

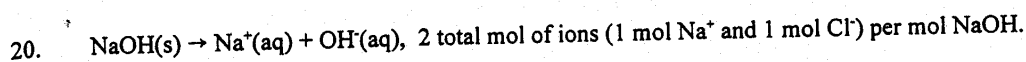
16. a.  $\frac{16.45 \text{ g NaCl}}{1.000 \text{ L}} \times \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} = 0.2815 \text{ M NaCl}$

b.  $853.5 \text{ mg KIO}_3 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol KIO}_3}{214.0 \text{ g KIO}_3} = 3.988 \times 10^{-3} \text{ mol KIO}_3$

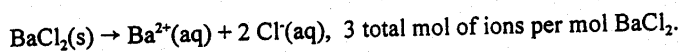
$\frac{3.988 \times 10^{-3} \text{ mol}}{250.0 \text{ mL}} \times \frac{1000 \text{ mL}}{\text{L}} = 1.595 \times 10^{-2} \text{ M KIO}_3$

c.  $0.4508 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} = 8.072 \times 10^{-3} \text{ mol Fe} = 8.072 \times 10^{-3} \text{ mol Fe}^{3+}$

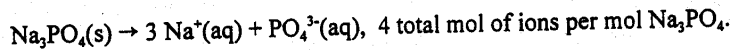
$\frac{8.072 \times 10^{-3} \text{ mol Fe}^{2+}}{500.0 \text{ mL}} \times \frac{1000 \text{ mL}}{\text{L}} = 1.614 \times 10^{-2} \text{ M Fe}^{3+}$



$0.1000 \text{ L} \times \frac{0.100 \text{ mol NaOH}}{\text{L}} \times \frac{2 \text{ mol ions}}{\text{mol NaOH}} = 2.0 \times 10^{-2} \text{ mol ions}$



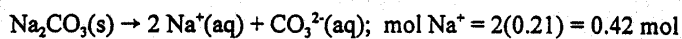
$0.0500 \text{ L} \times \frac{0.200 \text{ mol}}{\text{L}} \times \frac{3 \text{ mol ions}}{\text{mol BaCl}_2} = 3.0 \times 10^{-2} \text{ mol ions}$



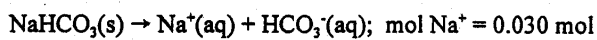
$0.0750 \text{ L} \times \frac{0.150 \text{ mol Na}_3\text{PO}_4}{\text{L}} \times \frac{4 \text{ mol ions}}{\text{mol Na}_3\text{PO}_4} = 4.50 \times 10^{-2} \text{ mol ions}$

75.0 mL of 0.150 M  $\text{Na}_3\text{PO}_4$  contains the largest number of ions.

26.  $\text{mol Na}_2\text{CO}_3 = 0.0700 \text{ L} \times \frac{3.0 \text{ mol Na}_2\text{CO}_3}{\text{L}} = 0.21 \text{ mol Na}_2\text{CO}_3$



$\text{mol NaHCO}_3 = 0.0300 \text{ L} \times \frac{1.0 \text{ mol NaHCO}_3}{\text{L}} = 0.030 \text{ mol NaHCO}_3$



$M_{\text{Na}^+} = \frac{\text{total mol Na}^+}{\text{total volume}} = \frac{0.42 \text{ mol} + 0.030 \text{ mol}}{0.0700 \text{ L} + 0.0300 \text{ L}} = \frac{0.45 \text{ mol}}{0.1000 \text{ L}} = 4.5 \text{ M Na}^+$

30. a. Possible products =  $\text{FeCl}_2$  and  $\text{K}_2\text{SO}_4$ ; Both salts are soluble so no precipitate forms.  
 b. Possible products =  $\text{Al}(\text{OH})_3$  and  $\text{Ba}(\text{NO}_3)_2$ ; precipitate =  $\text{Al}(\text{OH})_3(\text{s})$   
 c. Possible products =  $\text{CaSO}_4$  and  $\text{NaCl}$ ; precipitate =  $\text{CaSO}_4(\text{s})$   
 d. Possible products =  $\text{KNO}_3$  and  $\text{NiS}$ ; precipitate =  $\text{NiS}(\text{s})$

34. a.  $\text{AgCl}$  is insoluble.  $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$   
 b.  $\text{FeS}$  is insoluble.  $\text{Fe}^{2+}(\text{aq}) + \text{S}^{2-}(\text{aq}) \rightarrow \text{FeS}(\text{s})$   
 c. No reaction  
 d.  $\text{Hg}_2(\text{NO}_3)_2$  is made up of  $\text{Hg}_2^{2+}$  and  $\text{NO}_3^-$  ions.  $\text{Hg}_2\text{Cl}_2$ , mercury(I) chloride or mercurous chloride, is insoluble.  $\text{Hg}_2^{2+}(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow \text{Hg}_2\text{Cl}_2(\text{s})$

42. The balanced equation is:  $3 \text{BaCl}_2(\text{aq}) + \text{Fe}_2(\text{SO}_4)_3(\text{aq}) \rightarrow 3 \text{BaSO}_4(\text{s}) + 2 \text{FeCl}_3(\text{aq})$

$$100.0 \text{ mL BaCl}_2 \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.100 \text{ mol BaCl}_2}{\text{L}} = 1.00 \times 10^{-2} \text{ mol BaCl}_2$$

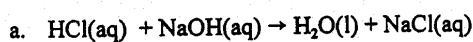
$$100.0 \text{ mL Fe}_2(\text{SO}_4)_3 \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.100 \text{ mol Fe}_2(\text{SO}_4)_3}{\text{L Fe}_2(\text{SO}_4)_3} = 1.00 \times 10^{-2} \text{ mol Fe}_2(\text{SO}_4)_3$$

The required mol  $\text{BaCl}_2$  to mol  $\text{Fe}_2(\text{SO}_4)_3$  ratio from the balanced reaction is 3:1. The actual mol ratio is  $0.0100/0.0100 = 1$  (1:1). This is well below the required mol ratio so  $\text{BaCl}_2$  is the limiting reagent.

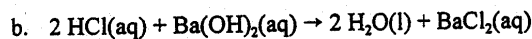
$$0.0100 \text{ mol BaCl}_2 \times \frac{3 \text{ mol BaSO}_4}{3 \text{ mol BaCl}_2} \times \frac{233.4 \text{ g BaSO}_4}{\text{mol BaSO}_4} = 2.33 \text{ g BaSO}_4$$

46. a.  $3 \text{HNO}_3(\text{aq}) + \text{Al}(\text{OH})_3(\text{s}) \rightarrow 3 \text{H}_2\text{O}(\text{l}) + \text{Al}(\text{NO}_3)_3(\text{aq})$   
 $3 \text{H}^+(\text{aq}) + 3 \text{NO}_3^-(\text{aq}) + \text{Al}(\text{OH})_3(\text{s}) \rightarrow 3 \text{H}_2\text{O}(\text{l}) + \text{Al}^{3+}(\text{aq}) + 3 \text{NO}_3^-(\text{aq})$   
 $3 \text{H}^+(\text{aq}) + \text{Al}(\text{OH})_3(\text{s}) \rightarrow 3 \text{H}_2\text{O}(\text{l}) + \text{Al}^{3+}(\text{aq})$   
 b.  $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{KC}_2\text{H}_3\text{O}_2(\text{aq})$   
 $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{K}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{K}^+(\text{aq}) + \text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$   
 $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$

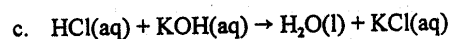
50. We begin with 25.00 mL of 0.200 M HCl or  $25.00 \times 10^{-3} \text{ L} \times 0.200 \text{ mol/L} = 5.00 \times 10^{-3} \text{ mol HCl}$ .



$$5.00 \times 10^{-3} \text{ mol HCl} \times \frac{1 \text{ mol NaOH}}{\text{mol HCl}} \times \frac{1 \text{ L}}{0.100 \text{ mol NaOH}} = 5.00 \times 10^{-2} \text{ L or } 50.0 \text{ mL}$$



$$5.00 \times 10^{-3} \text{ mol HCl} \times \frac{1 \text{ mol Ba(OH)}_2}{2 \text{ mol HCl}} \times \frac{1 \text{ L}}{0.0500 \text{ mol Ba(OH)}_2} = 5.00 \times 10^{-2} \text{ L} = 50.0 \text{ mL}$$



$$5.00 \times 10^{-3} \text{ mol HCl} \times \frac{1 \text{ mol KOH}}{\text{mol HCl}} \times \frac{1 \text{ L}}{0.250 \text{ mol KOH}} = 2.00 \times 10^{-2} \text{ L or } 20.0 \text{ mL}$$

58. a.  $\text{UO}_2^{2+}$ : O, -2; For U,  $x + 2(-2) = +2$ ,  $x = +6$

b.  $\text{As}_2\text{O}_3$ : O, -2; For As,  $2(x) + 3(-2) = 0$ ,  $x = +3$

c.  $\text{NaBiO}_3$ : Na, +1; O, -2; For Bi,  $+1 + x + 3(-2) = 0$ ,  $x = +5$

d.  $\text{As}_4$ : As, 0

e.  $\text{HAsO}_2$ : assign H = +1 and O = -2; For As,  $+1 + x + 2(-2) = 0$ ;  $x = +3$

f.  $\text{Mg}_2\text{P}_2\text{O}_7$ : Composed of  $\text{Mg}^{2+}$  ions and  $\text{P}_2\text{O}_7^{4-}$  ions. Oxidation states are:

Mg, +2; O, -2; P, +5

g.  $\text{Na}_2\text{S}_2\text{O}_3$ : Composed of  $\text{Na}^+$  ions and  $\text{S}_2\text{O}_3^{2-}$  ions. Na, +1; O, -2; S, +2

h.  $\text{Hg}_2\text{Cl}_2$ : Hg, +1; Cl, -1

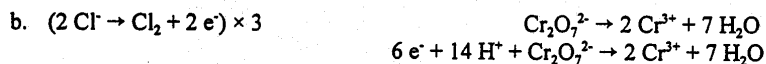
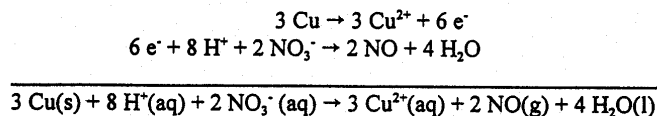
i.  $\text{Ca(NO}_3)_2$ : Composed of  $\text{Ca}^{2+}$  ions and  $\text{NO}_3^-$  ions. Ca, +2; O, -2; N, +5

| 62. | <u>Redox?</u> | <u>Oxidizing Agent</u> | <u>Reducing Agent</u> | <u>Substance Oxidized</u> | <u>Substance Reduced</u> |
|-----|---------------|------------------------|-----------------------|---------------------------|--------------------------|
| a.  | Yes           | $\text{Ag}^+$          | Cu                    | Cu                        | $\text{Ag}^+$            |
| b.  | No            | -                      | -                     | -                         | -                        |
| c.  | No            | -                      | -                     | -                         | -                        |
| d.  | Yes           | $\text{SiCl}_4$        | Mg                    | Mg                        | $\text{SiCl}_4$ (Si)     |
| e.  | No            | -                      | -                     | -                         | -                        |

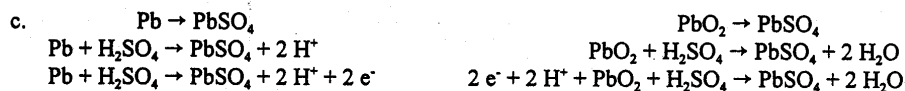
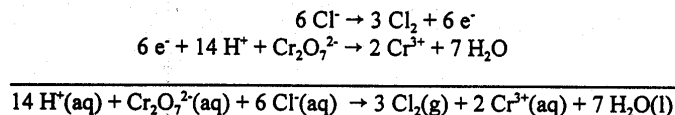
In b, c, and e, no oxidation numbers change.



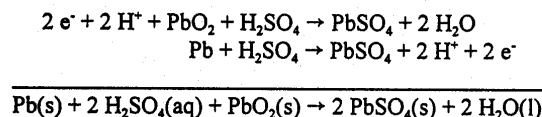
Adding the two balanced half-reactions so electrons cancel:



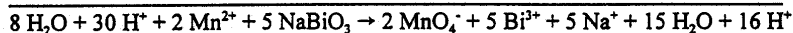
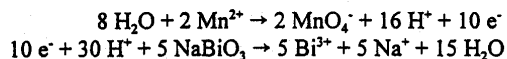
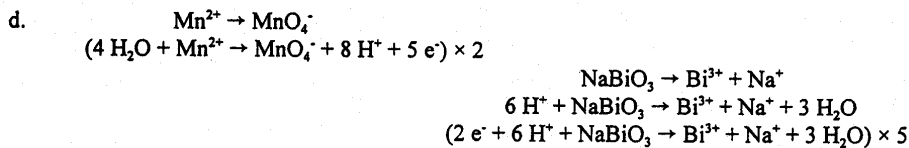
Add the two half-reactions with six electrons transferred:



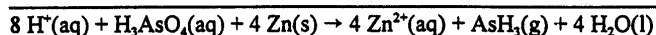
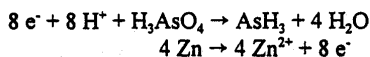
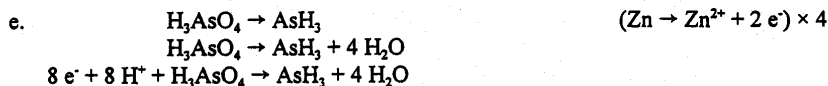
Add the two half-reactions with two electrons transferred:

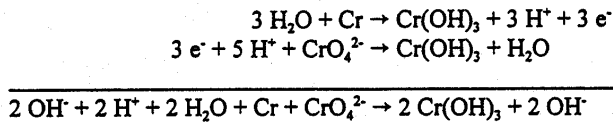
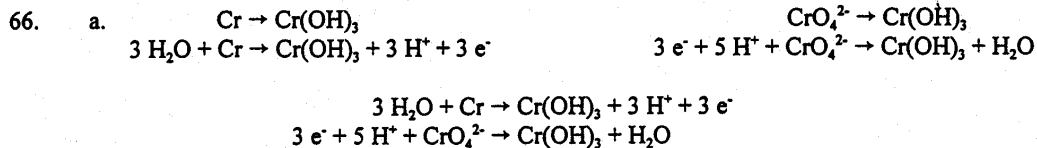


This is the reaction that occurs in an automobile lead storage battery.

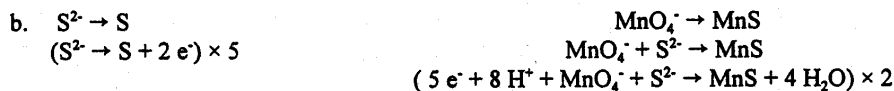
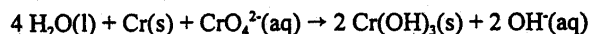


Simplifying :

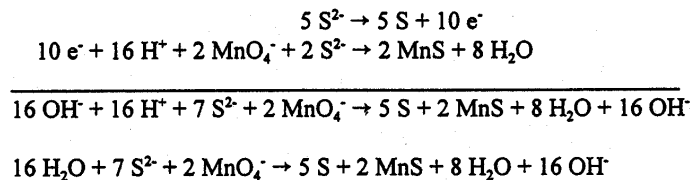




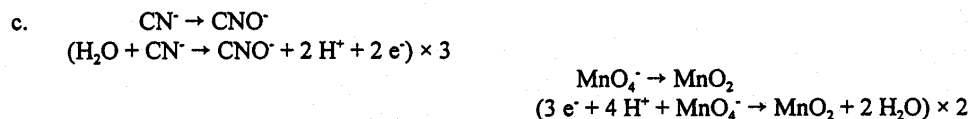
Two OH<sup>-</sup> were added above to each side to convert to basic solution. The two OH<sup>-</sup> react with the 2 H<sup>+</sup> on the reactant side to produce 2 H<sub>2</sub>O. The overall balanced equation is:



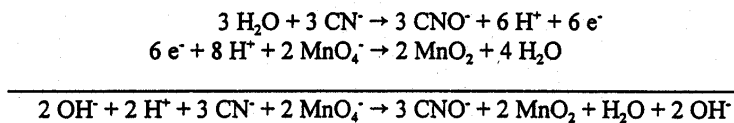
Common factor is a transfer of 10 e<sup>-</sup>.



Reducing gives:  $8 \text{H}_2\text{O(l)} + 7 \text{S}^{2-}(\text{aq}) + 2 \text{MnO}_4^-(\text{aq}) \rightarrow 5 \text{S(s)} + 2 \text{MnS(s)} + 16 \text{OH}^-(\text{aq})$



Common factor is a transfer of 6 electrons.



Reducing gives:

