Chapter 3

3-1. **(a)** SQRT returns the square root of a number or result of a calculation.

(b) AVERAGE returns the arithmetic mean of a series of numbers.

(c) PI returns the value of pi accurate to 15 digits

(d) FACT returns the factorial of a number, equal to $1 \times 2 \times 3 \times \ldots \times$ number.

(e) EXP returns e raised to the value of a given number.

(f) LOG returns the logarithm of a number to a base specified by the user.

Chapter 4

4-1. **(a)** The *millimole* is an amount of a chemical species, such as an atom, an ion, a molecule or an electron. There are

$$6.02\times10^{23}\ \frac{\text{particles}}{\text{mole}} \times 10^{-3}\ \frac{\text{mole}}{\text{millimole}} = 6.02\times10^{20}\ \frac{\text{particles}}{\text{millimole}}$$

(c) The *millimolar mass* is the mass in grams of one millimole of a chemical species.

4-3. The liter: $1\ \text{L} = \frac{1000\ \text{mL}}{1\ \text{L}} \times \frac{1\ \text{cm}^3}{1\ \text{mL}} \times \left(\frac{1\ \text{m}}{100\ \text{cm}}\right)^3 = 10^{-3}\ \text{m}^3$

Molar concentration: $1\ \text{M} = \frac{1\ \text{mol}}{1\ \text{L}} \times \frac{1\ \text{L}}{10^{-3}\ \text{m}^3} = \frac{1\ \text{mol}}{10^{-3}\ \text{m}^3}$

4-4. **(a)** $3.2\times10^{8}\ \text{Hz} \times \frac{1\ \text{MHz}}{10^{6}\ \text{Hz}} = 320\ \text{MHz}$

(c) $8.43\times10^{7}\ \mu\text{mol} \times \frac{1\ \text{mol}}{10^{6}\ \mu\text{mol}} = 84.3\ \text{mol}$

(e) $8.96\times10^{6}\ \text{nm} \times \frac{1\ \text{mm}}{10^{6}\ \text{nm}} = 8.96\ \text{mm}$

4-5. For oxygen, for example 15.999 u/atom = 15.999 g/6.022 $\times 10^{23}$ atoms = 15.999 g/mol.

So 1 u = 1 g/mol.

Thus, 1g = 1mol u.

4-7. $2.92\ \text{g}\ Na_3PO_4 \times \frac{1\ \text{mol}\ Na_3PO_4}{163.94\ \text{g}} \times \frac{3\ \text{mol}\ Na^+}{1\ \text{mol}\ Na_3PO_4} \times \frac{6.022\times10^{23}\ Na^+}{1\ \text{mol}\ Na^+} = 3.22 \times 10^{22}\ Na^+$

4-9. **(a)** $8.75\text{ g } B_2O_3 \times \dfrac{2\text{ mol B}}{1\text{ mol } B_2O_3} \times \dfrac{1\text{ mol } B_2O_3}{69.62\text{ g } B_2O_3} = 0.251\text{ mol B}$

(b) $167.2\text{ mg } Na_2B_4O_7 \bullet 10H_2O \times \dfrac{1\text{ g}}{1000\text{ mg}} \times \dfrac{7\text{ mol O}}{1\text{ mol } Na_2B_4O_7 \bullet 10H_2O} \times \dfrac{1\text{ mol } Na_2B_4O_7 \bullet 10H_2O}{381.37\text{ g}} = 3.07 \times 10^{-3}\text{ mol O} = 3.07\text{ mmol}$

(c) $4.96\text{ g } Mn_3O_4 \times \dfrac{1\text{ mol } Mn_3O_4}{228.81\text{ g } Mn_3O_4} \times \dfrac{3\text{ mol Mn}}{1\text{ mol } Mn_3O_4} = 6.50 \times 10^{-2}\text{ mol Mn}$

(d) $333\text{ mg } CaC_2O_4 \times \dfrac{1\text{ g}}{1000\text{ mg}} \times \dfrac{\text{mol } CaC_2O_4}{128.10\text{ g } CaC_2O_4} \times \dfrac{2\text{ mol C}}{1\text{ mol } CaC_2O_4} = 5.20 \times 10^{-3}\text{ mol C} = 5.20\text{ mmol}$

4-11. **(a)** $\dfrac{0.0555\text{ mol } KMnO_4}{\text{L}} \times \dfrac{1000\text{ mmol}}{1\text{ mol}} \times 2.00\text{ L} = 111\text{ mmol } KMnO_4$

(b) $\dfrac{3.25 \times 10^{-3}\text{ M KSCN}}{\text{L}} \times \dfrac{1000\text{ mmol}}{1\text{ mol}} \times \dfrac{\text{L}}{1000\text{ mL}} \times 750\text{ mL} = 2.44\text{ mmol KSCN}$

(c) $\dfrac{3.33\text{ mg } CuSO_4}{1\text{ L}} \times \dfrac{1\text{ g}}{1000\text{ mg}} \times \dfrac{1\text{ mol } CuSO_4}{159.61\text{ g } CuSO_4} \times \dfrac{1000\text{ mmol}}{1\text{ mol}} \times 3.50\text{ L} = 7.30 \times 10^{-2}\text{ mmol } CuSO_4$

(d) $\dfrac{0.414\text{ mol KCl}}{1\text{ L}} \times \dfrac{1000\text{ mmol}}{1\text{ mol}} \times \dfrac{1\text{ L}}{1000\text{ mL}} \times 250\text{ mL} = 103.5\text{ mmol KCl}$

4-13. **(a)** $0.367\text{ mol } HNO_3 \times \dfrac{63.01\text{ g } HNO_3}{1\text{ mol } HNO_3} \times \dfrac{1000\text{ mg}}{1\text{ g}} = 2.31 \times 10^4\text{ mg } HNO_3$

(b) $245\text{ mmol MgO} \times \dfrac{1\text{ mol}}{1000\text{ mmol}} \times \dfrac{40.30\text{ g MgO}}{1\text{ mol MgO}} \times \dfrac{1000\text{ mg}}{1\text{ g}} = 9.87 \times 10^3\text{ mg MgO}$

(c) $12.5 \text{ mol } NH_4NO_3 \times \frac{80.04 \text{ g } NH_4NO_3}{1 \text{ mol } NH_4NO_3} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 1.00 \times 10^6 \text{mg } NH_4NO_3$

(d) $4.95 \text{ mol } (NH_4)_2Ce(NO_3)_6 \times \frac{548.23 \text{ g } (NH_4)_2Ce(NO_3)_6}{1 \text{ mol } (NH_4)_2Ce(NO_3)_6} \times \frac{1000 \text{ mg}}{1 \text{ g}}$

$= 2.71 \times 10^6 \text{mg } (NH_4)_2Ce(NO_3)_6$

4-15. **(a)** $\frac{0.350 \text{ mol sucrose}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{342 \text{ g sucrose}}{1 \text{ mol sucrose}} \times \frac{1000 \text{ mg}}{1 \text{ g}}$

$\times 16.0 \text{ mL} = 1.92 \times 10^3 \text{mg sucrose}$

(b) $\frac{3.76 \times 10^{-3} \text{mol } H_2O_2}{1 \text{ L}} \times \frac{34.02 \text{ g } H_2O_2}{1 \text{ mol } H_2O_2} \times \frac{1000 \text{ mg}}{1 \text{ g}}$

$\times 1.92 \text{ L} = 246 \text{ mg } H_2O_2$

4-16. **(a)** $\frac{0.264 \text{ mol } H_2O_2}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{34.02 \text{ g } H_2O_2}{1 \text{ mol } H_2O_2} \times 250 \text{ mL}$

$= 2.25 \text{ g } H_2O_2$

(b) $\frac{5.75 \times 10^{-4} \text{mol benzoic acid}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{122 \text{ g benzoic acid}}{1 \text{ mol benzoic acid}}$

$\times 37.0 \text{ mL} = 2.60 \times 10^{-3} \text{g benzoic acid}$

4-17. **(a)** $\text{pNa} = -\log(0.0635 + 0.0403) = -\log(0.1038) = 0.9838$

$\text{pCl} = -\log(0.0635) = 1.197$

$\text{pOH} = -\log(0.0403) = 1.395$

(c)

$\text{pH} = -\log(0.400) = 0.398$

$\text{pCl} = -\log(0.400 + 2 \times 0.100) = -\log(0.600) = 0.222$

$\text{pZn} = -\log(0.100) = 1.00$

(e)

$$pK = -\log(4\times1.62\times10^{-7} + 5.12\times10^{-7}) = -\log(1.16\times10^{-6}) = 5.936$$

$$pOH = -\log(5.12\times10^{-7}) = 6.291$$

$$pFe(CN)_6 = -\log(1.62\times10^{-7}) = 6.790$$

4-18. **(a)** pH = 4.31, $\log[H_3O^+] = -4.31$, $[H_3O^+] = 4.9 \times 10^{-5}$ M

as in part (a)

(c) $[H_3O^+] = 0.26$ M

(e) $[H_3O^+] = 2.4 \times 10^{-8}$ M

(g) $[H_3O^+] = 5.8$ M

4-19. **(a)** $pNa = pBr = -\log(0.0300) = 1.523$

(c) $pBa = -\log(5.5 \times 10^{-3}) = 2.26$; $pOH = -\log(2 \times 5.5 \times 10^{-3}) = 1.96$

(e) $pCa = -\log(8.7 \times 10^{-3}) = 2.06$; $pBa = -\log(6.6 \times 10^{-3}) = 2.18$

$pCl = -\log(2 \times 8.7 \times 10^{-3} + 2 \times 6.6 \times 10^{-3}) = -\log(0.0306) = 1.51$

4-20. **(a)** pH = 1.020**;** $\log[H_3O^+] = -1.020$; $[H_3O^+] = 0.0955$ M

(c) pBr = 7.77; $[Br^-] = 1.70 \times 10^{-8}$ M

(e) pLi = 12.35; $[Li^+] = 4.5 \times 10^{-13}$ M

(g) pMn = 0.135; $[Mn^{2+}] = 0.733$ M

4-21. **(a)** $$1.08\times10^3 \text{ ppm } Na^+ \times \frac{1}{10^6 \text{ ppm}} \times \frac{1.02 \text{ g}}{1 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol } Na^+}{22.99 \text{ g}} = 4.79\times10^{-2} \text{ M } Na^+$$

$$270 \text{ ppm } SO_4^{2-} \times \frac{1}{10^6 \text{ ppm}} \times \frac{1.02 \text{ g}}{1 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol } SO_4^{3-}}{96.06 \text{ g}} = 2.87\times10^{-3} \text{ M } SO_4^{2-}$$

(b) $$pNa = -\log(4.79\times10^{-2}) = 1.320$$

$$pSO_4 = -\log(2.87\times10^{-3}) = 2.542$$

4-23. (a)

$$\frac{5.76\text{ g KCl•MgCl}_2\text{•6H}_2\text{O}}{2.00\text{ L}}\times\frac{1\text{ mol KCl•MgCl}_2\text{•6H}_2\text{O}}{277.85\text{ g}}=1.04\times10^{-2}\text{M KCl•MgCl}_2\text{•6H}_2\text{O}$$

(b) There is 1 mole of Mg^{2+} per mole of $KCl•MgCl_2$, so the molar concentration of Mg^{2+} is the same as the molar concentration of $KCl•MgCl_2$ or 1.04×10^{-2}M

(c) $$1.04\times10^{-2}\text{M KCl•MgCl}_2\text{•6H}_2\text{O}\times\frac{3\text{ mol Cl}^-}{1\text{ mol KCl•MgCl}_2\text{•6H}_2\text{O}}=3.12\times10^{-2}\text{M Cl}^-$$

(d) $$\frac{5.76\text{ g KCl•MgCl}_2\text{•6H}_2\text{O}}{2.00\text{ L}}\times\frac{1\text{ L}}{1000\text{ mL}}\times100\%=0.288\%\text{ (w/v)}$$

(e) $$\frac{3.12\times10^{-2}\text{ mol Cl}^-}{1\text{ L}}\times\frac{1\text{ L}}{1000\text{ mL}}\times\frac{1000\text{ mmol}}{1\text{ mol}}\times25\text{ mL}=7.8\times10^{-1}\text{ mmol Cl}^-$$

(f) $$1.04\times10^{-2}\text{M KCl•MgCl}_2\text{•6H}_2\text{O}\times\frac{1\text{ mol K}^+}{1\text{ mol KCl•MgCl}_2\text{•6H}_2\text{O}}\times\frac{39.10\text{ g K}^+}{1\text{ mol K}^+}\times\frac{1000\text{ mg}}{1\text{ g}}$$
$$=\frac{407\text{ mg}}{1\text{ L}}=407\text{ ppm K}^+$$

(g) $pMg = -\log(1.04 \times 10^{-2}) = 1.983$

(h) $pCl = -\log(3.12 \times 10^{-2}) = 1.506$

4-25. (a) $$6.42\%\text{ Fe(NO}_3)_3=\frac{6.42\text{ g Fe(NO}_3)_3}{100\text{ g solution}}\times\frac{1.059\text{ g}}{\text{mL}}\times\frac{1000\text{ mL}}{1\text{ L}}\times\frac{1\text{ mol Fe(NO}_3)_3}{241.86\text{ g}}$$
$$=2.81\times10^{-1}\text{ M Fe(NO}_3)_3=0.281\text{ M}$$

(b)

$$2.81\times10^{-1}\text{M Fe(NO}_3)_3=\frac{2.81\times10^{-1}\text{mol Fe(NO}_3)_3}{\text{L}}\times\frac{3\text{ mol NO}_3^-}{1\text{ mol Fe(NO}_3)_3}=8.43\times10^{-1}\text{M NO}_3^-$$

(c) $$\frac{2.81\times10^{-1}\text{mol Fe(NO}_3)_3}{\text{L}}\times\frac{241.86\text{ g Fe(NO}_3)_3}{1\text{ mol}}\times1\text{ L}=6.80\times10^{1}\text{g Fe(NO}_3)_3=68.0\text{ g}$$

4-27. **(a)** $\frac{4.75\text{ g } C_2H_5OH}{100\text{ mL soln}} \times 500\text{ mL soln} = 2.38\times10^{1}\text{ g } C_2H_5OH$

Weigh 23.8 g ethanol and add enough water to give a final volume of 500 mL

$$4.75\%\text{ (w/w) } C_2H_5OH = \frac{4.75\text{ g } C_2H_5OH}{100\text{ g soln}} \times 500\text{ g soln} = 2.38\times10^{1}\text{ g } C_2H_5OH$$

(b) 500 g soln=23.8 g C_2H_5OH+x g water

x g water = 500 g soln − 23.8 g C_2H_5OH = 476.2 g water

Mix 23.8 g ethanol with 476.2 g water

(c)
$$4.75\%\text{ (v/v) } C_2H_5OH = \frac{4.75\text{ mL } C_2H_5OH}{100\text{ mL soln}}$$

$$\frac{4.75\text{ mL } C_2H_5OH}{100\text{ mL soln}} \times 500\text{ mL soln} = 2.38\times10^{1}\text{ mL } C_2H_5OH$$

Dilute 23.8 mL ethanol with enough water to give a final volume of 500 mL.

4-29.

$$\frac{6.00\text{ mol } H_3PO_4}{\text{L}} \times \frac{1\text{ L}}{1000\text{ mL}} \times 750\text{ mL} = 4.50\text{ mol } H_3PO_4$$

$$\frac{86\text{ g } H_3PO_4}{100\text{ g reagent}} \times \frac{1.71\text{ g reagent}}{\text{g water}} \times \frac{\text{g water}}{\text{mL}} \times \frac{1000\text{ mL}}{\text{L}} \times \frac{\text{mol } H_3PO_4}{98.0\text{ g}}$$

$$= \frac{1.50\times10^{1}\text{mol } H_3PO_4}{\text{L}}$$

$$\text{volume 86\% (w/w) } H_3PO_4 \text{ required} = 4.50\text{ mol } H_3PO_4 \times \frac{\text{L}}{1.50\times10^{1}\text{mol } H_3PO_4} = 3.00\times10^{-1}\text{ L}$$

$$0.0750\text{ M } AgNO_3 = \frac{0.0750\text{ mol } AgNO_3}{\text{L}}$$

4-31. **(a)**
$$= \frac{0.0750\text{ mol } AgNO_3}{\text{L}} \times \frac{169.87\text{ g } AgNO_3}{1\text{ mol}} \times \frac{1\text{ L}}{1000\text{ mL}} \times 500\text{ mL}$$

$$= 6.37\text{ g } AgNO_3$$

Dissolve 6.37 g $AgNO_3$ in enough water to give a final volume of 500 mL.