11. volume of $NH_3 = 1.25 \times 10^4 \text{ kg } N_2H_4 \times \frac{10^3 \text{ g } N_2H_4}{1 \text{ kg } N_2H_4} \times \frac{1 \text{ mol } N_2H_4}{32.0 \text{ g } N_2H_4} \times \frac{2 \text{ mol } NH_3}{1 \text{ mol } N_2H_4} \times \frac{22.4 \text{ L } NH_3}{1 \text{ mol } NH_3}$

$= \mathbf{1.75 \times 10^7 \text{ L}}$

12. mass of $H_2SO_4 = 25.0 \text{ mL} \times 1.84 \frac{\text{g}}{\text{mL}} = 46.0 \text{ g}$

mass of $P_4O_{10} = 46.0 \text{ g } H_2SO_4 \times \frac{1 \text{ mol } H_2SO_4}{98.1 \text{ g } H_2SO_4} \times \frac{1 \text{ mol } P_4O_{10}}{6 \text{ mol } H_2SO_4} \times \frac{284.0 \text{ g } P_4O_{10}}{1 \text{ mol } P_4O_{10}} = \mathbf{22.2 \text{ g}}$

volume of $SO_3 = 46.0 \text{ g } H_2SO_4 \times \frac{1 \text{ mol } H_2SO_4}{98.1 \text{ g } H_2SO_4} \times \frac{6 \text{ mol } SO_3}{6 \text{ mol } H_2SO_4} \times \frac{22.4 \text{ L } SO_3}{1 \text{ mol } SO_3} = \mathbf{10.5 \text{ L}}$

13. mass of $Cl = 1.5 \times 10^{15} \text{ L } O_3 \times \frac{1 \text{ mol } O_3}{22.4 \text{ L } O_3} \times \frac{1 \text{ mol Cl}}{1.0 \times 10^5 \text{ mol } O_3} \times \frac{35.5 \text{ g Cl}}{1 \text{ mol Cl}} = \mathbf{2.4 \times 10^{10} \text{ g}}$

14. We know that 0.150 mol of R_4 reacts with 143.8 g of Q_2, but the reaction ($R_4 + 6\,Q_2 \longrightarrow 4\,RQ_3$) shows 1 mol of R_4 reacting with 6 mol of Q_2. The amount of Q_2 formed by 0.150 mol of R_4 is

moles of $Q_2 = 0.150 \text{ mol } R_4 \times \frac{6 \text{ mol } Q_2}{1 \text{ mol } R_4} = 0.900 \text{ mol.}$

But, if 0.15 mol of R_4 reacts with 0.900 mol of Q_2 and with 143.8 g of Q_2, then

$0.900 \text{ mol } Q_2 = 143.8 \text{ g } Q_2$, so that: $1 \text{ mol } Q_2 = 159.8 \text{ g}$.

Hence, the molar mass of Q is 159.8 g / 2 = **79.9 g.** (A check of the periodic chart shows that Q is "Br".)

15. First find how many MOLES of atoms are in 100.0 g of Ne.

moles of Ne $= 100.0 \text{ g} \times \frac{1 \text{ mol Ne}}{20.2 \text{ g Ne}} = 4.95 \text{ mol}$

moles of atoms from decomposing HgO = 4.95 mol / 3 = 1.65 mol.

Now, 2 HgO molecules decompose to form 4 atoms of products (2 Hg atoms and 2 O atoms).

moles of HgO needed $= 1.65 \text{ moles products} \times \frac{2 \text{ mol HgO}}{4 \text{ mol products}} = 0.825 \text{ mol}$

and: mass of HgO $= 0.825 \text{ mol} \times \frac{216.6 \text{ g}}{1 \text{ mol}} = \mathbf{179 \text{ g}}$

16. Balance the equation: $2\,XZO_3 \longrightarrow 3\,O_2 + 2\,XZ$. Using the mass of O_2, find the moles of XZ produced.

moles of XZ $= 2.208 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} \times \frac{2 \text{ mol XZ}}{3 \text{ mol } O_2} = 0.0460 \text{ mol}$

Now: molar mass of XZ $= \frac{5.474 \text{ g}}{0.0460 \text{ mol}} = 119 \text{ g/mol}$

Balance the double replacement equation: $XZ + AgNO_3 \longrightarrow AgZ + XNO_3$. The double replacement implies that 1 mol XZ produces 1 mol AgZ (or that 0.0460 mol XZ produces 0.0460 mol AgZ). Hence: 0.0460 mol AgZ = 8.639 g (from problem statement) and

molar mass of AgZ $= \frac{8.639 \text{ g}}{0.0460 \text{ mol}} = 188 \text{ g/mol}$

Since the molar mass of Ag is 107.9, then molar mass of Z = 188 − 107.9 = **8.0×10^1 g/mol** (= Br)

and: molar mass X = molar mass XZ − molar mass Z = 119 − 8.0×10^1 = **39 g/mol** (= K)

17. Moles of NaOH $= 50.0 \text{ L } H_2 \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} \times \frac{2 \text{ mol NaOH}}{3 \text{ mol } H_2} = 1.488 \text{ mol}$

volume of NaOH $= \frac{n}{c} = \frac{1.488 \text{ mol}}{3.00 \text{ mol/L}} = \mathbf{0.496 \text{ L}}$

18. The neutralization equation is: $HCl + NaOH \longrightarrow NaCl + H_2O$.

moles of NaOH $= 0.318\ \frac{mol}{L} \times 0.0250\ L = 7.95 \times 10^{-3}\ mol$ = moles HCl

volume of HCl $= \frac{n}{c} = \frac{0.00795\ mol}{0.250\ mol/L} = \mathbf{0.0318\ L\ (31.8\ mL)}$

19. (a) moles of $Cl^- = 0.0148\ \frac{mol}{L} \times 0.0154\ L = 2.279 \times 10^{-4}\ mol$

moles of $Hg^{2+} = 2.279 \times 10^{-4}\ mol\ Cl^- \times \frac{1\ mol\ Hg^{2+}}{2\ mol\ Cl^-} = 1.140 \times 10^{-4}\ mol$

= moles $HgCl_2$ (for second part of problem)

$[Hg^{2+}] = \frac{n}{V} = \frac{1.140 \times 10^{-4}\ mol}{0.0250\ L} = \mathbf{4.56 \times 10^{-3}\ M}$

(b) mass of $HgCl_2 = 1.140 \times 10^{-4}\ mol \times \frac{271.6\ g}{1\ mol} = \mathbf{0.0310\ g}$

20. (a) The neutralization reaction is: $Ca(OH)_2 + 2\,HCl \longrightarrow CaCl_2 + 2\,H_2O$.

moles of HCl $= 0.0156\ \frac{mol}{L} \times 0.0235\ L = 3.666 \times 10^{-4}\ mol$

moles of $Ca(OH)_2 = 3.666 \times 10^{-4}\ mol\ HCl \times \frac{1\ mol\ Ca(OH)_2}{2\ mol\ HCl} = 1.833 \times 10^{-4}\ mol$

$[Ca(OH)_2] = \frac{n}{V} = \frac{1.833 \times 10^{-4}\ mol}{0.0100\ L} = \mathbf{0.0183\ M}$

(b) mass of $Ca(OH)_2 = 0.01833\ \frac{mol}{L} \times 0.2500\ L \times \frac{74.1\ g}{1\ mol} = \mathbf{0.340\ g}$

21. (a) moles of $H_2O_2 = 1.24\ \frac{mol}{L} \times 0.00200\ L = 2.48 \times 10^{-3}\ mol$

moles of $MnO_4^- = 2.48 \times 10^{-3}\ H_2O_2 \times \frac{2\ mol\ MnO_4^-}{5\ mol\ H_2O_2} = 9.92 \times 10^{-4}\ mol$

volume of $MnO_4^- = \frac{n}{c} = \frac{9.92 \times 10^{-4}\ mol}{0.0496\ mol/L} = \mathbf{0.0200\ L\ (20.0\ mL)}$

(b) volume of $O_2 = 9.92 \times 10^{-4}\ mol\ MnO_4^- \times \frac{5\ mol\ O_2}{2\ mol\ MnO_4^-} \times \frac{22.4\ L\ O_2}{1\ mol\ O_2} = \mathbf{0.0556\ L}$

22. (a) moles of NaOH $= 0.853\ \frac{mol}{L} \times 0.0438\ L = 0.03736\ mol$

moles of $H_3PO_4 = 0.03736\ mol\ NaOH \times \frac{1\ mol\ H_3PO_4}{2\ mol\ NaOH} = 0.01868\ mol$

$[H_3PO_4] = \frac{n}{V} = \frac{0.01868\ mol}{0.00100\ L} = \mathbf{18.7\ M}$

(b) density $= 18.68\ \frac{mol}{L} \times \frac{98.0\ g}{1\ mol} = \mathbf{1.83 \times 10^3\ \frac{g}{L}}$

23. (a) moles of $Cr_2O_7^{2-} = 0.125 \frac{mol}{L} \times 0.0176\ L = 2.20 \times 10^{-3}$ mol

$$\text{moles of } Fe^{2+} = 2.20 \times 10^{-3} \text{ mol } Cr_2O_7^{2-} \times \frac{6 \text{ mol } Fe^{2+}}{1 \text{ mol } Cr_2O_7^{2-}} = 0.0132 \text{ mol}$$

$$[Fe^{2+}] = \frac{n}{V} = \frac{0.0132 \text{ mol}}{0.0250 \text{ L}} = \mathbf{0.528\ M}$$

(b) $\text{mass of Fe} = \text{mass of } Fe^{2+} = 0.01320 \text{ mol} \times \frac{55.8 \text{ g}}{1 \text{ mol}} = \mathbf{0.737\ g}$

24. (a) $[NH_4NO_3] = \frac{15.5 \text{ g}}{0.5000 \text{ L}} \times \frac{1 \text{ mol}}{80.0 \text{ g}} = 0.3875$ M

$$\text{moles of } NH_4NO_3 = 0.3875 \frac{mol}{L} \times 0.0100 \text{ L} = 3.875 \times 10^{-3} \text{ mol} = \text{moles NaOH}$$

$$[NaOH] = \frac{n}{V} = \frac{3.875 \times 10^{-3} \text{ mol}}{0.0250 \text{ L}} = \mathbf{0.155\ M}$$

(b) $\text{volume of } NH_3 = 3.875 \times 10^{-3} \text{ mol NaOH} \times \frac{1 \text{ mol } NH_3}{1 \text{ mol NaOH}} \times \frac{22.4 \text{ L } NH_3}{1 \text{ mol } NH_3} = \mathbf{0.0868\ L}$

25. (a) moles of $Ba(OH)_2$ (at start) $= 0.0538 \frac{mol}{L} \times 0.0250\ L = \mathbf{1.345 \times 10^{-3}\ mol}$

(b) moles of HCl $= 0.104 \frac{mol}{L} \times 0.0230\ L = 2.392 \times 10^{-3}$ mol

$$\text{moles of } Ba(OH)_2 \text{ (remaining)} = 2.392 \times 10^{-3} \text{ mol HCl} \times \frac{1 \text{ mol } Ba(OH)_2}{2 \text{ mol HCl}} = \mathbf{1.196 \times 10^{-3}\ mol}$$

(c) moles of $Ba(OH)_2$ (reacted) = moles $Ba(OH)_2$ (at start) – moles $Ba(OH)_2$ (remaining)
$= 1.345 \times 10^{-3} - 1.196 \times 10^{-3} = \mathbf{1.49 \times 10^{-4}\ mol}$

(d) $\text{moles of } CO_2 = 1.49 \times 10^{-4} \text{ mol } Ba(OH)_2 \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } Ba(OH)_2} = \mathbf{1.49 \times 10^{-4}\ mol}$

(e) $\text{volume of } CO_2 = 1.49 \times 10^{-4} \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 3.34 \times 10^{-3}$ L

$$\% \ CO_2 \text{ in air} = \frac{3.34 \times 10^{-3} \text{ L}}{10.0 \text{ L}} \times 100\% = \mathbf{0.0334\%}$$

26. $\text{mass of } CS_2 \text{ (based on C)} = 17.5 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} \times \frac{1 \text{ mol } CS_2}{5 \text{ mol C}} \times \frac{76.2 \text{ g } CS_2}{1 \text{ mol } CS_2} = 22.2 \text{ g}$

$$\text{mass of } CS_2 \text{ (based on } SO_2) = 39.5 \text{ g } SO_2 \times \frac{1 \text{ mol } SO_2}{64.1 \text{ g } SO_2} \times \frac{1 \text{ mol } CS_2}{2 \text{ mol } SO_2} \times \frac{76.2 \text{ g } CS_2}{1 \text{ mol } CS_2} = 23.5 \text{ g}$$

Since C produces the least amount of CS_2, then the mass of CS_2 produced is **22.2 g.** The SO_2 is present in excess, so the mass of SO_2 used can be calculated arbitrarily based on the mass of C.

$$\text{mass of } SO_2 \text{ used} = 17.5 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} \times \frac{2 \text{ mol } SO_2}{5 \text{ mol C}} \times \frac{64.1 \text{ g } SO_2}{1 \text{ mol } SO_2} = 37.4 \text{ g}$$

mass of SO_2 in excess $= 39.5 - 37.4 = \mathbf{2.1\ g}$