopper in the flask.

(6) Carefully fill the flask to the mark etched on the neck of the flask. Use a wash bottle or medicine dropper if necessary.

(7) Mix the solution thoroughly by stoppering the flask securely and inverting it ten to twelve times.

From a liquid or other solution

(1) Determine the concentration and amount of solution required for the experiment.

(2) Calculate the amount of stock solution or liquid required to prepare the desired solution (a stock solution is one with a known concentration greater than the solution you are preparing).

(3) Use a pipet to measure the amount of solution or liquid calculated in step (2).

(4) Add the solution or liquid to a volumetric flask of appropriate volume.

(5) Fill the volumetric flask approximately two thirds full and mix.

(6) Carefully fill the flask to the mark etched on the neck of the flask. Use a wash bottle or medicine dropper if necessary.

(7) Mix the solution thoroughly by stoppering the flask securely and inverting it ten to twelve times.

Preparing a solution of known concentration is perhaps the most common activity in any analytical lab. The method for measuring out the solute and the solvent depend on the desired concentration and how exact the solution's concentration needs to be known. Pipets and volumetric flasks are used when we need to know a solution's exact concentration; graduated cylinders, beakers, and/or reagent bottles suffice when a concentrations need only be approximate. Two methods for preparing solutions are described in this section.

Preparing Stock Solutions

A ***stock solution*** is prepared by weighing out an appropriate portion of a pure solid or by measuring out an appropriate volume of a pure liquid, placing it in a suitable flask, and diluting to a known volume. Exactly how one measure's the reagent depends

on the desired concentration unit. For example, to prepare a solution with a known molarity you weigh out an appropriate mass of the reagent, dissolve it in a portion of solvent, and bring it to the desired volume. To prepare a solution where the solute's concentration is a volume percent, you measure out an appropriate volume of solute and add sufficient solvent to obtain the desired total volume.

Example

Describe how to prepare the following three solutions:

(a) 500 mL of approximately 0.20 M NaOH using solid NaOH;

(b) 1 L of 150.0 ppm Cu^{2+} using Cu metal; and

(c) 2 L of 4% v/v acetic acid using concentrated glacial acetic acid (99.8% w/w acetic acid).

Solution

(a) Because the desired concentration is known to two significant figures, we do not need to measure precisely the mass of NaOH or the volume of solution.

The desired mass of NaOH is

$$0.20 \text{ mol NaOH} \text{L} \times 40.0 \text{ g NaOH} \text{mol NaOH} \times 0.50 \text{ L} = 4.0 \text{ g NaOH}$$

To prepare the solution, place 4.0 grams of NaOH, weighed to the nearest tenth of a gram, in a bottle or beaker and add approximately 500 mL of water.

(b) Since the desired concentration of Cu^{2+} is given to four significant figures, we must measure precisely the mass of Cu metal and the final solution volume. The desired mass of Cu metal is

$$150.0 \text{ mg Cu} \text{L} \times 1.000 \text{ M} \times 1 \text{ g} 1000 \text{ mg} = 0.1500 \text{ g Cu}$$

To prepare the solution, measure out exactly 0.1500 g of Cu into a small beaker and dissolve it using a small portion of concentrated HNO_3. To ensure a complete transfer of Cu^{2+} from the beaker to the volumetric flask—what we call a ***quantitative transfer***—rinse the beaker several times with small portions of water, adding each rinse to the volumetric flask. Finally, add additional water to the volumetric flask's calibration mark.

(c) The concentration of this solution is only approximate so it is not necessary to measure exactly the volumes, nor is it necessary to account for the fact that glacial acetic acid is slightly less than 100% w/w acetic acid (it is approximately 99.8% w/w). The necessary volume of glacial acetic acid is

$$4 \text{ mL } CH_3COOH100 \text{ mL} \times 2000 \text{ mL} = 80 \text{ mL } CH_3COOH$$

To prepare the solution, use a graduated cylinder to transfer 80 mL of glacial acetic acid to a container that holds approximately 2 L and add sufficient water to bring the solution to the desired volume.

Exercise

Provide instructions for preparing 500 mL of 0.1250 M $KBrO_3$.

Answer

Preparing 500 mL of 0.1250 M $KBrO_3$ requires

$$0.5000 \text{ L} \times 0.1250 \text{ mol KBrO3L} \times 167.00 \text{ g KBrO3mol KBrO3} = 10.44 \text{ g KBrO3}$$

Because the concentration has four significant figures, we must prepare the solution using volumetric glassware. Place a 10.44 g sample of $KBrO_3$ in a 500-mL volumetric flask and fill part way with water. Swirl to dissolve the $KBrO_3$ and then dilute with water to the flask's calibration mark.

Preparing Solutions by Dilution

Solutions are often prepared by diluting a more concentrated stock solution. A known volume of the stock solution is transferred to a new container and brought to a new volume. Since the total amount of solute is the same before and after dilution, we know that

$$Co \times Vo = Cd \times Vd$$

Where *Co* is the stock solution's concentration, *Vo* is the volume of stock solution being diluted, *Cd* is the dilute solution's concentration, and *Vd* is the volume of the dilute solution. Again, the type of glassware used to measure *Vo* and *Vd* depends on how precisely we need to know the solution's concentration.

Note that Equation: $Co \times Vo = Cd \times Vd$

Applies only to those concentration units that are expressed in terms of the solution's volume, including molarity, formality, normality, volume percent, and weight-to-volume percent. It also applies to weight percent, parts per million, and parts per billion if the solution's density is 1.00 g/mL.

If we express concentration in terms of molality as this is based on the mass of solvent, not the volume of solution.

Example

A laboratory procedure calls for 250 mL of an approximately 0.10 M solution of NH_3. Describe how you would prepare this solution using a stock solution of concentrated NH_3 (14.8 M).

Solution

Substituting known volumes into Equation: $Co \times Vo = Cd \times Vd$

14.8 M×*Vo*=0.10 M×250 mL and solving for *Vo*

Gives 1.7 mL. Since we are making a solution that is approximately 0.10 M NH_3, we can use a graduated cylinder to measure the 1.7 mL of concentrated NH_3, transfer the NH_3 to a beaker, and add sufficient water to give a total volume of approximately 250 mL. Although usually we express molarity as mol/L, we can express the volumes in mL if we do so both for both *Vo* and *Vd*

.

Exercise

To prepare a standard solution of Zn^{2+} you dissolve a 1.004 g sample of Zn wire in a minimal amount of HCl and dilute to volume in a 500-mL volumetric flask. If you dilute 2.000 mL of this stock solution to 250.0 mL, what is the concentration of Zn^{2+}, in µg/mL, in your standard solution?

Answer

As shown in the following example, we can use Equation: $Co \times Vo = Cd \times Vd$

To calculate a solution's original concentration using its known concentration after dilution.

Example

A sample of an ore was analyzed for Cu^{2+} as follows. A 1.25 gram sample of the ore was dissolved in acid and diluted to volume in a 250-mL volumetric flask. A 20 mL portion of the resulting solution was transferred by pipet to a 50-mL volumetric flask and diluted to volume. An analysis of this solution gives the concentration of Cu^{2+} as 4.62 µg/mL. What is the weight percent of Cu in the original ore?

Solution

Substituting known volumes (with significant figures appropriate for pipets and volumetric flasks) into Equation 2.5.1

(*C*Cu)*o*×20.00 mL=4.62*µ*g/mL Cu2+×50.00 Ml and solving for (*C*Cu)*o*

Gives the original concentration as 11.55 µg/mL Cu^{2+}. To calculate the grams of Cu^{2+} we multiply this concentration by the total volume

11.55*µ*g Cu2+mL×250.0 mL×1 g106*µ*g=2.888×10−3 g Cu2+

The weight percent Cu is

2.888×10−3 g Cu2+1.25 g sample×100=0.231% w/w Cu2+

The Plant Tissue Culture Medium components

One of the most important factors governing the growth and morphogenesis of the plant tissues in culture is the composition of the culture medium. The basic nutrient requirements of cultured plant cells are very similar to those of whole plants. The basic requirements of mineral elements required for the growth of plant tissues are fulfilled by providing their common salts in the medium. When mineral salts are dissolved in water, they undergo dissociation and ionization. The active factor in the medium is the ions of different types rather than the compounds. One type of ion may be contributed by more than one salt in the medium. Therefore, a meaningful comparison between two media can be made on the basis of total concentrations of different types of ions in them. Plant tissue culture media provide not only these inorganic nutrients, but usually a carbohydrate (sucrose is most common) to replace the carbon which the plant normally

fixes from the atmosphere by photosynthesis. To improve growth, many media also include trace amounts of certain organic compounds, notably vitamins, and plant growth regulators.

Plant tissue culture media are generally made up from solutions of the following components:

- Macronutrients
- Micronutrients
- Vitamins
- Amino acids or other nitrogen supplements
- Carbohydrates or sugars
- Solidifying agents or supporting systems and
- Growth regulators (plant hormones)

Stock solution for Tissue culture medium

Components (mg/l)	Murashige - Skoog (1962)	White (1963)	Gamborg (1968)	Heller (1953)	Schenk - Hildebrandt (1972)	Nitsch - Nitsch (1967)	Kohlenbach - Schmidt (1975)
$(NH_4)_2SO_4$	-	-	134	-	-	-	-
$MgSO_4.7H_2O$	370	720	500	250	400	125	185
Na_2SO_4	-	200	-	-	-	-	-
KCl	-	65	-	750	-	-	-
$CaCl_2.2H_2O$	440	-	150	75	200	-	166
$NaNO_3$	-	-	-	600	-	-	-
KNO_3	1 900	80	3 000	-	2 500	125	950
$Ca(NO_3)_2.4H_2O$	-	300	-	-	-	500	-
NH_4NO_3	1650*	-	-	-	-	-	720
$NaH_2PO_4.H_2O$	-	16.5	150	125	-	-	-
$NH_4H_2PO_4$	-	-	-	-	300	-	-
KH_2PO_4	170	-	-	_	-	125	68
$FeSO_4.7H_2O$	27.8	-	27.8	-	15	27.85	27.85
Na_2EDTA	37.3	-	37.3	-	20	37.25	37.25
$MnSO_4.4H_2O$	22.3	7	10 (H_2O)	(1	0.1	10	25	25
$ZnSO_4.7H_2O$	8.6	3	2	1	0.1	10	10
$CuSO_4.5H_2O$	0.025	-	0.025	0.03	0.02	0.025	0.025
$Fe_2(SO_4)_3$	-	2.5	-	-	-	-	-
$NiCl_2.6H_2O$	-	-	-	0.03	-	-	-
$CoC1_2.6H_2O$	0.025	-	0.025	-	0.1	0.025	-
$AlCl_3$	-	-	-	0.03	-	-	-
$FeCl_3.6H_2O$	-	-	-	1	-	-	-
KI	0.83	0.75	0.75	0.01	1	-	-
H_3BO_3	6.2	1.5	3	1	5	10	10
$Na_2MoO_4.2H_2O$	0.25	-	0.25	-	0.1	0.25	0.25
Myo-inositol	100	-	100	-	1 000	100	100
Nicotinic acid	0.5	0.5	1	-	0.5	5	5
Pyridoxine HCl	0.5	0.1	1	-	0.5	0.5	0.5
Thiamine HCl	0.1-1	0.1	10	1	5	0.5	0.5
Ca-antothenate	-	1	-	-	-	-	-
Biotin	-	-	-	-	-	0.05	0.05
Glycine	2	3	-	-	-	2	2

Components (mg/l)	Murashige - Skoog (1962)	White (1963)	Gamborg (1968)	Heller (1953)	Schenk Hildebrandt (1972)	- Nitsch - Nitsch (1967)	Kohlenbach - Schmidt (1975)
Cysteine HCl	-	1	-	-	-	-	-
Folic acid	-	-	-	-	-	0.5	0.5
Glutamine	-	-	-	-	-	-	14.7
Sucrose	30	20	20	20	30	20-30	10

pH: Acidic solution (pH 5.7-5.8) is used in the original study (Murashige and Skoog, 1962). Preparation of solid media **-0.8% Agar**

Working concentration

	Constituents	Concentration (mg/l)	Concentration of stock solution (mg/l)	Volume of stock/ liter of medium (ml)
Macroelements (stock-I)	NH_4NO_3	1,650	33,000	50
	KNO_3	1,900	38,000	
	$CaCl_2\ 2H_2O$	440	8,800	
	$MgSO_4\ 7H_2O$	370	7,400	
	KH_2PO_4	170	3,400	
Microelements (stock-II)	KI	0.83	166	5
	H_3BO_3	6.2	1,240	
	$MnSO_4\ 4H_2O$	22.3	4,460	
	$ZnSO_4\ 7H_2O$	8.60	1,720	
	$Na_2MoO_4\ 2H_2O$	0.25	50	
	$CuSO_4\ 5H_2O$	0.025	5	
	$CoCl_2\ 6H_2O$	0.025	5	
Iron (stock-III)	$FeSO_4\ 7H_2O$	27.85	5,560	5
	Na_2EDTA	37.25	7,460	
Vitamins (stock-IV)	Meso inositol	100	20,000	5
	Glycine	2.0	400	
	Nicotinic acid	0.5	100	
	Pyridoxine–HCl	0.5	100	
	Thiamine–HCl	0.1	20	

Preparation and use of stock solutions

It is very convenient to have stock solutions of the main salts and buffers used during purification. Correctly and carefully prepared stock solutions can noticeably improve accuracy and reproducibility of the purification procedures.

Stock solution preparation sequence

When preparing stock solutions, follow the sequence below:

Weigh powder → dissolve in about 80% of final required volume of ultra pure water→ adjust pH (for buffers and EDTA only**)** → **adjust to final volume with ultra pure water** → **filter (**also see poster in Apendix2**)**

The most useful stock solutions in protein purification are:

- ✓ **5M NaCl**
- ✓ **4M $(NH_4)_2SO_4$**
- ✓ **1M Tris-HCl, pH 8.0**

To prepare this solution you need to adjust the pH to 8.0 with concentrated HCl, this titration generates heat. However Tris buffer is temperature sensitive: raising the temperature by 3°C decreases pH by 0.1**.** To make a reproducible stock solution it is best to adjust pH on a water-ice bath with a thermometer placed in the solution, you are aiming for pH 8.0 at 20^{o}C. A significant volume of concentrated HCl is required to adjust pH, therefore Tris powder should be dissolved in 60-70% of the final volume, pH adjusted to 8.0, then water added to final volume.

Other stock solutions:

0.2M - 0.25M EDTA.

The stock concentration is relatively low due to the low solubility of this compound. Add 5M NaOH to the solution until all EDTA is dissolved (pH is 7.5-8) before you adjust it to required volume.

Buffers:

1M HEPES-NaOH pH 7.0 or 7.5
1M MES-NaOH pH 6.0 or 6.5

Unlike Tris buffer, these buffers are not temperature sensitive so there is no need to controltemperatures during their preparation.

It is best to keep stock buffers in the fridge.

Preparation of working buffers from stock solutions

By having stock solutions you can prepare any buffer for protein purification in seconds. Simply pour required volumes of stock solutions in to a Duran bottle and adjust the volume withultra pure water to the top mark on the bottle.

Worked example: to prepare 1 litre of buffer *50mM tris-HCl pH 8, 100 mM NaCl, 2mM EDTA*: pour 50 ml of 1M tris-HCl, 20 ml of 5M NaCl and 10 ml of 0.2M EDTA in to a 1 litre bottle and add ultra pure water to 1 litre mark.

Please note that dilution leads to a decrease in buffer pH. Normally we use 50 mM solutionfor purification (made from the 1M stock) and the actual pH for tris, MES or HEPES buffer is about 0.3 pH units lower than in 1M buffer. For 50mM tris buffer prepared from 1M stock pH 8.0 actual pH at 20^{o}C is about 7.7. However if we use it at 4^{o}C the pH is at about 8.

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 exam- ples 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.

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

$g_{NaCl} = 58.45 \text{ g/mol} \times 2 \text{ mol/L} \times 0.8 \text{ L} g_{NaCl} = 93.52 \text{ g NaCl}$

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 solu-tion.
- Calculate volume of starting solution (V_1) required using equa-tion 2. Note: V_1 must be in the same units as V_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.

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.

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.

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.

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 x 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

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
% 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.

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 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)

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.

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)

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)

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
1% 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
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)

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.

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% alcoholic: Dissolve 1 g of methyl green in 75 mL of 95% ethyl alcohol, then dilute to 100 mL with 95% ethyl alcohol. Stir, filter if necessary. Use 70% ethyl alcohol if stain is for plant tissue. (stain for plant tissue and supravital stain for small organisms)

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)

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 DIwater, then dilute to 1 L. Add 0.5 M sodium bicarbonate solution dropwise until solution is neutral. (digestive studies)

Phenantholine
See Ferroin Solution, page 1160.

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.

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)

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)

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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)

Preparation of Simple Inorganic Salt Solutions

Name / Formula / F.W.	Concentration	g/L
Aluminum chloride	0.2 M	48.3 g
$AlCl_3 \cdot 6H_2O$	0.05 M	12.1 g
241.43		
Aluminum nitrate	0.1 M	37.5 g
$Al(NO_3)_3 \cdot 9H_2O$		
375.13		
Aluminum sulfate	0.1 M	66.6 g
$Al_2(SO_4)_3 \cdot 18H_2O$		
666.42		
Ammonium acetate	1.0 M	77.1 g
$NH_4C_2H_3O_2$	0.1 M	7.7 g
77.08		
Ammonium chloride	1.0 M	53.5 g
NH_4Cl	0.5 M	26.7 g
53.49		
Ammonium nitrate	1.0 M	80.0 g
NH_4NO_3	0.5 M	40.0 g
80.04	0.1 M	8.0 g
Ammonium sulfate	0.1 M	13.2 g
$(NH_4)_2SO_4$		
132.1		
Barium chloride	0.1 M	24.4 g
$BaCl_2 \cdot 2H_2O$		
244.28		
Barium hydroxide	0.1 M	31.5 g
$Ba(OH)_2 \cdot 8H_2O$		
315.50		
Barium nitrate	0.5 M	130.7 g
$Ba(NO_3)_2$	0.1 M	26.1 g
261.35		
Bismuth nitrate	0.1 M	48.5 g in 500 mL 6M HNO_3*
$Bi(NO_3)_3 \cdot 5H_2O$		
485.1		

Name / Formula / F.W.	Concentration	g/L
Bismuth trichloride	0.2 M	63.1 g in 500 mL 3M HCl*
$BiCl_3$		
315.34		
Cadmium chloride	0.1 M	22.8 g
$CdCl_2 \cdot 2½H_2O$		
228.34		
Cadmium nitrate	0.1 M	30.8 g
$Cd(NO_3)_2 \cdot 4H_2O$		
308.49		
Calcium acetate	0.5 M	88.1 g
$Ca(C_2H_3O_2)_2 \cdot H_2O$	0.1 M	17.6 g
176.19		
Calcium chloride	1.0 M	147.0 g
$CaCl_2 \cdot 2H_2O$	0.1 M	14.7 g
147.02		
Calcium hydroxide	saturated	2 g†
$Ca(OH)_2$		
74.10		
Calcium nitrate	0.5 M	118.1
$Ca(NO_3)_2 \cdot 4H_2O$	0.1 M	23.6 g
236.16		
Chromium(III) chloride	0.1 M	26.6 g
$CrCl_3 \cdot 6H_2O$		
266.48		
Chromium(III) nitrate	0.1 M	40.0 g
$Cr(NO_3)_3 \cdot 9H_2O$		
400.18		
Cobalt(II) chloride	0.1 M	23.8 g
$CoCl_2 \cdot 6H_2O$		
237.95		
Cobalt(II) nitrate	0.1 M	29.1 g
$Co(NO_3)_2 \cdot 6H_2O$		
291.05		
Copper(II) chloride	0.5 M	85.2 g
$CuCl_2 \cdot 2H_2O$	0.1 M	17.0 g
170.49		
Copper(II) nitrate	0.5 M	120.8 g
$Cu(NO_3)_2 \cdot 3H_2O$	0.1 M	24.2 g
241.6		
Copper(II) sulfate	1.0 M	249.7 g
$CuSO_4 \cdot 5H_2O$	0.5 M	124.8 g
249.69		
Iron(II) sulfate	0.01 M	2.8 g and 1 mL conc. H_2SO_4*
$FeSO_4 \cdot 7H_2O$		
278.03		
Iron(III) chloride	1.0 M	270.3 g
$FeCl_3 \cdot 6H_2O$	0.1 M	27.0 g
270.32		
Iron(III) nitrate	0.1 M	40.4 g
$Fe(NO_3)_3 \cdot 9H_2O$		
404.00		

***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.

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.

Name / Formula / F.W.	Concentration	g/L
Potassium chromate	1.0 M	194.2 g
K_2CrO_4	0.5 M	97.1 g
194.21	0.1 M	19.4 g
Potassium dichromate	0.1 M	29.4 g
$K_2Cr_2O_7$		
294.22		
Potassium ferricyanide	0.5 M	164.6 g
$K_3Fe(CN)_6$	0.1 M	32.9 g
329.26		
Potassium ferrocyanide	0.1 M	42.2 g
$K_4Fe(CN)_6 \cdot 3H_2O$		
422.41		
Potassium hydrogen phthalate	0.1 M	20.4 g
$KHC_8H_4O_4$		
204.23		
Potassium hydroxide see page 118		
Potassium iodate	saturated	214.0 g†
KIO_3	0.2 M	42.8 g
214.01	0.1 M	21.4 g
Potassium iodide	1 M	166.0 g
Kl	0.5 M	83.0 g
166.01	0.2 M	33.2 g
Potassium nitrate	0.5 M	50.6 g
KNO_3	0.1 M	10.1 g
Potassium permanganate	0.2 M	31.6 g
$KMnO_4$	0.1 M	15.8 g
158.04	0.01 M	1.6 g
Potassium phosphate, monobasic	0.1 M	13.6 g
KH_2PO_4		
136.09		
Potassium phosphate, dibasic	0.1 M	17.4 g
K_2HPO_4		
174.18		

Name / Formula / F.W.	Concentration	g/L
Potassium phosphate, tribasic	0.1 M	21.2 g
K_3PO_4		
212.27		
Potassium sulfate	0.5 M	87.1 g
K_2SO_4	0.1 M	17.4 g
174.27		
Potassium thiocyanate	1.0 M	97.2 g
KSCN	0.5 M	48.6 g
97.18	0.1 M	9.7 g
Silver nitrate	0.5 M	84.9 g
$AgNO_3$	0.1 M	17.0 g
169.87		
Sodium acetate	1 M	136.1 g
$NaC_2H_3O_2 \cdot 3H_2O$	0.5 M	68.0 g
136.08		
Sodium bicarbonate	0.5 M	42.0 g
$NaHCO_3$	0.1 M	8.4 g
84.01		
Sodium borate	4 %	40.0 g
$Na_2B_4O_7 \cdot 10H_2O$		
381.42		
Sodium bromide	1.0 M	102.9 g
NaBr	0.1 M	10.3 g
102.90		
Sodium carbonate	saturated	214.0 g†
Na_2CO_3	1.0 M	106.0 g
105.99	0.1 M	10.6 g
Sodium carbonate	1.0 M	124.0 g
$Na_2CO_3 \cdot H_2O$	0.1 M	12.4 g
124.00		

***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.

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.

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 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
	0.1 M	26.8 g
$Na_2HPO_4 \cdot 7H_2O$		
268.07		
Sodium phosphate, dibasic	0.5 M	71.0 g
	0.1 M	14.2 g
Na_2HPO_4		
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.

Distilled or Deionized Water—Which Do I Need?

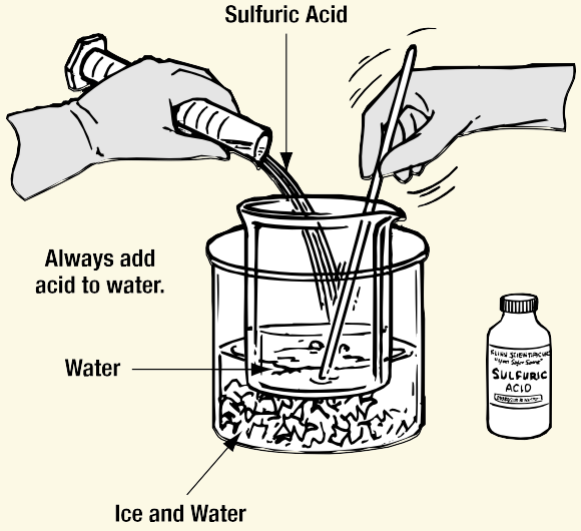
Distilled water is free of inorganic materials, suspended impurities, and most organic contaminants. To make or buy distilled water is expensive. While there may be school laboratory applications where distilled water is required, in many applications, deionized (aka demineralized) water will do just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

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.



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.