CHAPTER 2
TOOLS OF THE TRADE

2-1. The primary rule is to familiarize yourself with the hazards of what you are about to do and not to do something you consider to be dangerous.

2-3. Dichromate ($Cr_2O_7^{2-}$) is soluble in water and contains carcinogenic Cr(VI). Reducing Cr(VI) to Cr(III) decreases the toxicity of the metal. Converting aqueous Cr(III) to solid $Cr(OH)_3$ decreases the solubility of the metal and therefore decreases its ability to be spread by water. Evaporation produces the minimum volume of waste.

2-4. The upper "0" means that the reagent has no fire hazard. The right hand "0" indicates that the reagent is stable. The "3" tells us that the reagent is corrosive or toxic and we should avoid skin contact or inhalation.

2-5. The lab notebook must: (1) state what was done; (2) state what was observed; and (3) be understandable to a stranger.

2-6. See Section 2.3.

2-7. The buoyancy correction is 1 when the substance being weighed has the same density as the weights used to calibrate the balance.

2-8. $$m = \frac{(14.82\text{ g})\left(1 - \frac{0.001\,2\text{ g/mL}}{8.0\text{ g/mL}}\right)}{\left(1 - \frac{0.001\,2\text{ g/mL}}{0.626\text{ g/mL}}\right)} = 14.85\text{ g}$$

2-9. The smallest correction will be for PbO_2, whose density is closest to 8.0 g/mL. The largest correction will be for the least dense substance, lithium.

2-10. $$m = \frac{4.236\,6\text{ g}\left(1 - \frac{0.001\,2\text{ g/mL}}{8.0\text{ g/mL}}\right)}{\left(1 - \frac{0.001\,2\text{ g/mL}}{1.636\text{ g/mL}}\right)} = 4.239\,1\text{ g}$$

Without correcting for buoyancy, we would think the mass of primary standard is less than the actual mass and we would think the molarity of base reacting with the standard is also less than the actual molarity. The percentage error would be

$$\frac{\text{true mass} - \text{measured mass}}{\text{true mass}} \times 100 = \frac{4.239\,1 - 4.236\,6}{4.239\,1} \times 100 = 0.06\%.$$

2-11. (a) One mol of He (= 4.003 g) occupies a volume of

$$V = \frac{nRT}{P} = \frac{(1\ \cancel{\text{mol}})\left(0.083\,14 \dfrac{\text{L}\cdot\cancel{\text{bar}}}{\cancel{\text{mol}}\cdot\cancel{\text{K}}}\right)(293.15\ \cancel{\text{K}})}{1\ \cancel{\text{bar}}} = 24.37\ \text{L}$$

Density = 4.003 g / 24.37 L = 0.164 g/L = 0.000 164 g/mL

$$\text{(b)}\ m = \frac{(0.823\ \text{g})\left(1 - \dfrac{0.000\,164\ \cancel{\text{g/mL}}}{8.0\ \cancel{\text{g/mL}}}\right)}{\left(1 - \dfrac{0.000\,164\ \cancel{\text{g/mL}}}{0.97\ \cancel{\text{g/mL}}}\right)} = 0.823\ \text{g}$$

2-12. (a) (0.42) (2 330 Pa) = 979 Pa

(b) Air density =

$$\frac{(0.003\,485)(94\,000) - (0.001\,318)(979)}{293.15} = 1.11\ \text{g/L} = 0.001\,1\ \text{g/mL}$$

$$\text{(c) mass} = 1.000\,0\ \text{g}\left(\frac{1 - \dfrac{0.001\,1\ \cancel{\text{g/mL}}}{8.0\ \cancel{\text{g/mL}}}}{1 - \dfrac{0.001\,1\ \cancel{\text{g/mL}}}{1.00\ \cancel{\text{g/mL}}}}\right) = 1.001\,0\ \text{g}$$

2-13. $m_b = m_a \dfrac{r_a^2}{r_b^2} = (100.0000\ \text{g})\dfrac{(6\,370\,000\ \text{m})^2}{(6\,370\,030\ \text{m})^2} = 99.999\,1\ \text{g}$

2-14. TD means "to deliver" and TC means "to contain."

2-15. Dissolve (0.250 0 L)(0.150 0 mol/L) = 0.037 50 mol of K_2SO_4 (= 6.535 g, FM 174.26 g/mol) in less than 250 mL of water in a 250-mL volumetric flask. Add more water and mix. Dilute to the 250.0 mL mark and invert the flask many times for complete mixing.

2-16. The plastic flask is needed for trace analysis of analytes at ppb levels that might be lost by adsorption on the glass surface.

2-17. (a) With a suction device, suck liquid up past the 5.00 mL mark. Discard one or two pipet volumes of liquid to rinse the pipet. Take up a third volume past the calibration mark and quickly replace the bulb with your index finger. (Alternatively, use an automatic suction device that remains attached to the

pipet.) Wipe excess liquid off the outside of the pipet with a clean tissue. Touch the tip of the pipet to the side of a beaker and drain liquid until the bottom of the meniscus reaches the center of the mark. Transfer the pipet to a receiving vessel and drain it by gravity while holding the tip against the wall. After draining stops, hold the pipet to the wall for a few more seconds to complete draining. Do not blow out the last drop. The pipet should be nearly vertical at the end of delivery.

(b) Transfer pipet.

2-18. (a) Adjust the knob for 50.0 μL. Place a fresh tip tightly on the barrel. Depress the plunger to the first stop, corresponding to 50.0 μL. Hold the pipet vertically, dip it 3–5 mm into reagent solution, and slowly release the plunger to suck up liquid. Leave the tip in the liquid for a few more seconds. Withdraw the pipet vertically. Take up and discard three squirts of reagent to clean and wet the tip and fill it with vapor. To dispense liquid, touch the tip to the wall of the receiver and gently depress the plunger to the first stop. After a few seconds, depress the plunger further to squirt out the last liquid.

(b) The procedure in (a) is called forward mode. For a foaming liquid, use reverse mode. Depress the plunger beyond the 50.0 μL stop and take in more than 50.0 μL. To deliver 50.0 μL, depress the plunger to the first stop and not beyond.

2-19. The trap prevents liquid filtrate from being sucked into the vacuum system. The watchglass keeps dust out of the sample.

2-20. Phosphorus pentoxide

2-21. 20.214 4 g – 10.263 4 g = 9.951 0 g. Column 3 of Table 2-7 tells us that the true volume is (9.951 0 g)(1.002 9 mL/g) = 9.979 9 mL.

2-22. Expansion = $\frac{0.999\,102\,6}{0.997\,047\,9} = 1.002\,060\,8 \approx 0.2\%$. Densities were taken from Table 2-7. The 0.500 0 M solution at 25° would be (0.500 0 M)/(1.002) = 0.499 0 M.

2-23. Using column 2 of Table 2-7, mass in vacuum = (50.037 ~~mL~~)(0.998 207 1 g/~~mL~~) = 49.947 g.

Using column 3, mass in air = $\frac{50.037\ \cancel{\text{mL}}}{1.0029\ \cancel{\text{mL}}/\text{g}} = 49.892$ g.

2-24. When the solution is cooled to 20°C, the concentration will be higher than the concentration at 24°C by a factor of $\frac{\text{density at 20°C}}{\text{density at 24°C}}$. Therefore, the concentration needed at 24° will be lower than the concentration at 20°C.

$$\text{Desired concentration at 24°C} = (1.000\ \text{M})\left(\frac{0.997\,299\,5\ \cancel{\text{g/mL}}}{0.998\,207\,1\ \cancel{\text{g/mL}}}\right) = 0.999\,1\ \text{M}$$

(using the quotient of densities from Table 2-7). The true mass of KNO_3 needed is $\left(0.5000\ \cancel{\text{L}}\right)\left(0.9991\frac{\cancel{\text{mol}}}{\cancel{\text{L}}}\right)\left(101.103\frac{\text{g}}{\cancel{\text{mol}}}\right) = 50.506$ g.

$$m' = \frac{(50.506\ \text{g})\left(1-\frac{0.001\,2\ \text{g/mL}}{2.109\ \text{g/mL}}\right)}{\left(1-\frac{0.001\,2\ \text{g/mL}}{8.0\ \text{g/mL}}\right)} = 50.484\ \text{g}$$

2-25. (a) Fraction within specifications = $e^{-t(\ln 2)/t_m}$. If $t_m = 2$ yr and $t = 2$ yr, then fraction within specifications = $e^{-2(\ln 2)/2} = e^{-\ln 2} = \frac{1}{2}$.

(b) Fraction within specifications = $0.95 = e^{-t(\ln 2)/2\ \text{yr}}$

$\ln(0.95) = -t(\ln 2)/2 \Rightarrow t = -2\ln(0.95)/\ln 2 = 0.148$ yr = 54 days ≈ 8 weeks

To solve for t, take the natural logarithm of both sides:

2-26. Al extracted from glass = $(0.200\ \text{L})(5.2 \times 10^{-6}\ \text{M}) = 1.04 \times 10^{-6}$ mol

mass of Al = $(1.04 \times 10^{-6}\ \text{mol})(26.98\ \text{g/mol}) = 28.1\ \mu\text{g}$

This much Al was extracted from 0.50 g of glass, so

$$\text{wt\% Al extracted} = 100 \times \frac{28.1 \times 10^{-6}\ \text{g}}{0.50\ \text{g}} = 0.005\,6_2\ \text{wt\%}$$

$$\text{Fraction of Al extracted} = \frac{0.005\,6_2\ \text{wt\%}}{0.80\ \text{wt\%}} = 0.007\,0\ (\text{or } 0.70\%\ \text{of the Al})$$

2-27.

Graph of van Deemter Equation		
	Flow rate	Plate height
Constants	(mL/min)	(mm)
A =	4	8.194
1.65	6	6.092
B =	8	5.064
25.8	10	4.466
C =	20	3.412
0.0236	30	3.218
	40	3.239
	50	3.346
	60	3.496
	70	3.671
	80	3.861
	90	4.061
	100	4.268
Formula:		
C5 = $A$6+$A$8/B5+$A$10*B5