Key

2. (a) # of atoms = $5.5\ \text{mol} \times \frac{6.02 \times 10^{23}\ \text{atoms}}{1\ \text{mol}} = \mathbf{3.3 \times 10^{24}\ atoms}$

(b) # of moles = $25.0\ \text{L} \times \frac{1\ \text{mol}}{22.4\ \text{L}} = \mathbf{1.12\ mol}$

(c) # of moles = $7.0\ \text{g} \times \frac{1\ \text{mol}}{28\ \text{g}} = \mathbf{0.25\ mol}$

(d) # of seconds = $200.0\ \text{coulombs} \times \frac{1\ \text{s}}{35\ \text{coulombs}} = \mathbf{5.7\ s}$

(e) # of atmospheres = $4 \times 10^{-8}\ \text{kPa} \times \frac{1\ \text{atm}}{101.3\ \text{kPa}} = \mathbf{4 \times 10^{-10}\ atmospheres}$

(f) # of kilograms = $3.20 \times 10^{4}\ \text{troy ounce} \times \frac{0.0311\ \text{kg}}{1\ \text{troy ounce}} = \mathbf{995\ kg}$

(g) # of milliseconds = $5.0 \times 10^{-4}\ \text{s} \times \frac{1\ \text{ms}}{10^{-3}\ \text{s}} = \mathbf{0.50\ ms}$

(h) # of moles = $15\,100\ \text{kJ} \times \frac{1\ \text{mol}}{5450\ \text{kJ}} = \mathbf{2.77\ mol}$

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17. (a) # of milliseconds = $3\ \text{s} \times \frac{1\ \text{ms}}{10^{-3}\ \text{s}} = \mathbf{3 \times 10^{3}\ ms}$

(b) # of litres = $50.0\ \text{mL} \times \frac{10^{-3}\ \text{L}}{1\ \text{mL}} = \mathbf{5.0 \times 10^{-2}\ L}$

(c) # of microlitres = $2\ \text{L} \times \frac{1\ \mu\text{L}}{10^{-6}\ \text{L}} = \mathbf{2 \times 10^{6}\ \mu L}$

(d) # of grams = $25\ \text{kg} \times \frac{10^{3}\ \text{g}}{1\ \text{kg}} = \mathbf{2.5 \times 10^{4}\ g}$

(e) # of metres = $3\ \text{Mm} \times \frac{10^{6}\ \text{m}}{1\ \text{Mm}} = \mathbf{3 \times 10^{6}\ m}$

(f) # of decilitres = $2\ \text{L} \times \frac{1\ \text{dL}}{10^{-1}\ \text{L}} = \mathbf{2 \times 10^{1}\ dL}$

(g) # of milliseconds = $7\ \mu\text{s} \times \frac{10^{-6}\ \text{s}}{1\ \mu\text{s}} \times \frac{1\ \text{ms}}{10^{-3}\ \text{s}} = \mathbf{7 \times 10^{-3}\ ms}$

(h) # of milligrams = $51\ \text{kg} \times \frac{10^{3}\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mg}}{10^{-3}\ \text{g}} = \mathbf{5.1 \times 10^{7}\ mg}$

(i) # of kilolitres = $3125\ \mu\text{L} \times \frac{10^{-6}\ \text{L}}{1\ \mu\text{L}} \times \frac{1\ \text{kL}}{10^{3}\ \text{L}} = \mathbf{3.125 \times 10^{-6}\ kL}$

(j) # of centigrams = $1.7\ \mu\text{g} \times \frac{10^{-6}\ \text{g}}{1\ \mu\text{g}} \times \frac{1\ \text{cg}}{10^{-2}\ \text{g}} = \mathbf{1.7 \times 10^{-4}\ cg}$

2

31. $d = \frac{m}{V} = \frac{8.19\ \text{g}}{3.50\ \text{mL}} = \mathbf{2.34\ \frac{g}{mL}}$, or: $d = \frac{8.19\ \text{g}}{3.50 \times 10^{-3}\ \text{L}} = \mathbf{2.34 \times 10^{3}\ \frac{g}{L}}$

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32. $V = \frac{m}{d} = \frac{125\ \text{g}}{7.86 \times 10^{3}\ \text{g/L}} = \mathbf{0.0159\ L}$

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33. $m = d \cdot V = 961\ \frac{\text{g}}{\text{L}} \times 0.2000\ \text{L} = \mathbf{192\ g}$

5

34. $V = \frac{m}{d} = \frac{46\ \text{g}}{789\ \text{g/L}} = \mathbf{0.058\ L}$

6

35. $m = d \cdot V = 0.900\ \frac{\text{g}}{\text{L}} \times 22.4\ \text{L} = \mathbf{20.2\ g}$

7

56. (a) 6.3 (c) 1.33 (e) 3×10^{14} (g) 202 (i) 20 (k) 2
(b) 0.000 24 (d) 1.3×10^{2} (f) 5.11×10^{5} (h) 90 (j) 1×10^{-4} (l) 2.2×10^{-6}

8

17. (a) acetone
(b) The lower the boiling temperature of a liquid, the higher its vapour pressure.
(c) The higher the vapour pressure of a liquid, the faster its evaporation rate.
(d) Iron is known to melt at a very high temperature and to boil at an even higher temperature. The relationship for part (b), above, implies that iron has a very low vapour pressure.
(e) Since diethyl ether boils at a lower temperature than acetone, the relationship for parts (b) and (c) implies that diethyl ether has a higher vapour pressure and evaporation rate than acetone.

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19. (a) viscosity: hexane < carbon tetrachloride < glycerol
(b) density: hexane < glycerol < carbon tetrachloride
(c) There is no relationship between viscosity and density.

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4. (a) $Sn(SO_4)_2$ (e) $Hg_2(NO_2)_2$ (i) Cr_2O_3 (m) $(NH_4)_2Cr_2O_7$ (q) $Mg(MnO_4)_2$
(b) $(NH_4)_2C_2O_4$ (f) $Fe(OH)_3$ (j) MnF_2 (n) Cu_3PO_4 (r) WBr_5
(c) Li_2O (g) Ag_2SO_4 (k) KH_2PO_4 (o) $Ca(ClO)_2$ (s) $(NH_4)_3PO_4$
(d) Cu_3N (h) $Pb(ClO_4)_2$ (l) $U(SO_4)_2$ (p) $NaHSO_3$ (t) $Hg(CH_3COO)_2$

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5. (a) silver phosphate
(b) aluminum sulphate
(c) iron(III) sulphide
(d) copper(I) chloride
(e) ammonium carbonate
(f) vanadium(III) chloride
(g) mercury(I) carbonate
(h) copper(II) sulphate
(i) ammonium sulphide
(j) ammonium hydrogen carbonate
(k) iron(II) oxalate
(l) magnesium hydrogen sulphite
(m) lithium chlorite
(n) sodium monohydrogen phosphate
(o) aluminum hydroxide
(p) chromium(III) iodide
(q) tin(IV) oxide
(r) zinc dichromate
(s) vanadium(V) oxide
(t) strontium nitride

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8. (a) $\text{mass} = 1.00 \text{ mol} \times \frac{53.5 \text{ g}}{1 \text{ mol}} = \mathbf{53.5 \text{ g}}$

(b) $\text{mass} = 4.50 \text{ mol} \times \frac{53.5 \text{ g}}{1 \text{ mol}} = \mathbf{241 \text{ g}}$

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(c) $\text{mass} = 3.25 \text{ mol} \times \frac{137.5 \text{ g}}{1 \text{ mol}} = \mathbf{447 \text{ g}}$

(d) $\text{mass} = 0.00355 \text{ mol} \times \frac{142.0 \text{ g}}{1 \text{ mol}} = \mathbf{0.504 \text{ g}}$

(e) $\text{mass} = 0.0125 \text{ mol} \times \frac{207.3 \text{ g}}{1 \text{ mol}} = \mathbf{2.59 \text{ g}}$

(f) $\text{mass} = 2.60 \text{ mol} \times \frac{30.0 \text{ g}}{1 \text{ mol}} = \mathbf{78.0 \text{ g}}$

(g) $\text{mass} = 3.25 \times 10^{2} \text{ mol} \times \frac{17.0 \text{ g}}{1 \text{ mol}} = \mathbf{5.53 \times 10^{3} \text{ g}}$

(h) $\text{mass} = 7.90 \times 10^{-4} \text{ mol} \times \frac{82.1 \text{ g}}{1 \text{ mol}} = \mathbf{0.0649 \text{ g}}$

(i) $\text{mass} = 1.00 \times 10^{-3} \text{ mol} \times \frac{40.0 \text{ g}}{1 \text{ mol}} = \mathbf{0.0400 \text{ g}}$

(j) $\text{mass} = 1.75 \times 10^{-4} \text{ mol} \times \frac{55.8 \text{ g}}{1 \text{ mol}} = \mathbf{9.77 \times 10^{-3} \text{ g}}$

9. (a) # of moles = $17.0\ g \times \frac{1\ mol}{98.1\ g} = \mathbf{0.173\ mol}$

(b) # of moles = $91.5\ g \times \frac{1\ mol}{18.0\ g} = \mathbf{5.08\ mol}$

(c) # of moles = $53.0\ g \times \frac{1\ mol}{12.0\ g} = \mathbf{4.42\ mol}$

(d) # of moles = $1.25 \times 10^{-4}\ g \times \frac{1\ mol}{95.6\ g} = \mathbf{1.31 \times 10^{-6}\ mol}$

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(e) # of moles = $4.50\ kg \times \frac{10^{3}\ g}{1\ kg} \times \frac{1\ mol}{16.0\ g} = \mathbf{281\ mol}$

(f) # of moles = $225\ g \times \frac{1\ mol}{132.1\ g} = \mathbf{1.70\ mol}$

(g) # of moles = $55.2\ mg \times \frac{10^{-3}\ g}{1\ mg} \times \frac{1\ mol}{71.0\ g} = \mathbf{7.77 \times 10^{-4}\ mol}$

(h) # of moles = $128.2\ g \times \frac{1\ mol}{64.1\ g} = \mathbf{2.00\ mol}$

(i) # of moles = $2955\ kg \times \frac{10^{3}\ g}{1\ kg} \times \frac{1\ mol}{107.9\ g} = \mathbf{2.739 \times 10^{4}\ mol}$

(j) # of moles = $0.0845\ g \times \frac{1\ mol}{158.0\ g} = \mathbf{5.35 \times 10^{-4}\ mol}$

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10. (a) molar mass = $\frac{4.00\ g}{0.250\ mol} = \mathbf{16.0\ g/mol}$

(b) molar mass = $\frac{0.957\ g}{0.00248\ mol} = \mathbf{386\ g/mol}$

(c) molar mass = $\frac{7.76 \times 10^{-3}\ g}{6.47 \times 10^{-4}\ mol} = \mathbf{12.0\ g/mol}$

(d) molar mass = $\frac{74.8\ g}{3.44 \times 10^{-5}\ mol} = \mathbf{2.17 \times 10^{6}\ g/mol}$

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15. (a) # of moles = $10.6\ L \times \frac{1\ mol}{22.4\ L} = \mathbf{0.473\ mol}$

(b) # of moles = $7.50 \times 10^{21}\ molecules \times \frac{1\ mol\ molecules}{6.02 \times 10^{23}\ molecules} = \mathbf{0.0125\ mol}$

(c) # of moles = $425\ mg \times \frac{10^{-3}\ g}{1\ mg} \times \frac{1\ mol}{74.1\ g} = \mathbf{5.74 \times 10^{-3}\ mol}$

(d) # of moles = $4.25 \times 10^{12}\ molecule \times \frac{1\ mol\ molecules}{6.02 \times 10^{23}\ molecules} = \mathbf{7.06 \times 10^{-12}\ mol}$

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(e) # of moles = $0.950\ kg \times \frac{10^{3}\ g}{1\ kg} \times \frac{1\ mol}{40.0\ g} = \mathbf{23.8\ mol}$

(f) # of moles = $25.0\ mL \times \frac{10^{-3}\ L}{1\ mL} \times \frac{1\ mol}{22.4\ L} = \mathbf{1.12 \times 10^{-3}\ mol}$

(g) # of moles = $5.50 \times 10^{25}\ molecules \times \frac{1\ mol\ molecules}{6.02 \times 10^{23}\ molecules} = \mathbf{91.4\ mol}$

(h) # of moles = $0.120\ L \times \frac{1\ mol}{22.4\ L} = \mathbf{5.36 \times 10^{-3}\ mol}$

47. density $= \frac{1.59\ g}{0.850\ L} = 1.871$ g/L, and mass of 1 mol $= 1.871\ \frac{g}{L} \times 22.4\ L = 41.9$ g

empirical mass of $CH_2 = 12.0 + 2 \times 1.0 = 14.0$ g

$N = \frac{41.9\ g}{14.0\ g} = 2.99$. Therefore the molecular formula $= 3 \times (CH_2) = \mathbf{C_3H_6}$.

17 #7

48. moles N $= 30.4\ g \times \frac{1\ mol}{14.0\ g} = 2.17$ mol | 1

moles O $= 69.6\ g \times \frac{1\ mol}{16.0\ g} = 4.35$ mol | 2

and empirical formula $= \mathbf{NO_2}$, empirical mass $= 14.0 + 2 \times 16.0 = 46.0$ g

molar mass $= 4.11\ \frac{g}{L} \times 22.4\ L = 92.1$ g

$N = \frac{92.1\ g}{46.0\ g} = 2.0$. Therefore the molecular formula $= 2 \times (NO_2) = \mathbf{N_2O_4}$.

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49. Empirical mass of $C_5H_{11} = 71.0$ g

molar mass $= \frac{3.91\ g}{0.0275\ mol} = 142$ g/mol

$N = \frac{142\ g}{71.0\ g} = 2.0$. Therefore the molecular formula $= 2 \times (C_5H_{11}) = \mathbf{C_{10}H_{22}}$.

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50. density $= \frac{0.522\ g}{0.450\ L} = 1.16$ g/L, and mass of 1 mol $= 1.16\ \frac{g}{L} \times 22.4\ L = 26.0$ g

empirical mass $= 1 \times 12.0 + 1 \times 1.0 = 13.0$ g

$N = \frac{26.0\ g}{13.0\ g} = 2.0$. Therefore the molecular formula $= 2 \times (CH) = \mathbf{C_2H_2}$.

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59. (a) $[HCl] = \frac{0.26\ mol}{1.0\ L} = \mathbf{0.26\ M}$

(b) $[HNO_3] = \frac{2.8\ mol}{4.0\ L} = \mathbf{0.70\ M}$

(c) $[NH_4Cl] = \frac{0.0700\ mol}{0.0500\ L} = \mathbf{1.40\ M}$

(d) $[NaCl] = \frac{25.0\ g}{0.2500\ L} \times \frac{1\ mol}{58.5\ g} = \mathbf{1.71\ M}$

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(e) $[CoBr_2 \cdot 6H_2O] = \frac{1.50\ g}{0.6000\ L} \times \frac{1\ mol}{326.7\ g} = \mathbf{0.00765\ M}$

(f) $[Cr(NO_3)_3 \cdot 9H_2O] = \frac{10.0\ g}{0.325\ L} \times \frac{1\ mol}{400.0\ g} = \mathbf{0.0769\ M}$

61. moles $AlCl_3 = 0.250 \frac{mol}{L} \times 0.3500\ L =$ **0.0875 mol**

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62. moles $HCl = 100.0\ g \times \frac{1\ mol}{36.5\ g} = 2.74\ mol$

$c = \frac{n}{V}$, so $V = \frac{n}{c} = \frac{2.74\ mol}{2.40\ mol/L} =$ **1.14 L**

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66. $[CH_3COOH] = 1049 \frac{g}{L} \times \frac{1\ mol}{60.0\ g} =$ **17.5 M**

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67. $d = 17.6 \frac{mol}{L} \times \frac{100.5\ g}{1\ mol} =$ **$1.77 \times 10^3 \frac{g}{L}$**

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97. (a) $[LiOH]_{DIL}\ (\#1) = 3.55\ M \times \frac{125\ mL}{600\ mL} = 0.740\ M$

$[LiOH]_{DIL}\ (\#2) = 2.42\ M \times \frac{475\ mL}{600\ mL} = 1.92\ M$

[LiOH] (total) = 0.740 M + 1.92 M = **2.66 M**

(b) $[NaCl] = 0.250\ M \times \frac{200.0\ mL}{350.0\ mL} =$ **0.143 M**

(c) $[KBr]_{DIL}\ (\#1) = 12.0\ M \times \frac{100.0\ mL}{1050.0\ mL} = 1.14\ M$

$[KBr]_{DIL}\ (\#2) = 0.200\ M \times \frac{950.0\ mL}{1050.0\ mL} = 0.181\ M$

[KBr] (total) = 1.14 M + 0.181 M = **1.32 M**

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(d) $[KBr] = 2.50\ M \times \frac{5.0\ mL}{80\ mL} =$ **0.16 M**

(e) $[HCl] = 0.1105\ M \times \frac{850.0\ mL}{900.0\ mL} =$ **0.1044 M**

(f) $[HCl]_{DIL}\ (\#1) = 0.125\ M \times \frac{50.0\ mL}{125.0\ mL} = 0.0500\ M$

$[HCl]_{DIL}\ (\#2) = 0.350\ M \times \frac{75.0\ mL}{125.0\ mL} = 0.210\ M$

[HCl] (total) = 0.0500 M + 0.210 M = **0.260 M**

6. (a) mass of $NO = 2.00\ mol\ NH_3 \times \frac{4\ mol\ NO}{4\ mol\ NH_3} \times \frac{30.0\ g\ NO}{1\ mol\ NO} =$ **60.0 g**

(b) mass of $H_2O = 4.00\ mol\ O_2 \times \frac{6\ mol\ H_2O}{5\ mol\ O_2} \times \frac{18.0\ g\ H_2O}{1\ mol\ H_2O} =$ **86.4 g**

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(c) volume of $NH_3 = 3.00\ mol\ O_2 \times \frac{4\ mol\ NH_3}{5\ mol\ O_2} \times \frac{22.4\ L\ NH_3}{1\ mol\ NH_3} =$ **53.8 L**

(d) volume of $NH_3 = 0.750\ mol\ H_2O \times \frac{4\ mol\ NH_3}{6\ mol\ H_2O} \times \frac{22.4\ L\ NH_3}{1\ mol\ NH_3} =$ **11.2 L**

7. (a) mass of CO_2 = 100.0 g C_5H_{12} x $\frac{1 \text{ mol } C_5H_{12}}{72.0 \text{ g } C_5H_{12}}$ x $\frac{5 \text{ mol } CO_2}{1 \text{ mol } C_5H_{12}}$ x $\frac{44.0 \text{ g } CO_2}{1 \text{ mol } CO_2}$ = **306 g**

(b) mass of O_2 = 60.0 g H_2O x $\frac{1 \text{ mol } H_2O}{18.0 \text{ g } H_2O}$ x $\frac{8 \text{ mol } O_2}{6 \text{ mol } H_2O}$ x $\frac{32.0 \text{ g } O_2}{1 \text{ mol } O_2}$ = **142 g**

(c) mass of C_5H_{12} = 90.0 L CO_2 x $\frac{1 \text{ mol } CO_2}{22.4 \text{ L } CO_2}$ x $\frac{1 \text{ mol } C_5H_{12}}{5 \text{ mol } CO_2}$ x $\frac{72.0 \text{ g } C_5H_{12}}{1 \text{ mol } C_5H_{12}}$ = **57.9 g**

(d) volume of O_2 = 70.0 g CO_2 x $\frac{1 \text{ mol } CO_2}{44.0 \text{ g } CO_2}$ x $\frac{8 \text{ mol } O_2}{5 \text{ mol } CO_2}$ x $\frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2}$ = **57.0 L**

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(e) volume of O_2 = 48.0 L CO_2 x $\frac{1 \text{ mol } CO_2}{22.4 \text{ L } CO_2}$ x $\frac{8 \text{ mol } O_2}{5 \text{ mol } CO_2}$ x $\frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2}$ = **76.8 L**

(f) mass of H_2O = 106 L CO_2 x $\frac{1 \text{ mol } CO_2}{22.4 \text{ L } CO_2}$ x $\frac{6 \text{ mol } H_2O}{5 \text{ mol } CO_2}$ x $\frac{18.0 \text{ g } H_2O}{1 \text{ mol } H_2O}$ = **102 g**

32.) a.) $Al_2(SO_4)_{3(s)} \longrightarrow \underline{2}\ Al^{+3}_{(aq)} + \underline{3}\ SO_4^{-2}_{(aq)}$

0.135 M ? M

$$\frac{0.135\ mol\ Al_2(SO_4)_3}{1\ L} \times \frac{3\ mol\ SO_4^{-2}}{1\ mol\ Al_2(SO_4)_3} = \boxed{\frac{0.405\ mol\ SO_4^{-2}}{1\ L}}$$

33.) $BaCl_{2(s)} \longrightarrow Ba^{+2}_{(aq)} + \underline{2}\ Cl^-_{(aq)}$

$$10.0\ g\ BaCl_2 \times \frac{1\ mol\ BaCl_2}{208.2\ g\ BaCl_2} \times \frac{1}{0.600\ L} = 0.08005\ M$$

$$\frac{0.08005\ mol\ BaCl_2}{1\ L} \times \frac{2\ mol\ Cl^-}{1\ mol\ BaCl_2} = \boxed{0.160\ M\ Cl^-}$$

34.) $0.055\ L \times \frac{0.300\ mol\ HCl}{1\ L} \times \frac{1}{0.135\ L} = \underline{0.1222\ M\ HCl}$

$C_{conc} V_{conc} = C_{dil} V_{dil}$ / $(0.550)(80.0) = (C_{conc})(135.0)$

$C_{conc} = 0.3259\ M\ CaCl_2$

$HCl_{(s)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

0.122 M 0.122 M $\boxed{0.122\ M}$

$CaCl_{2(s)} \longrightarrow Ca^{+2}_{(aq)} + \underline{2}\ Cl^-_{(aq)}$

0.3259 M 0.3259 M $\boxed{0.652\ M}$

$+ = \boxed{0.774\ M\ Cl^-}$

35.) $MgCl_{2\,(s)} \longrightarrow Mg^{+2}_{(aq)} + 2Cl^{-}_{(aq)}$ ← answer.

0.318 M → 0.318 M → 0.636 M

$0.350\,L \times \frac{0.250\ mol\ MgCl_2}{1\,L} \times \frac{1}{0.275\,L} = 0.31818\ M\ MgCl_2$

OR

$C_{conc} V_{con} = C_{dil} V_{dil}$ / $(0.250)(0.350) = (C_{conc})(0.275)$

$C_{conc} = 0.31818\ M\ MgCl_2$

36.) a.) $K_2SO_{4\,(s)} \longrightarrow 2K^{+}_{(aq)} + SO_4^{-2}{}_{(aq)}$

0.12 mol → 0.24 mol → 0.12 mol

$0.60\,L \times \frac{0.20\ mol}{1\,L} = 0.12\ mol\ K_2SO_4$

b.) $Na_3PO_{4\,(s)} \longrightarrow 3Na^{+}_{(aq)} + PO_4^{-3}{}_{(aq)}$

0.135 mol → 0.405 mol → 0.135 mol

$0.450\,L \times \frac{0.300\ mol}{1\,L} = 0.135\ mol\ Na_3PO_4$

c.) $MnCl_{2\,(s)} \longrightarrow Mn^{+2}_{(aq)} + 2Cl^{-}_{(aq)}$

0.012 mol → 0.012 mol → 0.024 mol

$0.075\,L \times \frac{0.160\ mol}{1\,L} = 0.012\ mol\ MnCl_2$

D.) $Fe_2(SO_4)_{3\,(s)} \longrightarrow 2Fe^{+3}_{(aq)} + 3SO_4^{-2}{}_{(aq)}$

0.0223 mol → 0.0447 → 0.0670 mol

$0.0950\,L \times \frac{0.235\ mol}{1\,L} = 0.022325\ mol\ Fe_2(SO_4)_3$