

(1)

$$6. \quad P_A V = n_A RT \quad (14.8 \text{ g Ne}) \left(\frac{1 \text{ mol}}{20.18 \text{ g}} \right) = 0.733 \text{ mol Ne}$$

$$P_{\text{tot}} V = n_{\text{tot}} RT \quad (37.6 \text{ g Ar}) \left(\frac{1 \text{ mol}}{39.95 \text{ g}} \right) = 0.941$$

1.674 mol total

$$V = \frac{n RT}{P} = \frac{(1.674 \text{ mol})(0.08206 \frac{\text{L atm}}{\text{K mol}})(304.2 \text{ K})}{14.5 \text{ atm}} = 2.88 \text{ L}$$

7. CO_2 14.8 cm
unk 17.6 cm
unk must be lighter
travels faster.

$$N \sqrt{\frac{M_{\text{unk}}}{M_{\text{CO}_2}}} = \frac{14.8 \text{ cm}}{17.6 \text{ cm}}$$

↑ smaller ↓ larger

$$\frac{M_{\text{unk}}}{M_{\text{CO}_2}} = \left(\frac{14.8}{17.6} \right)^2$$

$$M_{\text{unk}} = M_{\text{CO}_2} \left(\frac{14.8}{17.6} \right)^2$$

$$M_{\text{unk}} = 31.1 \text{ g/mol}$$

$$10. \quad 0.0400 \text{ L} \times 0.100 \text{ M} = 0.004 \text{ mol AlCl}_3 = 0.004^0 \text{ mol Al}^{3+} \times 3$$

$$0.0120 \text{ mol Cl}^-$$

$$0.010 \text{ L} \times 0.300 \text{ M} = 0.003 \text{ mol Na}_2\text{S} = 0.0060^0 \text{ mol Na}^+$$

$$0.00300 \text{ mol S}^{2-}$$

alternate method:

	2 Al ³⁺	+ 3 S ²⁻	→	Al ₂ S ₃ (s)
Start	0.004	0.003	0	
Δ	-2x	-3x	+x	
End	0.004 - 2x	0.003 - 3x	x	
		= 0 LR		
	0.003 = 3x			
	x = 0.001			

$$(0.00300 \text{ mol S}^{2-}) \left(\frac{2 \text{ mol Al}^{3+}}{3 \text{ mol S}^{2-}} \right) = 0.00200 \text{ mol Al}^{3+} \underline{\text{used}}$$

$$\text{Need: } \frac{3 \text{ mol S}^{2-}}{2 \text{ mol Al}^{3+}} = \frac{1.5 \text{ S}^{2-}}{1 \text{ Al}^{3+}}$$

$$\text{have: } \frac{0.003 \text{ S}^{2-}}{0.004 \text{ Al}^{3+}} = \frac{0.75 \text{ S}^{2-}}{1 \text{ Al}^{3+}}$$

not enough S²⁻ - LR

$$\frac{0.00400 \text{ mol Al}^{3+} \text{ start} - 0.00200 \text{ mol Al}^{3+} \text{ used}}{0.00200 \text{ mol Al}^{3+} \text{ left at end}}$$

(2)

10. continued

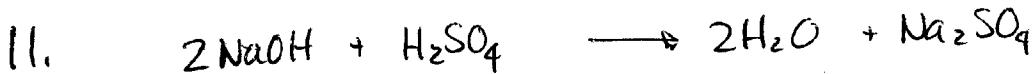
$$V_{\text{total}} = \frac{50.0 \text{ mL}}{0.0500 \text{ L}} = 1.00 \text{ L}$$

$[S^{2-}]$ at end = 0 (used up)

$$\text{Al}^{3+}: \frac{-0.004 - 2(0.001)}{2} = 0.00200 \text{ mol} \div 0.05 \text{ L} = 0.0400 \text{ M Al}^{3+}$$

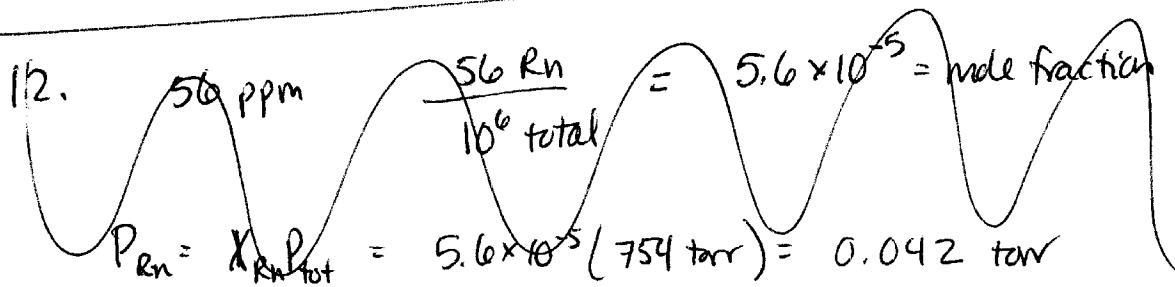
$$\text{Na}^+: 0.00600 \text{ mol} \div 0.05 \text{ L} = 0.120 \text{ M Na}^+$$

$$\text{Cl}^-: 0.012 \text{ mol} \div 0.05 \text{ L} = 0.240 \text{ M Cl}^-$$



$$\left(\frac{0.03501 \text{ L NaOH}}{\text{L}} \right) \left(\frac{0.4002 \text{ mol NaOH}}{\text{mol}} \right) \left(\frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}} \right) = \frac{0.0070055 \text{ mol H}_2\text{SO}_4}{\text{L}}$$

$$\frac{0.0070055 \text{ mol H}_2\text{SO}_4}{0.02546 \text{ L}} = 0.2752 \text{ M H}_2\text{SO}_4$$



14. absorbed

$$\Delta E = -2.18 \times 10^{-18} \text{ J} \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

$$-2.18 \times 10^{-18} \text{ J} \left(\frac{1}{4^2} - \frac{1}{1^2} \right)$$

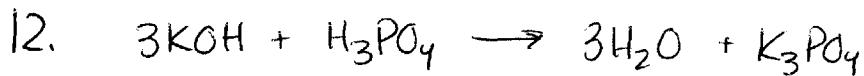
$$= +2.04375 \times 10^{-18} \text{ J} \quad -0.9375$$

$$\lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{sec})(7.998 \times 10^8 \text{ m/sec})}{2.04375 \times 10^{-18} \text{ J}}$$

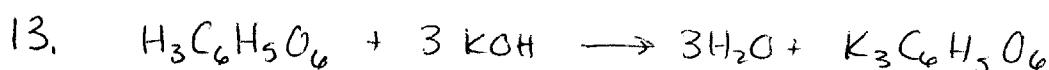
$$\lambda = 9.72 \times 10^{-8} \text{ m} = 97.2 \text{ nm}$$

$$\left(\frac{2.04375 \times 10^{-18} \text{ J}}{\text{photon}} \right) \left(\frac{1 \text{ kJ}}{1000 \text{ J}} \right) \left(\frac{6.022 \times 10^{23} \text{ photon}}{1 \text{ mole}} \right) = 1231 \text{ kJ/mol}$$

(3)



$$\left(0.02500\text{ L H}_3\text{PO}_4\right) \left(\frac{0.2009 \text{ mol H}_3\text{PO}_4}{1 \text{ L}}\right) \left(\frac{3 \text{ mol KOH}}{1 \text{ mol H}_3\text{PO}_4}\right) \left(\frac{1 \text{ L KOH}}{0.3007 \text{ mol KOH}}\right) = 0.5011 \text{ L KOH} \text{ or } 501.1 \text{ mL KOH}$$



$$\left(0.02507 \text{ L KOH}\right) \left(\frac{1.531 \text{ mol KOH}}{1 \text{ L}}\right) \left(\frac{1 \text{ mol VitC}}{3 \text{ mol KOH}}\right) \left(\frac{176.124 \text{ g}}{1 \text{ mol VitC}}\right) = 2.25334 \text{ g VitC}$$

$$\frac{2.25334 \text{ g VitC}}{10.89 \text{ g sample}} \times 100 = \underline{\underline{20.69\% \text{ VitC}}}$$

15. $P_{\text{O}_2} = 738 - 19.8 = 718.2 \text{ mmHg} \quad \div 760 = 0.945 \text{ atm}$

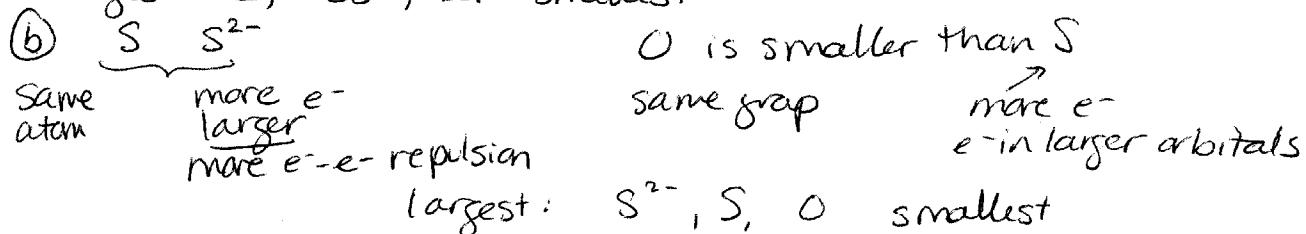
$$n = \frac{PV}{RT} = \frac{(0.945 \text{ atm})(0.0912 \text{ L})}{(0.08206 \frac{\text{L atm}}{\text{K mol}})(295 \text{ K})} = 0.00356 \text{ mol}$$

$$\times \frac{32.00 \text{ g}}{1 \text{ mol}} = 0.1139 \text{ g}$$

$$= 0.114 \text{ g}$$



isoelectronic - more p^+ , smaller - nucleus pulls in more
largest I^- , Cs^+ , Ba^{2+} smallest



20. need 250.0 mL 0.400 M Cl^-

$$\left(0.2500 \text{ L}\right) \left(\frac{0.400 \text{ mol Cl}^-}{1 \text{ L}}\right) \left(\frac{1 \text{ mol CaCl}_2}{2 \text{ mol Cl}^-}\right) \left(\frac{110.98 \text{ g CaCl}_2}{1 \text{ mol CaCl}_2}\right) = 5.55 \text{ g CaCl}_2$$

weigh out 5.55 g CaCl_2 . Place in 250.0 mL volumetric flask.
add H_2O + mix to dissolve. Add H_2O until $V_{\text{total}} = 250.0 \text{ mL}$.

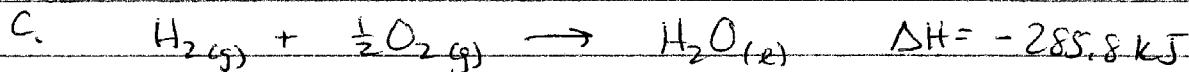
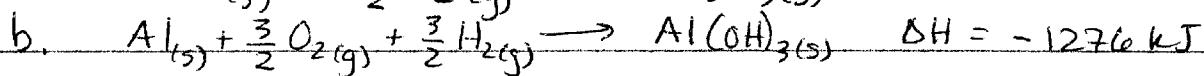
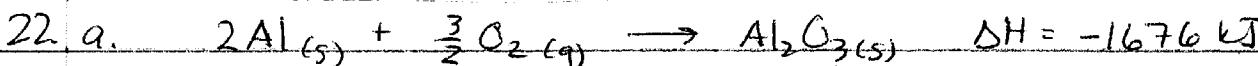
(4)

$$21. M_c V_c = M_d V_d$$

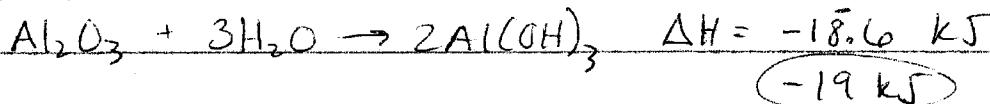
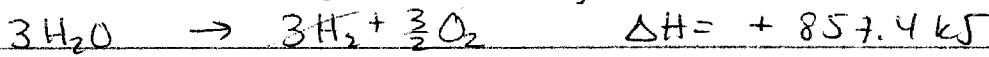
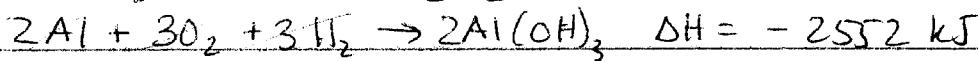
$$V_d = \frac{M_c V_c}{M_d} = \frac{(2.00\text{M})(350.\text{mL})}{(0.500\text{M})} = 1400 \text{ mL} = \text{total final V.}$$

$$= V_c + V_{\text{water added}}$$

$$\begin{array}{r} 1400 \text{ mL} \\ - 350. \text{ mL} \\ \hline 1050 \text{ mL} \end{array} \text{ or } (1.05 \text{ L}) \text{ H}_2\text{O to be added.}$$



d. Reverse rxn (A), Rxn (B) $\times 2$, Reverse and $\times 3$ Rxn C



$$23. a. W = -P\Delta V = -\Delta n g_{\text{gas}} RT = -(4-2 \text{ mol})(8.314 \text{ J/mol}\cdot\text{K})(298\text{K}) = -4955 \text{ J}$$

$$-4.955 \text{ kJ}$$

b. $\Delta E = q + W = 256 \text{ kJ} - 4.955 \text{ kJ} = +251 \text{ kJ}$

c. bomb calorimeter (ΔE) \Rightarrow 251 kJ absorbed.

~~The T would decrease.~~

24. ① water warming 19.7 \rightarrow 47.1 ② steam cooling 121.3 \rightarrow 100

$$q = sm\Delta T \quad q_{\oplus}$$

$$q = (4.184 \text{ J/gC})(\text{m})(27.4^\circ\text{C})$$

$$q = 114.64 \text{ m}$$

$$q = sm\Delta T \quad q_{\ominus}$$

$$q = (2.05 \text{ J/gC})(35 \text{ g})(-21.3^\circ\text{C})$$

$$q = -1491 \text{ J}$$

③ steam condensing @ 100°C q_{\ominus}

$$(35 \text{ g}) \left(\frac{-2260 \text{ J}}{\text{g}} \right) = -79100 \text{ J}$$

$$-(q_{\text{exo}}^{\text{total}}) = (q_{\text{endo}}^{\text{total}})$$

$$-q_1 = q_2 + q_3 + q_4$$

④ hot water cooling 100 \rightarrow 47.1°C

$$q = sm\Delta T \quad q_{\ominus}$$

$$q = (4.184 \text{ J/gC})(35 \text{ g})(-52.9^\circ\text{C})$$

$$q = -7746.676 \text{ J}$$

5

$$\begin{aligned} -q_1 &= q_2 + q_3 + q_4 \\ -114.64 \text{ m} &= -1491 - 79100 - 7746.676 \text{ J} \\ -114.64 \text{ m} &= -88337.676 \\ m &= \frac{-88337.676}{-114.64} = 770.5659 \end{aligned}$$

771 g H₂O

25. a. endo b. absorbed

$$c. (5.00 \text{ g C}) \left(\frac{1 \text{ mol C}}{12.01 \text{ g C}} \right) \left(\frac{+464.8 \text{ kJ}}{3 \text{ mol C}} \right) = +64.5 \text{ kJ } (\underline{\text{absorbed}})$$

$$26. \Delta T = 22.77 - 21.43 = +1.34^\circ\text{C}$$

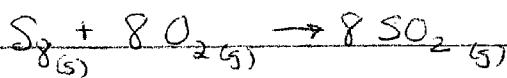
$$-q_{rxn} = q_{bond} + q_w \quad q_{bond} = 4.333 \text{ kJ/g} \cdot (1.34^\circ\text{C}) = 5.806 \text{ kJ}$$

$$q_{cal} = 5.806 \text{ kJ}$$

$$q_{rxn} = -5.806 \text{ kJ}$$

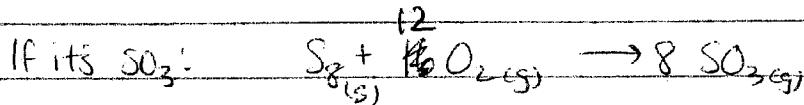
$$(5.00 \text{ g S}_8) \left(\frac{1 \text{ mol}}{256.56 \text{ g}} \right) = 0.01949 \text{ mol S}_8 \quad \frac{-5.806 \text{ kJ}}{0.01949 \text{ mol S}_8} = 297.9 \text{ kJ/mol S}_8$$

$$\Rightarrow -297.9 \text{ kJ/mol S}_8$$



$$\Delta E = -298 \text{ kJ}$$

$$W = 0 \text{ because } \Delta n_{gas} = 0 \quad \text{so } \Delta H = -298 \text{ kJ}$$



$$\Delta E = -298 \text{ kJ}$$

$$W = -\Delta n_{gas} RT = -(8-12)(8.314)(294 \text{ K}) = 9843.77 \text{ J}$$

$$\Delta E = \Delta H + W = -298 \text{ kJ} - 9.84 \text{ kJ} = -308 \text{ kJ}$$

27. Al is more resistant to temp changes. Fe will reach bdy T first.

$$28. a. \Delta H_{rxn} = [-461.96 + 2(-167.2) + 0] - [0 + 2(0) + 2(-167.2)]$$

$$\Delta H_{rxn} = -460.96 \text{ kJ}$$

$$b. (0.200 \text{ g Mg}) \left(\frac{1 \text{ mol}}{24.31 \text{ g}} \right) = 0.008227 \text{ mol Mg} \quad (0.100 \text{ L})(1.0 \text{ mol HCl}) = 0.100 \text{ mol HCl}$$

Need $\frac{2 \text{ HCl}}{1 \text{ Mg}}$ have $\frac{0.100}{0.008227} = \frac{12 \text{ HCl}}{1 \text{ Mg}}$ plenty of HCl. Mg is limiting

(6)

$$\frac{(0.008227 \text{ mol Mg})}{(1 \text{ mol Mg})} \left(-461.96 \text{ kJ} \right) = -3.8005 \text{ kJ}$$

released = -3800.5 J

water in calorimeter will absorb $+3800.5 \text{ J}$

assume: $d_{\text{solution}} = d_{\text{H}_2\text{O}}$

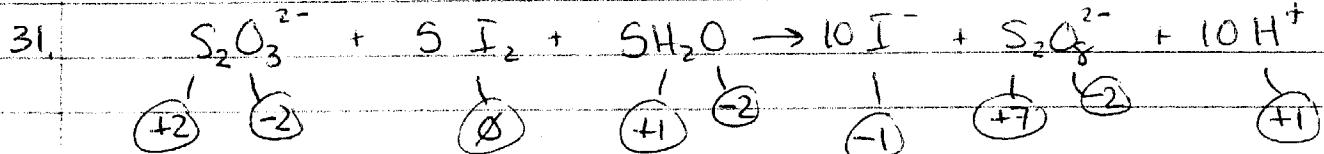
heat capacity = heat cap H_2O

no heat is lost to surroundings.

$$q_w = S_w M_w \Delta T_w \quad \Delta T_w = \frac{q}{sm} = \frac{3800.5 \text{ J}}{(4.184 \text{ J/gC})(100 \text{ g})} = 9.08^\circ\text{C}$$

$$T_f = T_i + \Delta T = 20 + 9.08 \Rightarrow 29^\circ\text{C}$$

[29, 30] these are on extra thermo probs handout.



$$2S + 3(-2) = -2$$

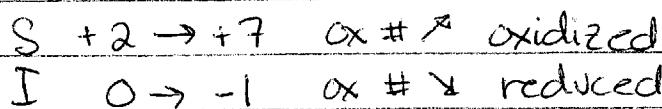
$$\begin{array}{r} 2S \\ +6 \\ \hline -6 = -2 \end{array}$$

$$\begin{array}{r} 2S \\ +2 \\ \hline S = +2 \end{array}$$

$$2S + 8(-2) = -2$$

$$\begin{array}{r} 2S \\ +16 \\ \hline -16 = -2 \end{array}$$

$$\begin{array}{r} 2S \\ +14 \\ \hline S = +7 \end{array}$$



(7)

32. assume:
 Solution is mostly water, density of solution is close to density of water, heat capacity of solution is close to that of water, no heat lost to surroundings, heat capacity of cup is negligible.
- $$q_{\text{cal}} = Cm\Delta T \quad \Delta T = 27.5 - 19.2 = 8.3^{\circ}\text{C} \quad 200\text{ mL solution} \approx 200\text{ g solution}$$
- $$q_{\text{cal}} = (4.184 \text{ J/g}^{\circ}\text{C})(202 \text{ g})(8.3^{\circ}\text{C}) = 7014.9 \text{ J absorbed by solution}$$

so $q_{\text{rxn}} = -7014.9 \text{ J}$ for the amounts we used.

÷ # moles LR. which is LR?

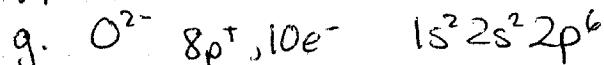
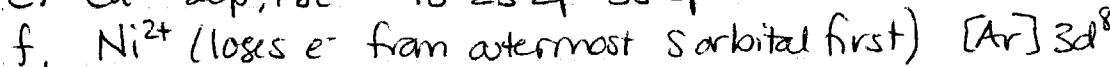
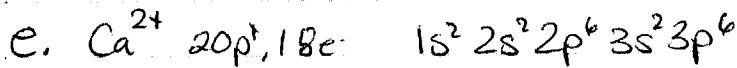
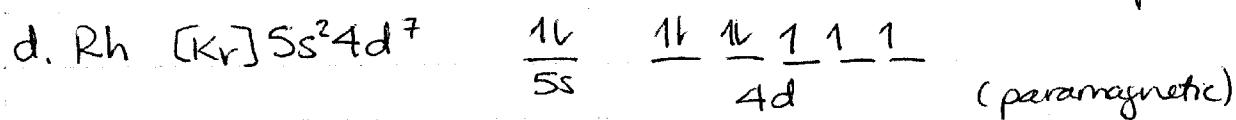
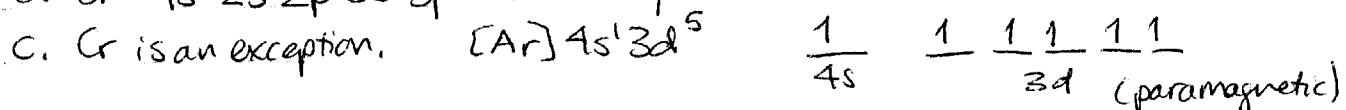
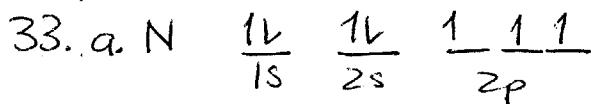
$$(2.00\text{ g CaO}) / \left(\frac{1 \text{ mol CaO}}{56.08 \text{ g CaO}} \right) = 0.03576 \text{ mol CaO} \quad \text{need } \frac{2 \text{ HBr}}{1 \text{ CaO}}$$

$$(0.200\text{ L HBr}) / \left(\frac{1.50 \text{ mol HBr}}{1 \text{ L sdn}} \right) = 0.300 \text{ mol HBr} \quad \text{have } \frac{0.3 \text{ mol HBr}}{0.03576 \text{ mol CaO}} = \frac{8.4 \text{ HBr}}{1 \text{ CaO}}$$

CaO is LR. $\frac{\text{so}}{\text{# mol CaO}}$

$$\Delta H = \frac{-7014.9 \text{ J}}{0.03576 \text{ mol CaO}} = -196716 \text{ J/mol CaO} \quad \text{or} \quad -2.0 \times 10^2 \text{ kJ/mol CaO}$$

coefficient in front of CaO is 1, so this is ΔH . $\boxed{\Delta H = -2.0 \times 10^2 \text{ kJ}}$

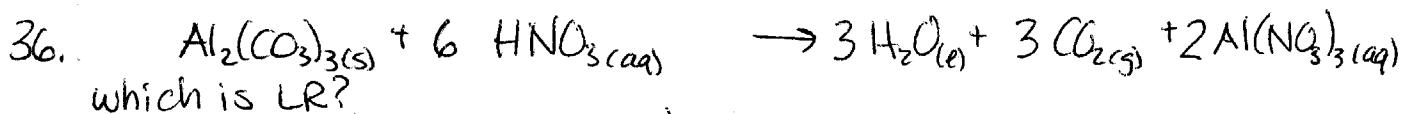


34. d = # g/L Find # g in 1L $PV = nRT$ $n = \frac{PV}{RT} = \frac{(1.0789 \text{ atm})(1.00\text{ L})}{(0.08206 \frac{\text{L atm}}{\text{K mol}})(298\text{ K})}$
- $$(820 \text{ mmHg}) / \left(\frac{1 \text{ atm}}{760 \text{ mmHg}} \right) = 1.0789 \text{ atm}$$
- $$n = 0.04412 \text{ mol in 1L}$$
- $$(0.04412 \text{ mol SO}_2) / \left(\frac{64.07 \text{ g SO}_2}{1 \text{ mol}} \right) = 2.83 \text{ g SO}_2 \text{ in 1L so d} = \boxed{2.83 \text{ g/L}}$$

(8)

35. $d = \frac{1.06\text{ g}}{\text{L}}$ find # mol in 1L. $PV=nRT$ $n = \frac{PV}{RT} = \frac{(0.988\text{ atm})(1.00\text{ L})}{(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}})(298\text{ K})}$

$n = 0.03909 \text{ mol gas in 1L}$ $\text{MM} = \# \text{g/mol}$
 so $\frac{1.06 \text{ g/L}}{0.03909 \text{ mol/L}} = 27.1 \text{ g/mol}$



which is LR?

$$(2.00\text{ g } \text{Al}_2(\text{CO}_3)_3) \left(\frac{1 \text{ mol } \text{Al}_2(\text{CO}_3)_3}{233.99 \text{ g } \text{Al}_2(\text{CO}_3)_3} \right) = 0.008547 \text{ mol } \text{Al}_2(\text{CO}_3)_3$$

$$(0.100 \text{ L}) \left(\frac{0.100 \text{ mol HNO}_3}{\text{L}} \right) = 0.0100 \text{ mol HNO}_3$$

need $\frac{6 \text{ HNO}_3}{1 \text{ Al}_2(\text{CO}_3)_3}$ have $\frac{0.0100 \text{ mol HNO}_3}{0.008547 \text{ mol Al}_2(\text{CO}_3)_3} = \frac{1.17 \text{ HNO}_3}{1 \text{ Al}_2(\text{CO}_3)_3}$ $\leftarrow \text{HNO}_3 \text{ is LR}$

$$(0.0100 \text{ mol HNO}_3) \left(\frac{3 \text{ mol CO}_2}{6 \text{ mol HNO}_3} \right) = 0.00500 \text{ mol CO}_2 \text{ will be produced}$$

collected over water $\text{VP} @ 25^\circ\text{C} = 23.76 \text{ mmHg}$

$$P_{\text{CO}_2} = P_{\text{atm}} - \text{VP} = 753.2 - 23.76 = 729.44 \text{ mmHg} \div 760 \Rightarrow 0.959789 \text{ atm}$$

$$\text{PV} = nRT \quad V = \frac{nRT}{P} = \frac{(0.00500 \text{ mol})(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}})(298\text{ K})}{0.959789 \text{ atm}}$$

$$V = 0.127 \text{ L or } 127 \text{ mL}$$

(9)

37. $\Delta T = 10.14^\circ C$

$$q_{\text{cal}} = C \Delta T = \left(8.271 \frac{\text{kJ}}{\text{C}}\right) (10.14^\circ C) = 83.868 \text{ kJ}$$

$$q_{\text{rxn}} = -q_{\text{cal}} = -83.868 \text{ kJ}$$

$$3.00 \text{ g } N_2H_3CH_3 \left(\frac{1 \text{ mol}}{46.078 \text{ g}} \right) = 0.065107 \text{ mol } N_2H_3CH_3$$

$$\Delta E = \frac{\text{heat per}}{4 \text{ moles } N_2H_3CH_3}$$

$$\Delta E = \frac{-83.868 \text{ kJ}}{0.065107 \text{ mol}} \times \frac{4}{4} = \frac{-5152.6 \text{ kJ}}{4 \text{ mol } N_2H_3CH_3}$$

$$\Delta E = -5150 \text{ kJ}$$

$$\Delta E = \Delta H + w_p$$

$$w = -\Delta n_{\text{gas}} RT \quad (\text{if at constant P})$$

$$\Delta n_{\text{gas}} = (4+9)-(0) = +13$$

$$w = -(13)(8.314 \text{ J/mol.k})(302 \text{ K})$$

$$w = -32641 \text{ J} = -32.6 \text{ kJ}$$

$$\Delta H = \Delta E - w_p = -5152.6 \text{ kJ} - (-32.6 \text{ kJ}) = -5120 \text{ kJ}$$

$$\Delta H = -5120 \text{ kJ}$$