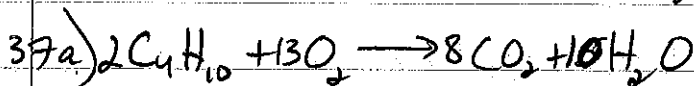


$$3) a) \frac{2.25 \text{ mol Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} = 2.50 \text{ mol Fe}$$

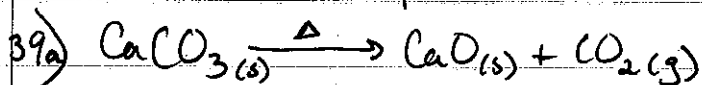
$$b) \frac{3.75 \text{ mol Fe}}{2 \text{ mol Fe}} \times \frac{3 \text{ mol H}_2}{1 \text{ mol Fe}} = 5.63 \text{ mol H}_2$$

$$c) \frac{2.50 \text{ mol H}_2\text{O}}{3 \text{ mol H}_2\text{O}} \times \frac{1 \text{ mol Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \times 159.7 \text{ g Fe}_2\text{O}_3 = 665 \text{ g Fe}_2\text{O}_3$$



$$b) \frac{2.46 \text{ g H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{1 \text{ mol H}_2\text{O}}{10 \text{ mol H}_2\text{O}} \times \frac{2 \text{ mol C}_4\text{H}_{10}}{1 \text{ mol C}_4\text{H}_{10}} \times 58.14 \text{ g C}_4\text{H}_{10} = 1.59 \text{ g C}_4\text{H}_{10}$$

$$38) \frac{100 \text{ g Al}}{26.98 \text{ g Al}} \times \frac{1 \text{ mol Al}}{3 \text{ mol Al}} \times \frac{3 \text{ mol NH}_4\text{ClO}_4}{1 \text{ mol NH}_4\text{ClO}_4} \times 117.49 \text{ g NH}_4\text{ClO}_4 = 4.355 \text{ kg NH}_4\text{ClO}_4$$



$$b) 1.605 \text{ g CaCO}_3 - 0.657 \text{ g CO}_2 = 0.948 \text{ g CaO}$$

$$\frac{0.657 \text{ g CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CO}_2} \times \frac{1 \text{ mol CaCO}_3}{1 \text{ mol CaCO}_3} \times 100.08 \text{ g CaCO}_3 = 1.49 \text{ g CaCO}_3$$

$$\frac{\text{actual}}{\text{given}} \times 100 = \frac{1.49 \text{ g}}{1.605 \text{ g}} \times 100 = 93.1\%$$

c) answers vary

$$40) a) \frac{12.0 \text{ g H}_2}{2.02 \text{ g H}_2} \times \frac{1 \text{ mol H}_2}{2 \text{ mol H}_2} \times \frac{1 \text{ mol CH}_3\text{OH}}{1 \text{ mol CH}_3\text{OH}} \times 32.05 \text{ g} = 95.2 \text{ g CH}_3\text{OH}$$

$$\frac{74.5 \text{ g CO}}{28.01 \text{ g CO}} \times \frac{1 \text{ mol CO}}{1 \text{ mol CO}} \times \frac{1 \text{ mol CH}_3\text{OH}}{1 \text{ mol CH}_3\text{OH}} \times 32.05 \text{ g CH}_3\text{OH} = 85.3 \text{ g CH}_3\text{OH}$$

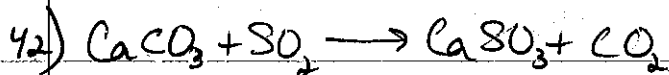
CO is limiting

$$b) \frac{74.5 \text{ g CO}}{28.01 \text{ g CO}} \times \frac{1 \text{ mol CO}}{1 \text{ mol CO}} \times \frac{2 \text{ mol H}_2}{1 \text{ mol H}_2} \times 2.02 \text{ g H}_2 = 10.75 \text{ g H}_2$$

$$12.0 \text{ g H}_2 - 10.75 \text{ g H}_2 = 1.25 \text{ g H}_2 \text{ excess}$$

$$41) \frac{15.4 \text{ g C}_2\text{H}_4}{28.06 \text{ g C}_2\text{H}_4} \times \frac{1 \text{ mol C}_2\text{H}_4}{1 \text{ mol C}_2\text{H}_4} \times \frac{1 \text{ C}_2\text{H}_4\text{Cl}_2}{1 \text{ mol C}_2\text{H}_4} \times \frac{98.96 \text{ g C}_2\text{H}_4\text{Cl}_2}{1 \text{ mol C}_2\text{H}_4\text{Cl}_2} = 54.3 \text{ g C}_2\text{H}_4\text{Cl}_2$$

$$\frac{3.74 \text{ g Cl}_2}{70.9 \text{ g Cl}_2} \times \frac{1 \text{ mol Cl}_2}{1 \text{ mol Cl}_2} \times \frac{1 \text{ mol C}_2\text{H}_4\text{Cl}_2}{1 \text{ mol Cl}_2} \times \frac{98.96 \text{ g C}_2\text{H}_4\text{Cl}_2}{1 \text{ mol C}_2\text{H}_4\text{Cl}_2} = \boxed{5.22 \text{ g C}_2\text{H}_4\text{Cl}_2}$$



$$\frac{255 \text{ g CaCO}_3}{100.09 \text{ g CaCO}_3} \times \frac{1 \text{ mol CaCO}_3}{1 \text{ mol CaCO}_3} \times \frac{1 \text{ mol CaSO}_3}{1 \text{ mol CaCO}_3} \times \frac{143.62 \text{ g CaSO}_3}{1 \text{ mol CaSO}_3} = 365.9 \text{ g CaSO}_3$$

$$\frac{135 \text{ g SO}_2}{64.07 \text{ g SO}_2} \times \frac{1 \text{ mol SO}_2}{1 \text{ mol SO}_2} \times \frac{1 \text{ mol CaSO}_3}{1 \text{ mol SO}_2} \times \frac{143.62 \text{ g CaSO}_3}{1 \text{ mol CaSO}_3} = \underline{302.6 \text{ g CaSO}_3}$$

$$\% \text{ yield} = \frac{198 \text{ g}}{302.6 \text{ g}} \times 100 = \boxed{65.4\% \text{ yield}}$$

$$43) \frac{3.58 \text{ g CH}_3\text{CO}_2\text{H}}{60.06 \text{ g}} \times \frac{1 \text{ mol CH}_3\text{CO}_2\text{H}}{1 \text{ mol acid}} \times \frac{1 \text{ mol ester}}{1 \text{ mol ester}} \times \frac{130.21 \text{ g ester}}{1 \text{ mol ester}} = 7.76 \text{ g ester}$$

$$\frac{4.75 \text{ g C}_2\text{H}_5\text{OH}}{88.17 \text{ g alcohol}} \times \frac{1 \text{ mol alcohol}}{1 \text{ mol alcohol}} \times \frac{1 \text{ mol ester}}{1 \text{ mol ester}} \times \frac{130.21 \text{ g ester}}{1 \text{ mol ester}} = \underline{7.015 \text{ g ester}}$$

$$7.015 \text{ g} \times 0.45 = \boxed{3.16 \text{ g ester}}$$

$$44) 100 \text{ g} \times 0.65 = 65 \text{ g C}_6\text{H}_5\text{Cl yield}$$

$$\frac{65 \text{ g C}_6\text{H}_5\text{Cl}}{112.56 \text{ g C}_6\text{H}_5\text{Cl}} \times \frac{1 \text{ mol C}_6\text{H}_5\text{Cl}}{1 \text{ mol C}_6\text{H}_5\text{Cl}} \times \frac{1 \text{ mol C}_6\text{H}_6}{1 \text{ mol C}_6\text{H}_5\text{Cl}} \times \frac{78.12 \text{ g C}_6\text{H}_6}{1 \text{ mol C}_6\text{H}_6} = \boxed{45.1 \text{ g C}_6\text{H}_6}$$

45) STP = 100 kPa 273.15 K $R = 8.314 \frac{\text{kPa} \cdot \text{dm}^3}{\text{K} \cdot \text{mol}}$

a) $54.5 \text{ dm}^3 \text{ CH}_4 = V$ $PV = nRT$

$$\frac{(100 \text{ kPa})(54.5 \text{ dm}^3)}{(8.314)(273.15 \text{ K})} = n$$

$$n = 2.40 \text{ mol CH}_4$$

b) $250.0 \text{ cm}^3 \text{ CO} = 0.2500 \text{ dm}^3 = V$

$$\frac{(100 \text{ kPa})(0.2500)}{(8.314)(273.15)} = n$$

$$n = 0.0110 \text{ mol CO}$$

c) $1.0 \text{ m}^3 \text{ O}_2 = 1000 \text{ dm}^3 \text{ O}_2 = V$

$$\frac{(100)(1000)}{(8.314)(273.15)} = n$$

$$n = 44.0 \text{ mol O}_2$$

46) a) $\frac{44.00 \text{ g N}_2}{28.02 \text{ g N}_2} \cdot 1 \text{ mol N}_2 = 1.57 \text{ mol N}_2$ $PV = nRT$

$$(100) V = (1.57)(8.314)(273.15)$$

$$V = 35.66 \text{ dm}^3 \text{ N}_2$$

b) $0.25 \text{ mol NH}_3 = n$ $(100) V = (0.25)(8.314)(273.15)$

$$V = 5.68 \text{ dm}^3 \text{ NH}_3$$

47) $\frac{12.45 \text{ g H}_2\text{O}}{216.59 \text{ g H}_2\text{O}} \cdot 1 \text{ mol H}_2\text{O} \cdot \frac{1 \text{ mol O}_2}{2 \text{ mol H}_2\text{O}} = 0.0287 \text{ mol O}_2$

$$(100 \text{ kPa}) V = (0.0287)(8.314)(273.15)$$

$$V = 0.65 \text{ dm}^3$$

48) $\frac{3.14 \text{ dm}^3 \text{ Br}_2}{22.7 \text{ dm}^3 \text{ Br}_2} \cdot 1 \text{ mol Br}_2 \cdot \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol Br}_2} = 8.33 \times 10^{22} \text{ molecules Br}_2$

$$\frac{11.07 \text{ g Cl}_2}{70.91 \text{ g Cl}_2} \cdot 1 \text{ mol Cl}_2 \cdot \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol Cl}_2} = 9.3 \times 10^{22} \text{ molecules Cl}_2$$

$$49) \frac{0.200 \text{ g Ca} \mid 1 \text{ mol Ca} \mid 1 \text{ mol H}_2 \mid 22.7 \text{ dm}^3 \text{ H}_2}{40.08 \text{ g Ca} \mid 1 \text{ mol Ca} \mid 1 \text{ mol H}_2} = \boxed{0.113 \text{ dm}^3 \text{ H}_2}$$

$$50) \frac{1.0 \text{ g NH}_4\text{NO}_3 \mid 1 \text{ mol NH}_3 \mid 1 \text{ mol N}_2\text{O} \mid 22.7 \text{ dm}^3}{80.04 \text{ g} \mid 1 \text{ mol NH}_4\text{NO}_3 \mid 1 \text{ mol N}_2\text{O}} = \boxed{0.28 \text{ dm}^3 \text{ N}_2\text{O}}$$

$$51) P_1 = 85 \text{ kPa} \quad V_1 = 2.5 \text{ dm}^3 \quad T_1 = 25^\circ\text{C} + 273.15 = 298.15 \text{ K}$$

$$P_2 = ? \quad V_2 = 2.75 \text{ dm}^3 \quad T_2 = 75^\circ\text{C} + 273.15 = 348.15 \text{ K}$$

$$\frac{(85)(2.50)}{298.15} = \frac{P_2(2.75)}{348.15} \quad \boxed{P_2 = 90 \text{ kPa}}$$

$$52) P_1 = 100 \text{ kPa} \quad V_1 = 0.675 \text{ dm}^3 \quad T_1 = ?$$

$$P_2 = 200 \text{ kPa} \quad V_2 = 0.350 \text{ dm}^3 \quad T_2 = 27.0^\circ\text{C} + 273.15 = 300.15 \text{ K}$$

$$\frac{(100)(0.675)}{T_1} = \frac{(200)(0.350)}{300.15} \rightarrow \frac{67.5}{0.233} = T_1 \quad \boxed{T_1 = 290 \text{ K}}$$

$$53) P_1 = P \quad T_1 = T \quad V_1 = 4.0 \text{ dm}^3$$

$$P_2 = P \cdot 4 \quad T_2 = 3T \quad V_2 = ?$$

$$\frac{P \cdot 4.0}{T} = \frac{(4P)(V_2)}{3T}$$

$$\frac{(3T)(4P)}{(4P)(T)} = V_2 \quad \boxed{V_2 = 3.0 \text{ dm}^3}$$

$$54) \frac{4.40 \text{ g CO}_2 \mid 1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} = 0.09998 \text{ mol CO}_2 \quad PV = nRT$$

$$T = 27^\circ\text{C} + 273.15 = 300.15 \text{ K}$$

$$(90)(V) = (0.09998)(8.314)(300.15) \quad \boxed{V = 2.77 \text{ dm}^3}$$

$$55) \frac{5.84 \text{ g}}{\text{dm}^3} \bigg| \frac{22.7 \text{ dm}^3}{1 \text{ mol}} = 132 \text{ g/mol} = \text{Xe}$$

$$56) P = 1300 \text{ kPa} \quad V = 0.255 \text{ dm}^3 \quad T = 25.0^\circ\text{C} + 273.15$$

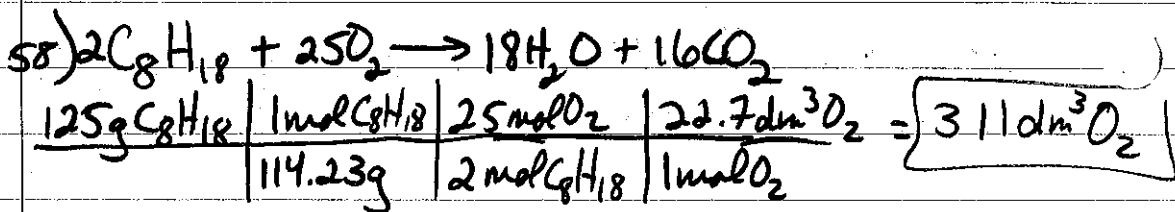
$$(1300)(0.255) = n(8.314)(298.15) \quad n = 1.34 \times 10^{-4} \text{ mol}$$

$$g = 12.1 \text{ mg} = 0.0121 \text{ g}$$

$$\text{molar mass} = \frac{0.0121}{1.34 \times 10^{-4}} = 90.3 \text{ g/mol}$$

$$57) \text{He} = 4.00 \text{ g/mol} \quad \frac{4.00 \text{ gHe}}{1 \text{ mol}} \bigg| \frac{1 \text{ mol}}{22.7 \text{ dm}^3} = \boxed{0.176 \text{ g/dm}^3 \text{ He}}$$

$$\text{H}_2 = 2.02 \text{ g/mol} \quad \frac{2.02 \text{ gH}_2}{1 \text{ mol}} \bigg| \frac{1 \text{ mol}}{22.7 \text{ dm}^3} = 0.089 \text{ g/dm}^3 \text{ H}_2$$



$$59) \text{S: } \frac{1.448 \text{ g S}}{32 \text{ g S}} \bigg| \frac{1 \text{ mol S}}{1 \text{ mol S}} = \frac{0.04525 \text{ mol S}}{0.04525} = 1$$

$$\text{O: } \frac{2.1720 \text{ g O}}{16.00 \text{ g O}} \bigg| \frac{1 \text{ mol O}}{1 \text{ mol O}} = \frac{0.13575 \text{ mol O}}{0.04525} = 3$$

$$P = 99 \text{ kPa} = P$$

$$1.120 \text{ dm}^3 = V \quad T = 25^\circ\text{C} + 273.15 = 298.15 \text{ K}$$

$$(99)(1.120) = n(8.314)(298.15) \quad n = 0.0447 \text{ mol}$$

$$g = 3.620 \text{ g} \quad \text{molecular mass} = \frac{3.620 \text{ g}}{0.0447 \text{ mol}} = 80.98 \text{ g/mol}$$

$$\text{SO}_3 = 80 \text{ g/mol}$$

$$\boxed{\text{SO}_3 = \text{E.F. and M.F.}}$$

60) Boyle's Law + answers will vary
61) answers vary

62) answers vary - we will explore this more in Ch 4.

63) B

$$64) 0.200 \text{ mol dm}^{-3} = c \quad V = 0.250 \text{ dm}^3 \quad c = \frac{n}{V}$$
$$(0.200)(0.250) = n \quad n = 0.0500 \text{ mol KOH}$$

$$\frac{0.0500 \text{ mol KOH}}{1 \text{ mol KOH}} \left| \frac{56.11 \text{ g KOH}}{1 \text{ mol KOH}} \right. = \boxed{2.81 \text{ g KOH}}$$

$$65) \text{MgSO}_4 \cdot 7\text{H}_2\text{O} = 246.48 \text{ g/mol} \quad V = 0.100 \text{ dm}^3$$
$$(0.100)(0.200) = n \quad n = 0.0200 \text{ mol} \quad c = 0.200 \text{ mol dm}^{-3}$$

$$\frac{0.0200 \text{ mol hydrate}}{1 \text{ mol hydrate}} \left| \frac{246.48 \text{ g hydrate}}{1 \text{ mol hydrate}} \right. = \boxed{4.93 \text{ g MgSO}_4 \cdot 7\text{H}_2\text{O}}$$

66) mole ratio Zn^{2+} to $\text{Cl}^- = 1:2$ $n_{\text{Cl}^-} = ?$

$$V = 0.250 \text{ dm}^3 \quad c = 0.0200 \text{ mol dm}^{-3}$$

$$(0.0200)(0.250) = n \quad n = 0.00500 \text{ mol ZnCl}_2$$

$$2n = \text{Cl}^- \text{ moles} \quad \boxed{n_{\text{Cl}^-} = 0.0100 \text{ mol Cl}^-}$$

67) $g = 5.85 \text{ g NaCl}$ $V = 0.250 \text{ dm}^3$ $c = ?$

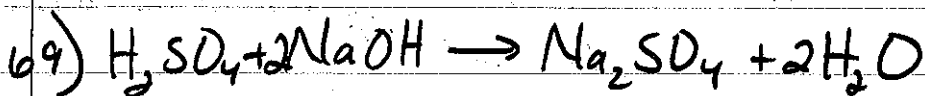
$$\frac{5.85 \text{ g NaCl}}{58.44 \text{ g NaCl}} \left| \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} \right. = 0.100 \text{ mol NaCl}$$

$$c = \frac{0.100 \text{ mol NaCl}}{0.250 \text{ dm}^3} = \boxed{0.400 \text{ mol dm}^{-3} \text{ NaCl}}$$

68) HNO_3 $C_1 V_1 = C_2 V_2$ $C_1 = 16.0 \text{ mol dm}^{-3}$ $C_2 = 0.50 \text{ mol dm}^{-3}$
 $V_1 = ?$ $V_2 = 0.100 \text{ dm}^3$

$$(16.0) V_1 = (0.50)(0.100)$$

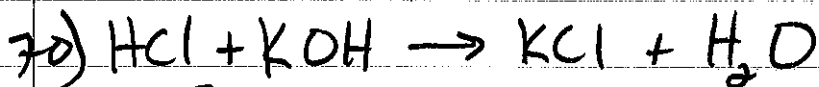
$$V_1 = 0.00313 \text{ dm}^3 \text{ or } 3.13 \text{ cm}^3 \text{ conc. HNO}_3$$



$$\frac{\text{mol NaOH}}{\text{dm}^3} : \frac{0.147 \text{ mol}}{0.03642 \text{ dm}^3} = 0.00535 \text{ mol NaOH}$$

$$\frac{0.00535 \text{ mol NaOH}}{2 \text{ mol NaOH}} \times 1 \text{ mol H}_2\text{SO}_4 = 0.00268 \text{ mol H}_2\text{SO}_4$$

$$C_{\text{H}_2\text{SO}_4} = \frac{0.00268 \text{ mol H}_2\text{SO}_4}{0.01500 \text{ dm}^3 \text{ H}_2\text{SO}_4} = 0.18 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$$



$$C_A = ?$$

$$V_A = 0.00500 \text{ dm}^3$$

$$C_B = 0.0100 \text{ mol dm}^{-3}$$

$$V_B = 0.01100 \text{ dm}^3$$

$$\text{mol KOH} : \frac{0.0100 \text{ mol}}{\text{dm}^3} \times 0.01100 \text{ dm}^3 = 1.10 \times 10^{-4} \text{ mol KOH}$$

$$\text{mol HCl} : \frac{1.10 \times 10^{-4} \text{ mol KOH}}{1 \text{ mol KOH}} \times 1 \text{ mol HCl} = 1.10 \times 10^{-4} \text{ mol HCl}$$

$$C_A = \frac{1.10 \times 10^{-4} \text{ mol HCl}}{0.00500 \text{ dm}^3} = 0.0220 \text{ mol dm}^{-3} \text{ HCl} = C_A$$

$$\text{mass HCl} = 36.46 \text{ g/mol}$$

$$\text{amount of HCl/g in the sample} : \frac{0.0220 \text{ mol}}{1 \text{ mol}} \times 36.46 \text{ g} = 0.802 \text{ g HCl}$$



$$\begin{array}{l} \frac{1\text{g}}{\text{cm}^3} \mid \frac{1000\text{cm}^3}{1\text{dm}^3} \\ \text{mass of unknown sol'n: } 1\text{g/cm}^3 \text{ or } 1000\text{g/dm}^3 \\ \frac{1000\text{g}}{\text{dm}^3} \mid 0.005\text{dm}^3 = 5.0\text{g unknown sol'n} \end{array}$$

$$\% \text{ by mass: } \frac{0.802\text{g HCl}}{5\text{g sol'n}} \times 100 = \boxed{16\% \text{ HCl}}$$

$$\begin{array}{l} \frac{1 \text{ g}}{\text{cm}^3} \left| \frac{1000 \text{ cm}^3}{1 \text{ dm}^3} \right. \\ \text{mass of unknown sol'n: } 1 \text{ g/cm}^3 \text{ or } 1000 \text{ g/dm}^3 \\ \frac{1000 \text{ g}}{\text{dm}^3} \left| 0.005 \text{ dm}^3 \right. = 5.0 \text{ g unknown sol'n} \end{array}$$

$$\% \text{ by mass: } \frac{0.802 \text{ g HCl}}{5 \text{ g sol'n}} \times 100 = \boxed{16\% \text{ HCl}}$$