VOLUMETRIC GLASSWARE:
GRADUATED CYLINDERS,BURETS, AND PIPETS

Many chemical reactions in the laboratory are carried out in solution, therefore, the preparation and measurement of solutions is important. For the preparation of solutions, volumetric flasks are most commonly used, they are illustrated in the section on *Laboratory Glassware and Apparatus*. Some glassware, such as graduated cylinders, are meant to *contain* a specific range of liquid volumes while others, such as pipets, are meant to *deliver* specific amounts of liquids. Such glassware is marked either TC or TD on its label along with a temperature, usually 20°C. (See Figure V-1) The letters TD mean "to deliver" and indicate that the item of glassware will deliver the designated volume marked on it. TD glassware is calibrated to account for drops of liquid which adhere to the surface of the glass and it is not necessary to shake or force out the last remaining drops of liquid, doing so will result in an error in your volume measurement. TC glassware is calibrated "to contain" the indicated volume marked on it and must be emptied out to obtain an accurate volume. The calibration temperature is included since liquid volumes change due to expansion or contraction as temperature changes.

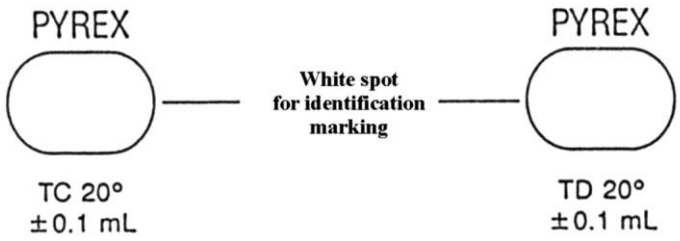


Figure V-1. Labels on volumetric glassware.

The Graduated Cylinder

One of the most commonly used measuring devices in the laboratory is the graduated cylinder. The graduated cylinder is used to measure and dispense liquid samples. Figure V-2 shows a typical 100-mL graduated cylinder.

Note that the 100-mL graduated cylinder is shown with a plastic safety ring positioned near the top of the cylinder. This ring serves two purposes. First, it can prevent the cylinder form shattering if it is knocked over on the lab bench and, second, it acts as a splash guard to protect your hand from drips or splashes when pouring liquids in or from the cylinder. If your graduated cylinder does not have a safety ring, obtain one from the chemistry stockroom or from your instructor.

Figure V-3 shows the graduations on the 10-mL and the 100-mL graduated cylinders. Examine the graduations on the diagrams with the graduated cylinders in your locker. What liquid volume is represented by each graduation on these graduated cylinders?

Note that the graduations on a 10-mL graduated cylinder are in 0.1 mL increments. A 10-mL graduated cylinder can be read to 0.05 mL and estimated to 0.01 mL. A 100-mL graduated cylinder is graduated in 1 mL increments and can be read to 0.1 mL.

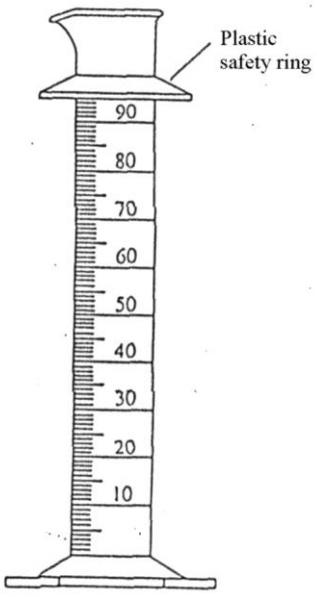


Figure V-2. A 100-mL graduated cylinder.

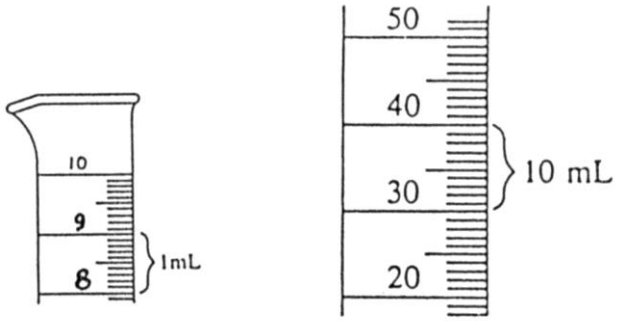


Figure V-3. Comparison of the graduations on a 10-mL and a 100-mL graduated cylinder

Pour some water into a graduated cylinder. Notice that the water surface is curved downward. This surface is called the **meniscus**. When reading the volume of the liquid, hold the cylinder so the meniscus is at eye level and read the volume at the lowest point of the curve (see Figure V-4). It may be helpful to place a white piece of paper or card behind the meniscus when reading the volume.

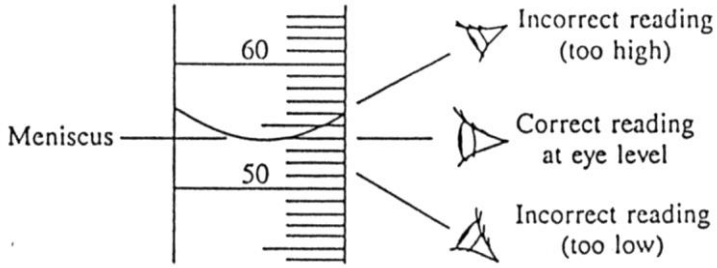


Figure V-4. Reading the volume of a liquid. The reading on the graduate cylinder shown is 54.0 mL.

The Pipet

Two types of pipets are commonly used in the laboratory. These are the Mohr or graduated pipet and the volumetric or transfer pipet. These are shown in Figure V-5.

The Mohr pipet is graduated to deliver a range of volumes within its total capacity. For example, the 10-mL Mohr pipet shown in Figure V-5, can be used to deliver volumes up to 10 mL in 0.1 mL increments. The volumetric pipet, is used deliver only a single specific volume of liquid.

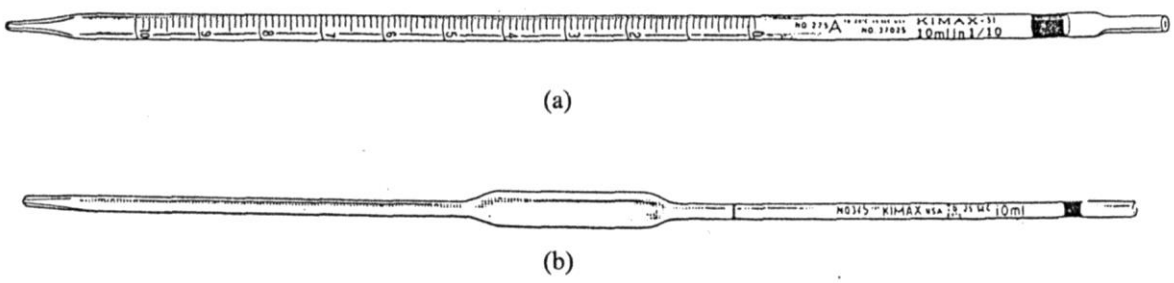
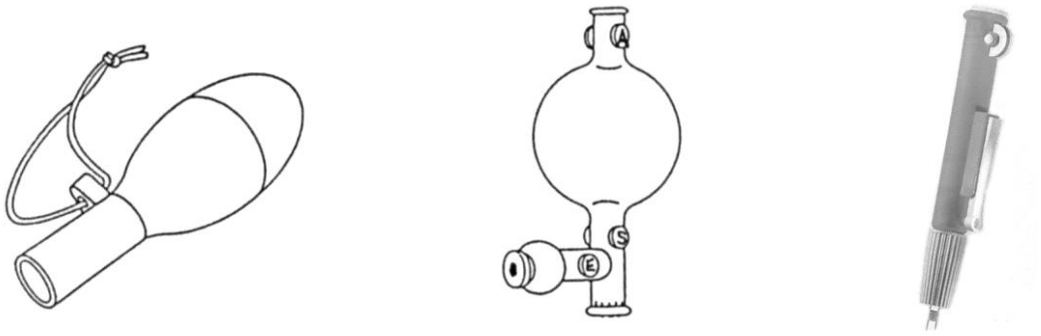


Figure V-5. (a) The Mohr pipet and (b) the Volumetric pipet

When using a pipet, always fill the pipet using a pipet safety bulb to suck the liquid into the pipet. **NEVER PIPET BY MOUTH**. Three types of pipet safety bulbs are shown in Figure V-6.



(a) (b) (c)

Figure V-6. Three types of pipet safety bulbs, (a) The simple bulb, (b) The valve-type bulb, and (c) the pipet pump.

To use the simple bulb, hold the tip of the pipet under the surface of the liquid to be measured, squeeze the bulb then press it against the top of the pipet and slowly release your pressure on the bulb allowing the liquid to be gently sucked into the pipet until it passes the volume mark on the pipet stem, then *quickly* remove the bulb placing the tip of your index finger over the top of the pipet. You can now use your index finger to control the flow of liquid form the pipet. Practice this technique. (see Figure V-7)

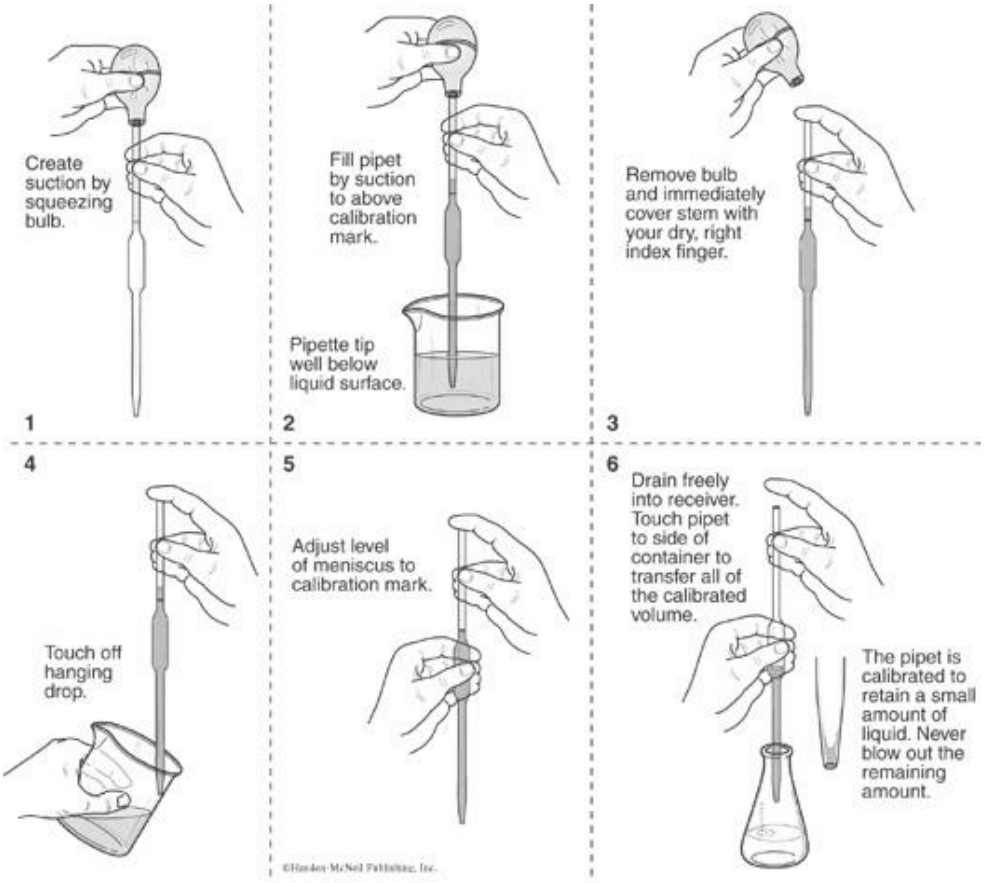


Figure V-7. Using a simple pipet safety bulb

To use the valve-type bulb, squeeze the valve marked "A" and at the same time squeeze the rubber bulb to expel the air. Release valve "A" before releasing the rubber bulb. Attach the bulb to the top of the pipet, place the tip of the pipet under the surface of the liquid to be measured, and squeeze valve "S"; this will allow liquid to be sucked into the pipet. When the liquid level rises above the volume mark on the pipet, release valve "S". To empty liquid form the pipet, squeeze valve "E". Practice this technique. (See Figure V-8)

To use the pipet pump, insert the pipet into the opening on the bottom of the pump, place the tip of the pipet under the surface of the liquid to be measured, and use your thumb to turn the wheel on the side of the pump. When the liquid is slightly above the volume mark on the pipet, stop turning the wheel. Carefully turn the wheel to adjust the liquid level to the volume mark. The pipet is emptied by either rotating the wheel to empty the pipet or, if the pipet pump is so equipped, squeeze the release valve. (See Figure V-8)

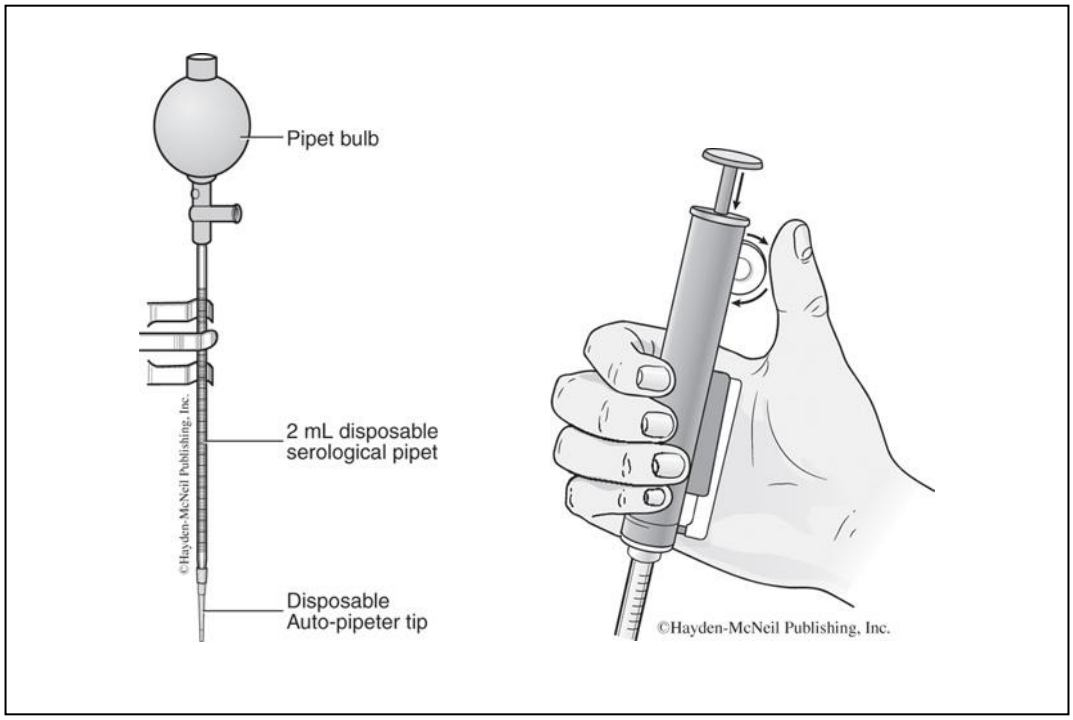


Figure V-8. Using pipets with (a) a valve-type bulb and (b) a pipet pump

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When using a pipet always observe the following:

1. Rinse the pipet with the liquid to be measured at least twice. Drain the rinse liquid into a beaker for waste solution for proper disposal. This step insures the solution delivered will be at the proper concentration.

2. When filling the pipet, always keep the tip of the pipet under the surface of the liquid. If not, air bubbles will be sucked into the pipet and liquid will be sucked into the pipet bulb. This will result in contamination of the solution being measured.

3. When using a Mohr (graduated) pipet, observe the last graduation. Some pipets will deliver a volume, such as 10 mL, when the liquid level reaches the 10 mL graduation line leaving as much as 1 mL in the pipet below the last graduation. Some pipets must be emptied to deliver the marked volume.

4. Always rinse the pipet at least three times with distilled water between measurements of different liquids and when you are finished using it.

The Buret

The most accurate piece of apparatus for measuring and dispensing small amounts of liquids is the buret (see Figure V-9). The buret consists of a long graduated glass tube with a stopcock near the tip to control the liquid flow.

To use the buret, first empty out any liquid in it (the burets are sometimes stored containing distilled water). If available, place a small funnel on top of the buret. (See Figure V-10) Add approximately 10 mL of the liquid to be measured to the buret. Move to a sink or place a large beaker on the bench top, tilt the buret almost on its side with the open end over the sink or the large beaker, and rotate it so that the liquid comes in contact with the entire internal surface of the graduated tube. If any liquid spills out the open end, it will fall into the sink or the large beaker. Clamp the buret upright and drain the liquid through the tip by opening the stopcock. Repeat the rinsing procedure TWO MORE TIMES using 10 mL of fresh liquid each time before filling the buret to the top (the zero line). Note that the buret is read from top to bottom as the liquid flows out.

It is not necessary to fill the buret up to the top for each new measurement. Simply record the initial and final reading of the liquid volume and subtract them to find the volume dispensed. Do not, however, allow the liquid level to go below the 50-mL graduation line (or the bottom graduation on a smaller buret) as the concentration cannot not be read below that line.

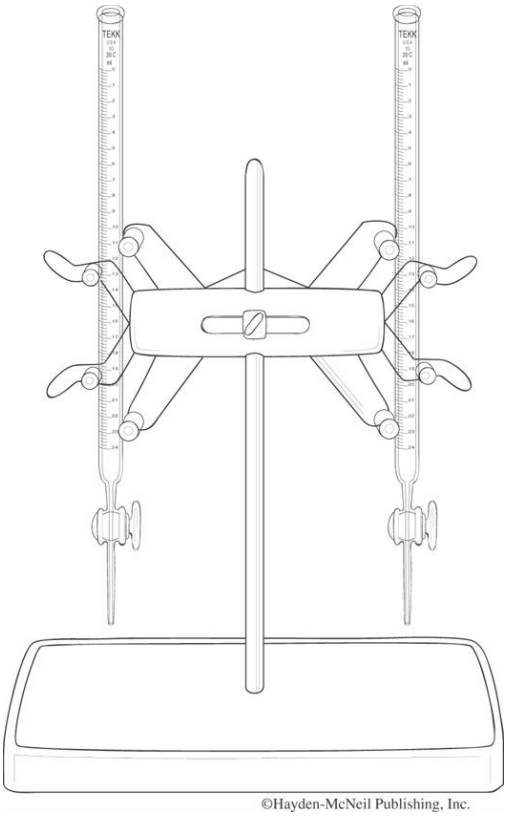

Figure V-9. The Buret showing the double buret clamp and stand.

To titrate a solution using a buret, use one hand to operate the stopcock, preferably holding it from the reverse side, and allow a slow flow of liquid while swirling the receiver flask with your other hand. (See Figure V-11) If you do not have a buret stand with a white base, place a piece of white paper under the flask to increase the visibility of any color change of the indicator solution in the flask.

When finished with the buret, empty any solution left in it and dispose of it as directed. Rinse the buret three times with distilled water, then fill it with distilled water or store it as instructed by your laboratory instructor.

It is not necessary to remove the stopcock from a buret unless it become stuck or clogged. Always ask your instructor for assistance if the stopcock assembly needs servicing. The proper arrangement of the stopcock assembly is shown in Figure S-12.

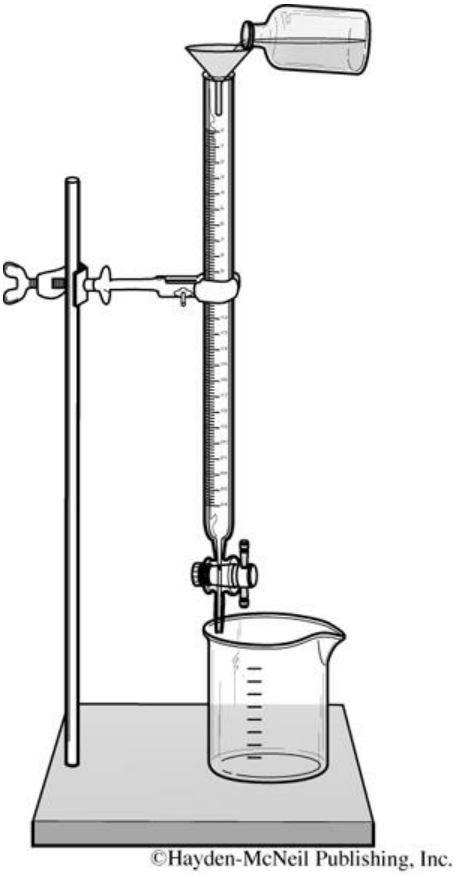

Figure V-10. Filling a buret

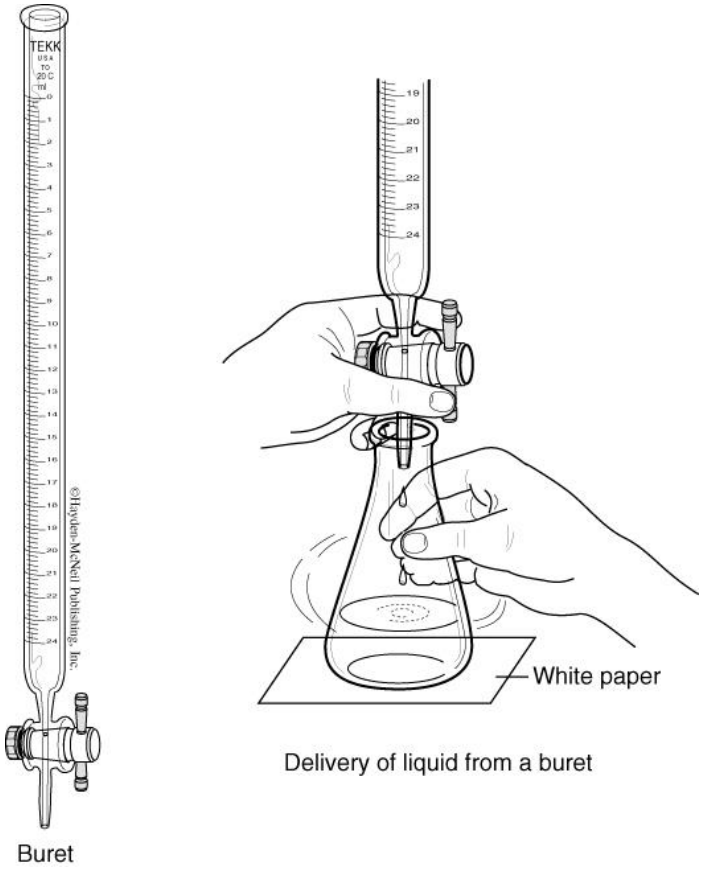

Figure V-11. Titrating with a buret

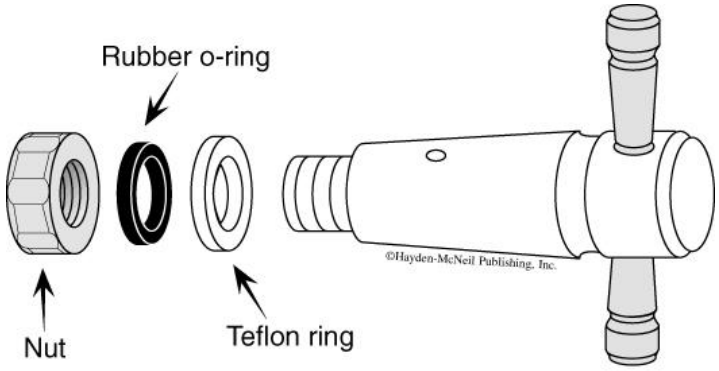

Figure V-12. The stopcock assembly for a buret.