36) a) $1.25\ \text{mol}\ Fe_2O_3 \left| \frac{2\ \text{mol}\ Fe}{1\ \text{mol}\ Fe_2O_3} \right. = \boxed{2.50\ \text{mol}\ Fe}$

b) $3.75\ \text{mol}\ Fe \left| \frac{3\ \text{mol}\ H_2}{2\ \text{mol}\ Fe} \right. = \boxed{5.63\ \text{mol}\ H_2}$

c) $12.50\ \text{mol}\ H_2O \left| \frac{1\ \text{mol}\ Fe_2O_3}{3\ \text{mol}\ H_2O} \right| \frac{159.7\ g\ Fe_2O_3}{1\ \text{mol}\ Fe_2O_3} = \boxed{665\ g\ Fe_2O_3}$

37) a) $2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$

b) $2.46\ g\ H_2O \left| \frac{1\ \text{mol}\ H_2O}{18.02\ g\ H_2O} \right| \frac{2\ \text{mol}\ C_4H_{10}}{10\ \text{mol}\ H_2O} \left| \frac{58.14\ g\ C_4H_{10}}{1\ \text{mol}\ C_4H_{10}} \right. = \boxed{1.59\ g\ C_4H_{10}}$

38) $1000\ g\ Al \left| \frac{1\ \text{mol}\ Al}{26.98\ g\ Al} \right| \frac{3\ \text{mol}\ NH_4ClO_4}{3\ \text{mol}\ Al} \left| \frac{117.49\ g\ NH_4ClO_4}{1\ \text{mol}\ NH_4ClO_4} \right. = \boxed{4.355\ Kg\ NH_4ClO_4}$

39) a) $CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$

b) $1.605\ g\ CaCO_3 - 0.657\ g\ CO_2 = 0.948\ g\ CaO$

$0.657\ g\ CO_2 \left| \frac{1\ \text{mol}\ CO_2}{44.01\ g\ CO_2} \right| \frac{1\ \text{mol}\ CaCO_3}{1\ \text{mol}\ CO_2} \left| \frac{100.08\ g\ CaCO_3}{1\ \text{mol}\ CaCO_3} \right. = 1.49\ g\ CaCO_3$

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

c) answers vary

40) a) $12.0\ g\ H_2 \left| \frac{1\ \text{mol}\ H_2}{2.02\ g\ H_2} \right| \frac{1\ \text{mol}\ CH_3OH}{2\ \text{mol}\ H_2} \left| \frac{32.05\ g}{1\ \text{mol}\ CH_3OH} \right. = \boxed{95.2\ g\ CH_3OH}$

$74.5\ g\ CO \left| \frac{1\ \text{mol}\ CO}{28.01\ g\ CO} \right| \frac{1\ \text{mol}\ CH_3OH}{1\ \text{mol}\ CO} \left| \frac{32.05\ g\ CH_3OH}{1\ \text{mol}\ CH_3OH} \right. = \boxed{85.3\ g\ CH_3OH}$ → CO is limiting

b) $74.5\ g\ CO \left| \frac{1\ \text{mol}\ CO}{28.01\ g\ CO} \right| \frac{2\ \text{mol}\ H_2}{1\ \text{mol}\ CO} \left| \frac{2.02\ g\ H_2}{1\ \text{mol}\ H_2} \right. = 10.75\ g\ H_2$

$12.0\ g\ H_2 - 10.75\ g\ H_2 = \boxed{1.25\ g\ H_2\ \text{excess}}$

41) $\frac{15.40\text{g } C_2H_4}{} \left| \frac{1\text{mol } C_2H_4}{28.06\text{g } C_2H_4} \right| \frac{1\ C_2H_4Cl_2}{1\text{mol } C_2H_4} \left| \frac{98.96\text{g } C_2H_4Cl_2}{1\text{mol } C_2H_4Cl_2} \right. = 54.3\text{g } C_2H_4Cl_2$

$\frac{3.74\text{g } Cl_2}{} \left| \frac{1\text{mol } Cl_2}{70.9\text{g } Cl_2} \right| \frac{1\text{mol } C_2H_4Cl_2}{1\text{mol } Cl_2} \left| \frac{98.96\text{g } C_2H_4Cl_2}{1\text{mol } C_2H_4Cl_2} \right. = \boxed{5.22\text{g } C_2H_4Cl_2}$

42) $CaCO_3 + SO_2 \longrightarrow CaSO_3 + CO_2$

$\frac{255\text{g } CaCO_3}{} \left| \frac{1\text{mol } CaCO_3}{100.09\text{g } CaCO_3} \right| \frac{1\text{mol } CaSO_3}{1\text{mol } CaCO_3} \left| \frac{143.62\text{g } CaSO_3}{1\text{mol } CaSO_3} \right. = 365.9\text{g } CaSO_3$

$\frac{135\text{g } SO_2}{} \left| \frac{1\text{mol } SO_2}{64.07\text{g } SO_2} \right| \frac{1\text{mol } CaSO_3}{1\text{mol } SO_2} \left| \frac{143.62\text{g } CaSO_3}{1\text{mol } CaSO_3} \right. = 302.6\text{g } CaSO_3$

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

43) $\frac{3.58\text{g } CH_3CO_2H}{} \left| \frac{1\text{mol } CH_3CO_2H}{60.06\text{g}} \right| \frac{1\text{mol ester}}{1\text{mol acid}} \left| \frac{130.21\text{g ester}}{1\text{mol ester}} \right. = 7.76\text{g ester}$

$\frac{4.75\text{g } C_5H_{11}OH}{} \left| \frac{1\text{mol alcohol}}{88.17\text{g alcohol}} \right| \frac{1\text{mol ester}}{1\text{mol alcohol}} \left| \frac{130.2\text{g ester}}{1\text{mol ester}} \right. = 7.015\text{g ester}$

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

44) $100\text{g} \times 0.65 = 65\text{g } C_6H_5Cl$ yield

$\frac{65\text{g } C_6H_5Cl}{} \left| \frac{1\text{mol } C_6H_5Cl}{112.56\text{g } C_6H_5Cl} \right| \frac{1\text{mol } C_6H_6}{1\text{mol } C_6H_5Cl} \left| \frac{78.12\text{g } C_6H_6}{1\text{mol } C_6H_6} \right. = \boxed{45.1\text{g } C_6H_6}$

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

a) $54.5 dm^3 CH_4 = V$ $PV = nRT$

$\frac{(100 kPa)(54.5 dm^3)}{(8.314)(273.15 K)} = n$ $n = 2.40 mol\ CH_4$

b) $250.0 cm^3 CO = 0.2500 dm^3 = V$

$\frac{(100 kPa)(0.2500)}{(8.314)(273.15)} = n$ $n = 0.0110 mol\ CO$

c) $1.0 m^3 O_2 = 1000 dm^3 O_2 = V$

$\frac{(100)(1000)}{(8.314)(273.15)} = n$ $n = 44.0 mol\ O_2$

46) a) $44.00 g N_2 \left| \frac{1 mol N_2}{28.02 N_2} \right. = 1.570 mol N_2$ $PV = nRT$

$(100)V = (1.570)(8.314)(273.15)$ $V = 35.660 dm^3 N_2$

b) $0.25 mol NH_3 = n$ $(100)V = (0.25)(8.314)(273.15)$

$V = 5.68 dm^3 NH_3$

47) $12.45 g HgO \left| \frac{1 mol HgO}{216.59 g HgO} \right| \frac{1 mol O_2}{2 mol HgO} = 0.0287 mol O_2$

$(100 kPa)V = (0.0287)(8.314)(273.15)$

$V = 0.65 dm^3 O_2$

48) $3.14 dm^3 Br_2 \left| \frac{1 mol Br_2}{22.7 dm^3 Br_2} \right| \frac{6.02 \times 10^{23} molecules}{1 mol Br_2} = 8.33 \times 10^{22} molecules\ Br_2$

$11.07 g Cl_2 \left| \frac{1 mol Cl_2}{70.91 g Cl_2} \right| \frac{6.02 \times 10^{23} molecules}{1 mol Cl_2} = 9.3 \times 10^{22} molecules\ Cl_2$

49) $0.200\,g\,Ca \left| \frac{1\,mol\,Ca}{40.08\,g\,Ca} \right| \frac{1\,mol\,H_2}{1\,mol\,Ca} \left| \frac{22.7\,dm^3\,H_2}{1\,mol\,H_2} \right. = \boxed{0.113\,dm^3\,H_2}$

50) $1.0\,g\,NH_4NO_3 \left| \frac{1\,mol\,NH_4NO_3}{80.04\,g} \right| \frac{1\,mol\,N_2O}{1\,mol\,NH_4NO_3} \left| \frac{22.7\,dm^3}{1\,mol\,N_2O} \right. = \boxed{0.28\,dm^3\,N_2O}$

51) $P_1 = 85\,kPa$, $V_1 = 2.50\,dm^3$, $T_1 = 25°C + 273.15 = 298.15\,K$

$P_2 = ?$ $V_2 = 2.75\,dm^3$ $T_2 = 75°C + 273.15 = 348.15\,K$

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

52) $P_1 = 100\,kPa$ $V_1 = 0.675\,dm^3$ $T_1 = ?$

$P_2 = 200\,kPa$ $V_2 = 0.350\,dm^3$ $T_2 = 27.0°C + 273.15 = 300.15\,K$

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

53) $P_1 = P$ $T_1 = T$ $V_1 = 4.0\,dm^3$

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

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

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

54) $4.40\,g\,CO_2 \left| \frac{1\,mol\,CO_2}{44.01\,g\,CO_2} \right. = 0.09998\,mol\,CO_2$ $PV = nRT$

$T = 27°C + 273.15 = 300.15\,K$

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

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

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

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

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

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

57) $He = 4.00\text{g/mol}$

$H_2 = 2.02\text{g/mol}$

$\frac{4.00\text{g He}}{1\text{mol}} \left| \frac{1\text{mol}}{22.7\text{dm}^3} \right. = 0.176\text{g/dm}^3\text{ He}$

$\frac{2.02\text{g H}_2}{1\text{mol}} \left| \frac{1\text{mol}}{22.7\text{dm}^3} \right. = 0.089\text{g/dm}^3\text{ H}_2$

58) $2C_8H_{18} + 25O_2 \longrightarrow 18H_2O + 16CO_2$

$\frac{125\text{g } C_8H_{18}}{} \left| \frac{1\text{mol } C_8H_{18}}{114.23\text{g}} \right. \left| \frac{25\text{mol } O_2}{2\text{mol } C_8H_{18}} \right. \left| \frac{22.7\text{dm}^3 O_2}{1\text{mol } O_2} \right. = 311\text{dm}^3 O_2$

59) S: $\frac{1.448\text{g S}}{32\text{g S}} \left| \frac{1\text{mol S}}{} \right. = \frac{0.04525\text{mol S}}{0.04525} = 1$ $SO_3 = \text{E.F.}$

O: $\frac{2.172\text{g O}}{16.0\text{g O}} \left| \frac{1\text{mol}}{} \right. = \frac{0.13575\text{mol O}}{0.04525} = 3$

$99\text{kPa} = P$

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

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

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

$SO_3 = 80\text{g/mol}$ $SO_3 = \text{E.F. and M.F.}$

60) Boyle's Law + answers will vary

61) answers vary

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

63) B

64) $0.200 mol\,dm^{-3} = c \quad V = 0.250 dm^3 \quad c = \frac{n}{V}$

$(0.200)(0.250) = n \quad n = 0.0500 mol\ KOH$

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

65) $MgSO_4 \cdot 7H_2O = 246.48 g/mol \quad V = 0.100 dm^3$

$(0.100)(0.200) = n \quad n = 0.0200 mol \quad c = 0.200 mol\,dm^{-3}$

$0.0200 mol\ hydrate \left| \frac{246.48 g\ Hydrate}{1 mol\ Hydrate} \right. = \boxed{4.93 g\ MgSO_4 \cdot 7H_2O}$

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

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

$(0.0200)(0.250) = n \quad n = 0.00500 mol\ ZnCl_2$

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

67) $g = 5.85 g\ NaCl \quad V = 0.250 dm^3 \quad c = ?$

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

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

68) HNO_3 $C_1V_1 = C_2V_2$ $C_1 = 16.0\ mol\ dm^{-3}$ $C_2 = 0.50\ mol\ dm^{-3}$

$V_1 = ?$ $V_2 = 0.100\ dm^3$

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

$V_1 = 0.00313\ dm^3$ or $3.13\ cm^3$ conc. HNO_3

69) $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

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

$0.00535\ mol\ NaOH \mid \frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH} = 0.00268\ mol\ H_2SO_4$

$C_{H_2SO_4} = \frac{0.00268\ mol\ H_2SO_4}{0.01500\ dm^3\ H_2SO_4} = 0.18\ mol\ dm^{-3}\ H_2SO_4$

70) $HCl + KOH \rightarrow KCl + H_2O$

$C_A = ?$ $V_A = 0.00500\ dm^3$

$C_B = 0.0100\ mol\ dm^{-3}$ $V_B = 0.01100\ dm^3$

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

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

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

mass $HCl = 36.46\ g/mol$

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

→

$\frac{1\,g}{cm^3} \left| \frac{1000\,cm^3}{1\,dm^3} \right.$

mass of unknown soln: $1\,g/cm^3$ or $1000\,g/dm^3$

$\frac{1000\,g}{dm^3} \left| \frac{0.0050\,dm^3}{} \right. = 5.0\,g$ unknown soln

% by mass: $\frac{0.802\,g\,HCl}{5\,g\,soln} \times 100 =$ **16% HCl**

$\frac{1\,g}{cm^3} \left| \frac{1000\,cm^3}{1\,dm^3} \right.$

mass of unknown soln: $1\,g/cm^3$ or $1000\,g/dm^3$

$\frac{1000\,g}{dm^3} \left| \frac{0.0050\,dm^3}{} \right. = 5.0\,g$ unknown soln

% by mass: $\frac{0.802\,g\,HCl}{5\,g\,soln} \times 100 =$ **16% HCl**