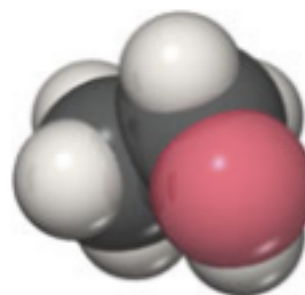
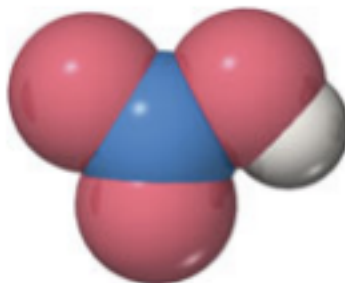
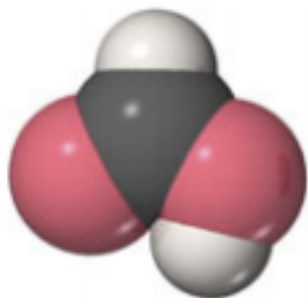


4.3 Use the molecular representations shown here to classify each compound as either a nonelectrolyte, a weak electrolyte, or a strong electrolyte (see inside back cover for element color scheme). [Sections 4.1 and 4.3]



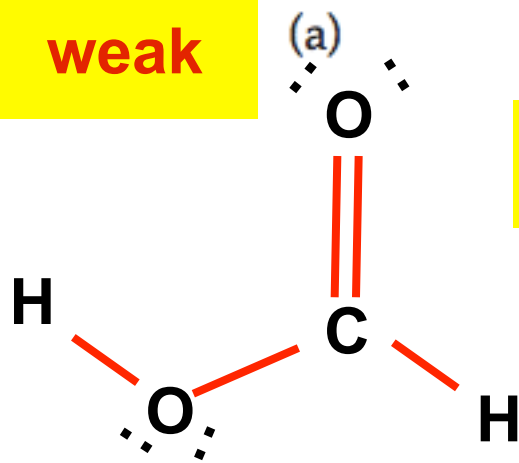
non

weak

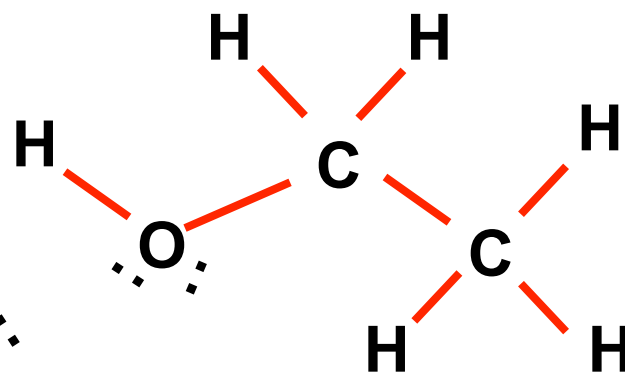
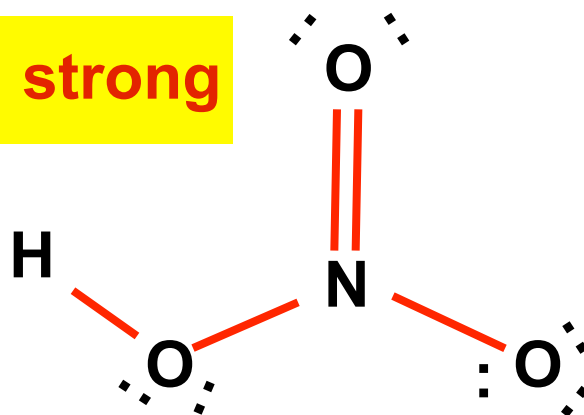
(a)

(b)

(c)



strong



formic acid

nitric acid

ethanol

HCOOH

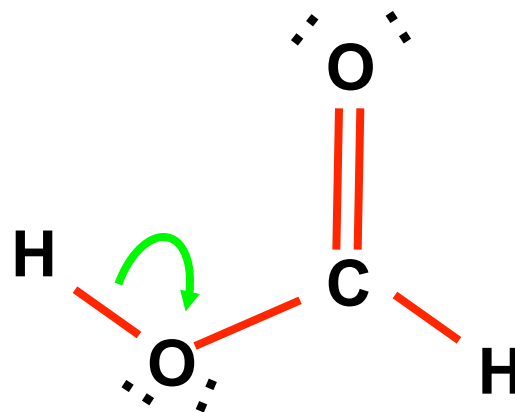
HNO₃

CH₃CH₂OH

4.17 Formic acid, HCOOH, is a weak electrolyte. What solute particles are present in an aqueous solution of this compound? Write the chemical equation for the ionization of HCOOH.



98 %

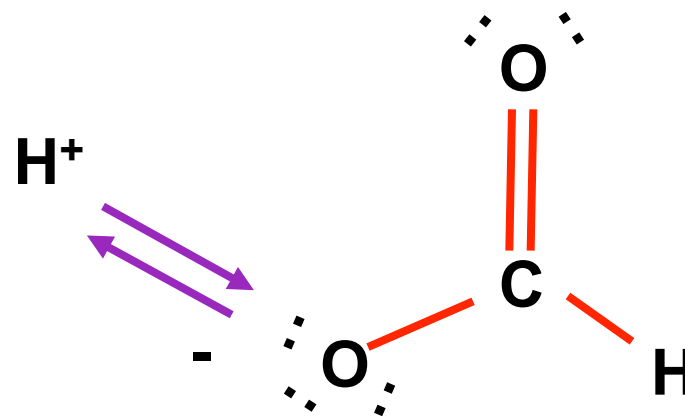


4.17 Formic acid, HCOOH , is a weak electrolyte. What solute particles are present in an aqueous solution of this compound? Write the chemical equation for the ionization of HCOOH .

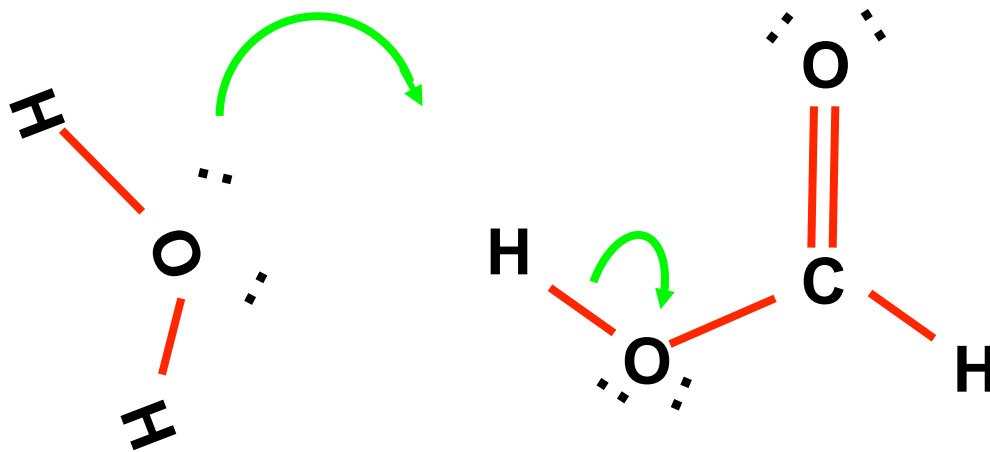


98 %

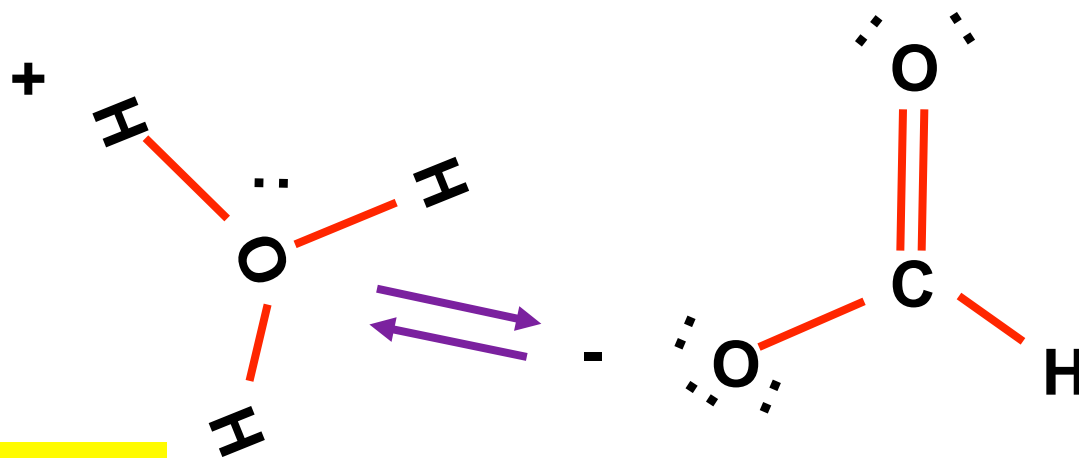
proton



4.17 Formic acid, HCOOH , is a weak electrolyte. What solute particles are present in an aqueous solution of this compound? Write the chemical equation for the ionization of HCOOH .



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hydronium ion



4.21 Will precipitation occur when the following solutions are mixed? If so, write a balanced chemical equation for the reaction. (a) Na_2CO_3 and AgNO_3 , (b) NaNO_3 and NiSO_4 , (c) FeSO_4 and $\text{Pb}(\text{NO}_3)_2$.

a)

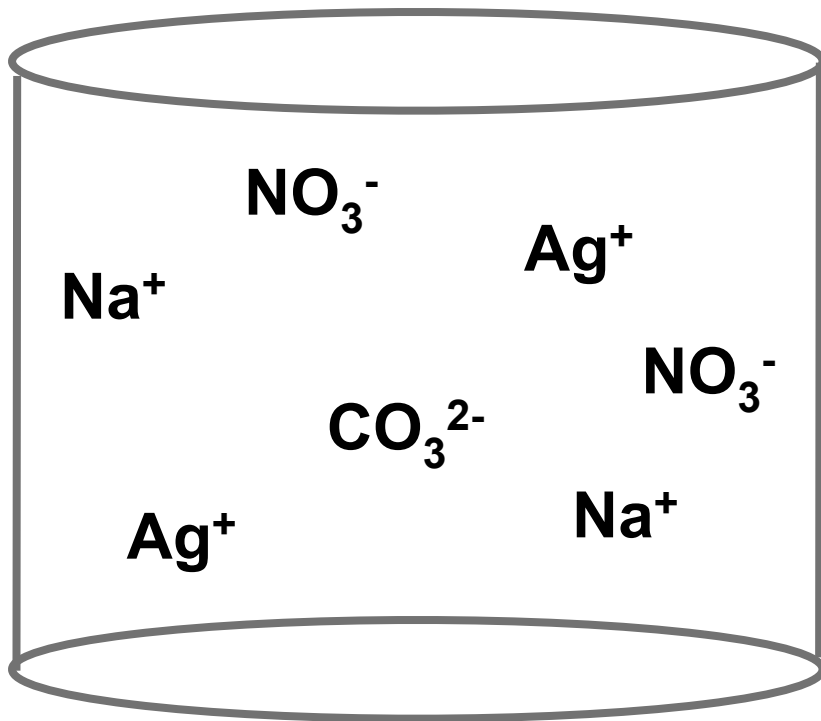


TABLE 4.1 • Solubility Guidelines for Common Ionic Compounds in Water

Soluble Ionic Compounds		Important Exceptions
Compounds containing	NO_3^-	None
	CH_3COO^-	None
	Cl^-	Compounds of Ag^+ , Hg_2^{2+} , and Pb^{2+}
	Br^-	Compounds of Ag^+ , Hg_2^{2+} , and Pb^{2+}
	I^-	Compounds of Ag^+ , Hg_2^{2+} , and Pb^{2+}
	SO_4^{2-}	Compounds of Sr^{2+} , Ba^{2+} , Hg_2^{2+} , and Pb^{2+}
Insoluble Ionic Compounds		Important Exceptions
Compounds containing	S^{2-}	Compounds of NH_4^+ , the alkali metal cations, Ca^{2+} , Sr^{2+} , and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
	OH^-	Compounds of NH_4^+ , the alkali metal cations, Ca^{2+} , Sr^{2+} , and Ba^{2+}

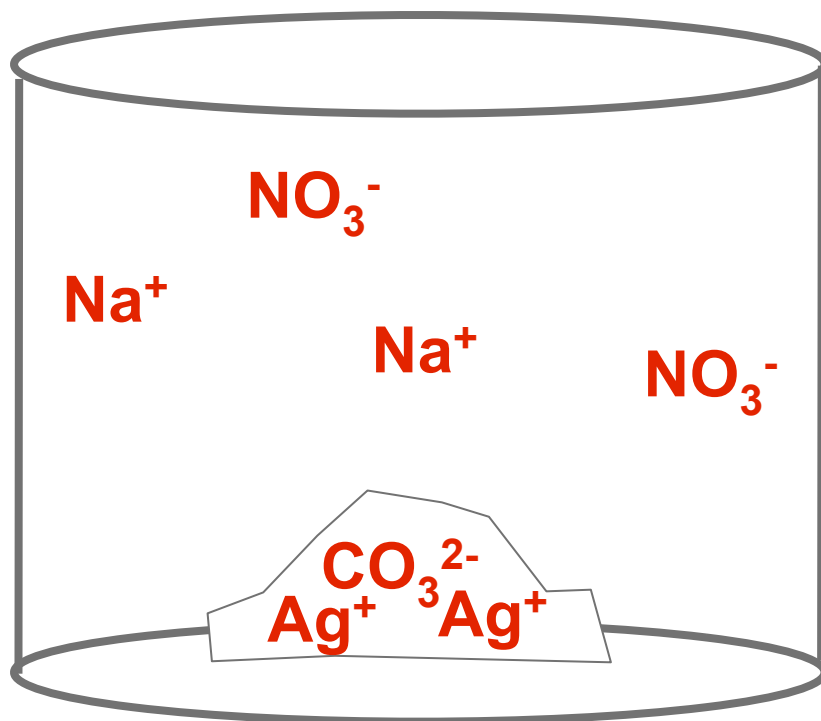
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a)



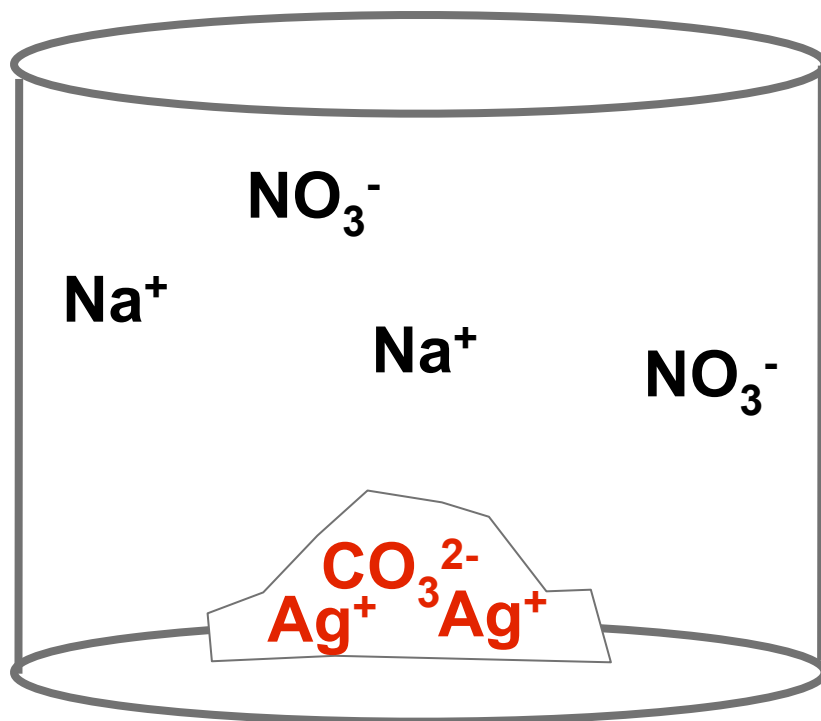
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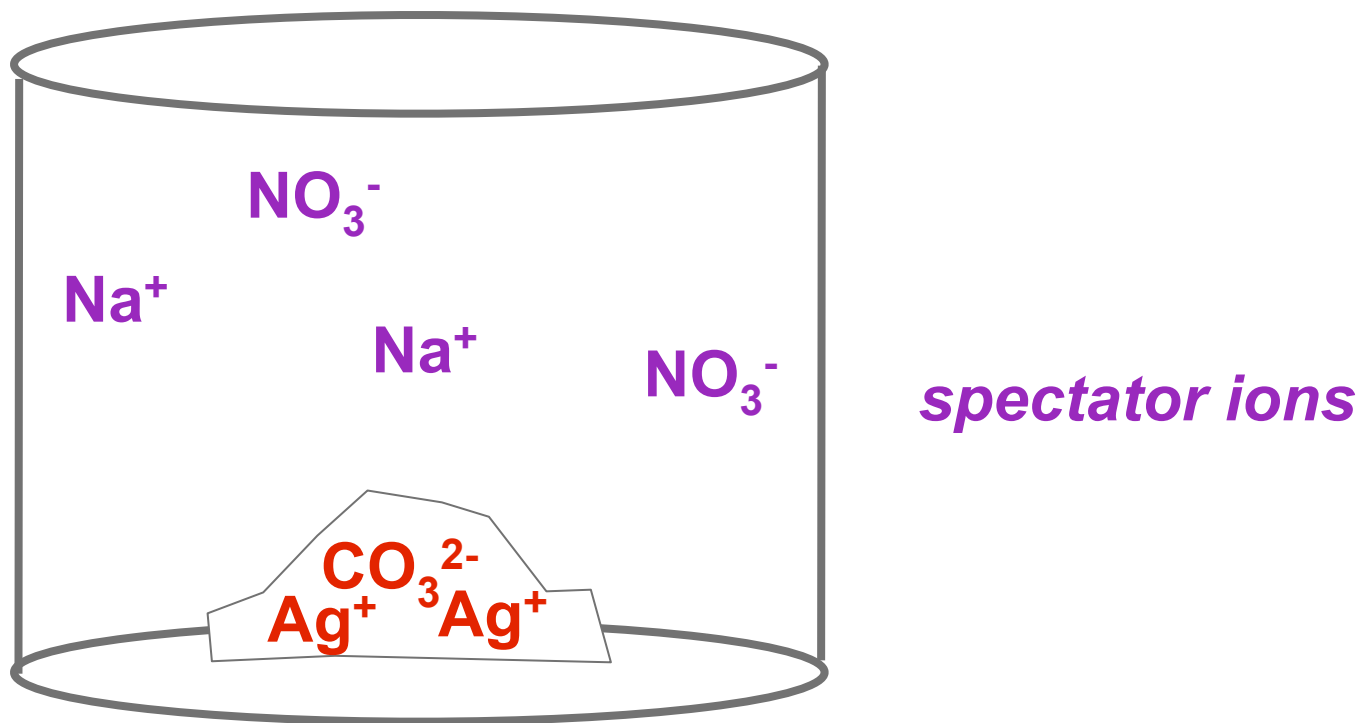
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a)



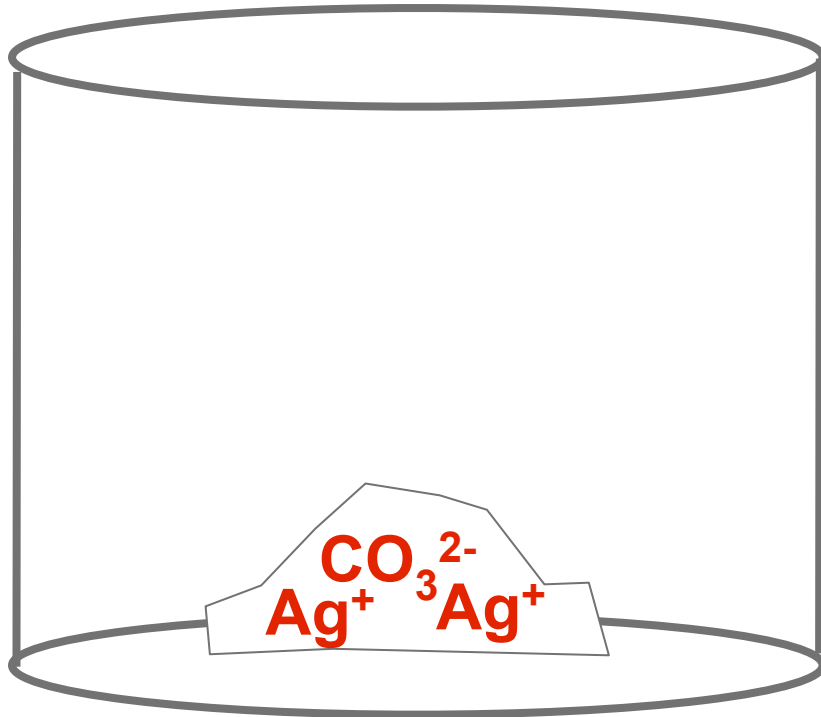
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a)



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a) *net ionic equation*



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a)



b)

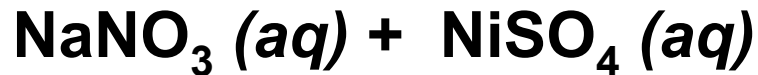


TABLE 4.1 • Solubility Guidelines for Common Ionic Compounds in Water

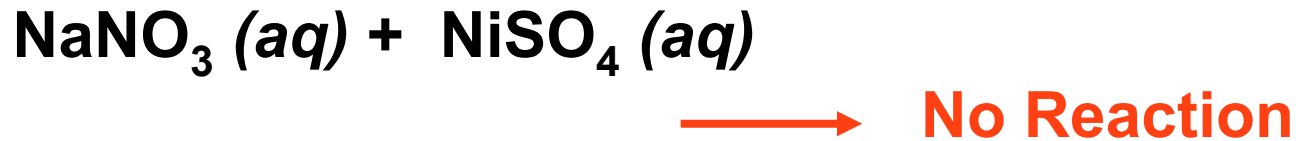
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a)



b)



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b)

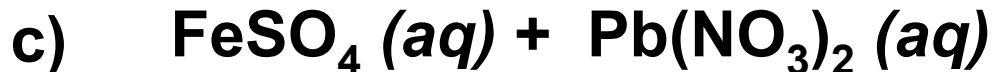
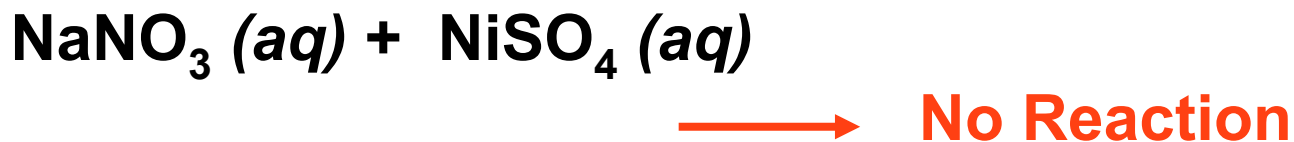


TABLE 4.1 • Solubility Guidelines for Common Ionic Compounds in Water

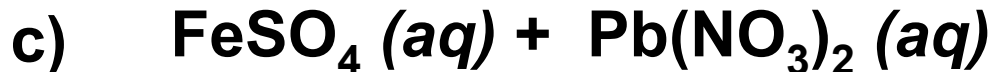
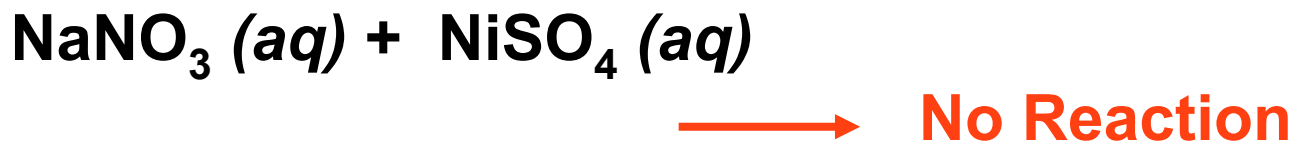
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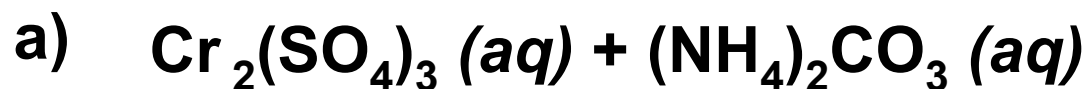
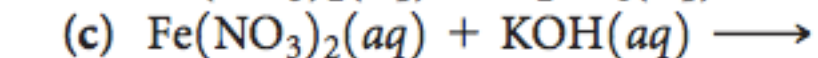
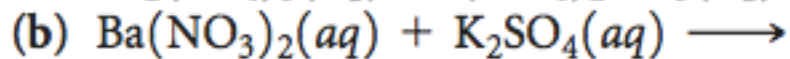
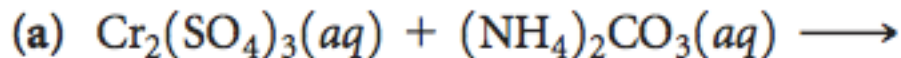
a)



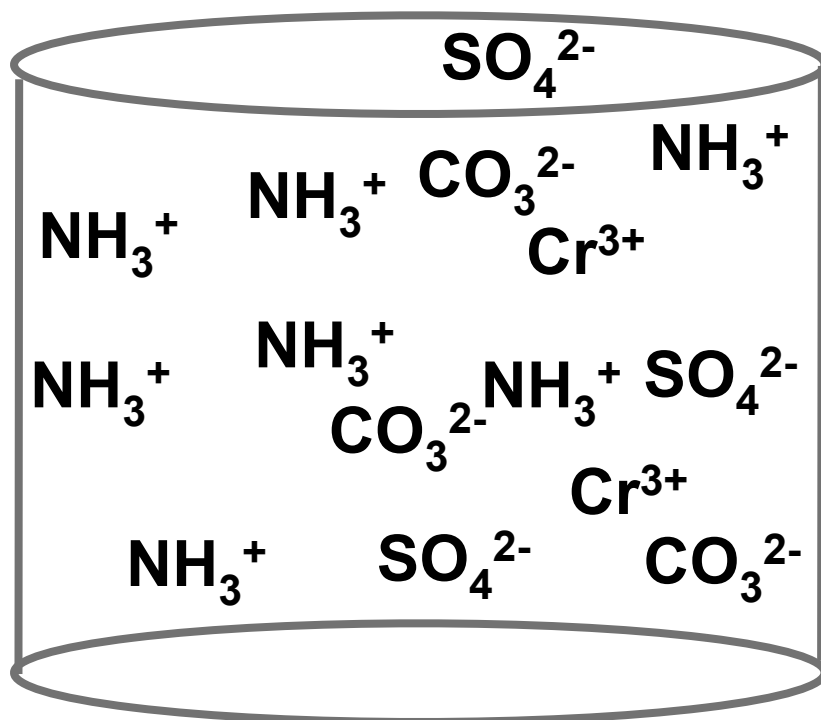
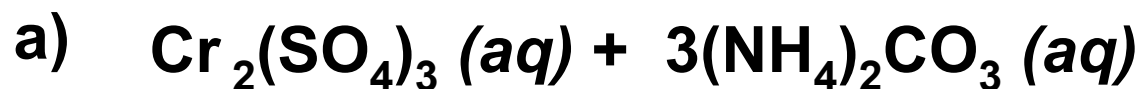
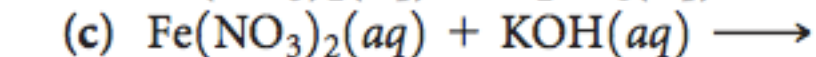
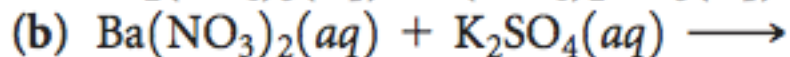
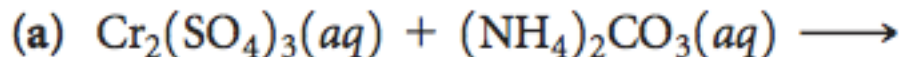
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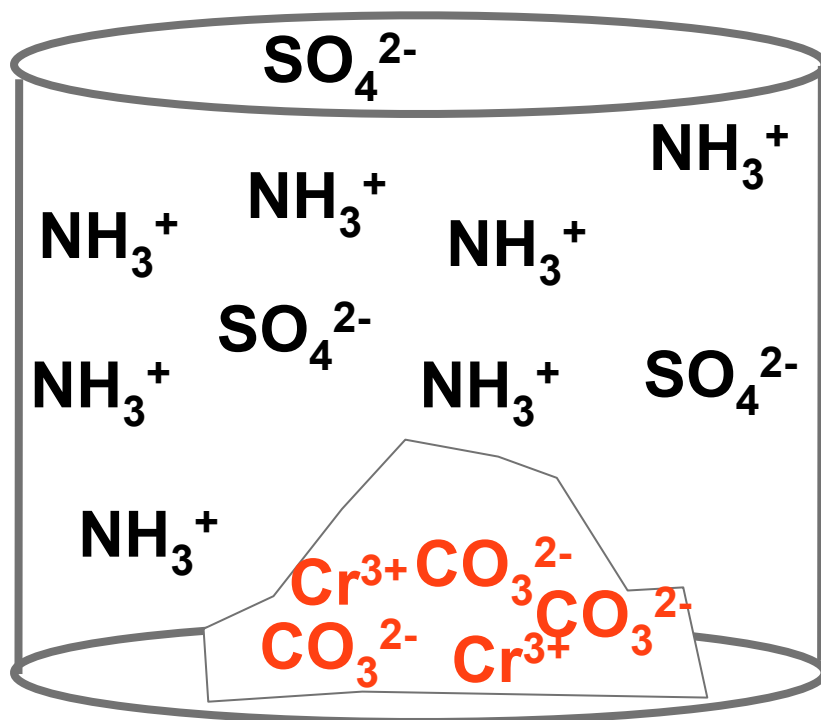
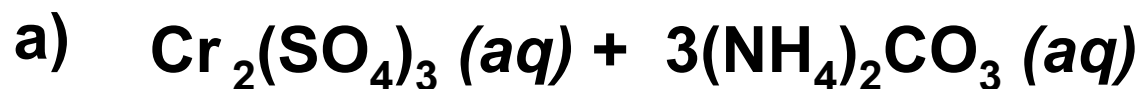
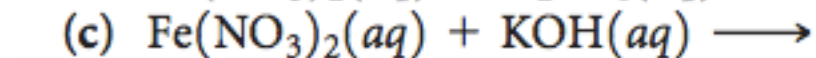
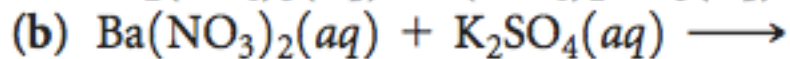
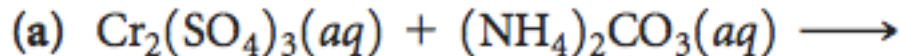
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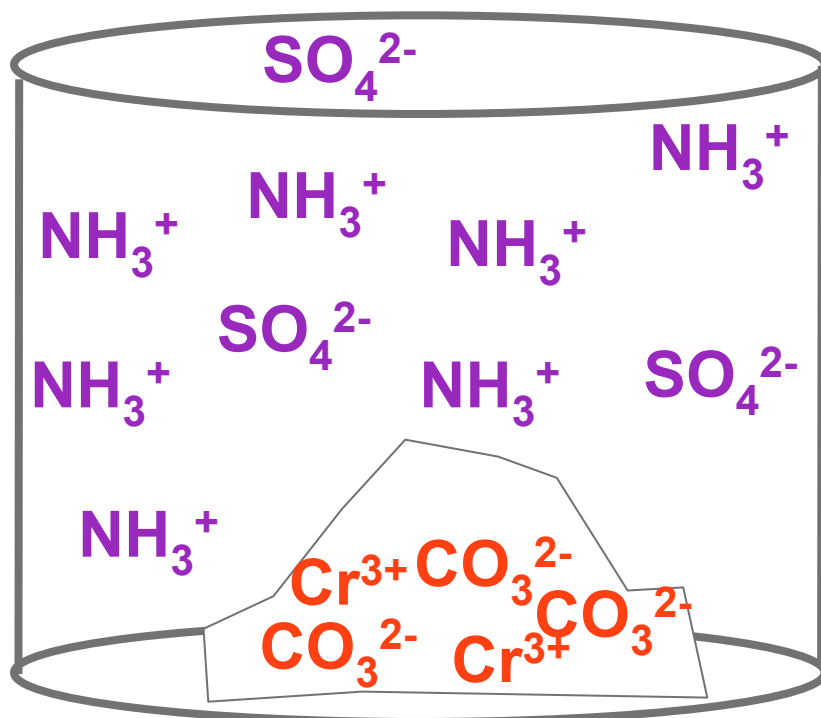
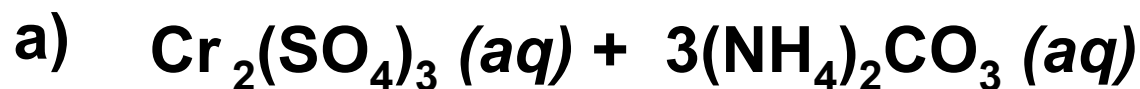
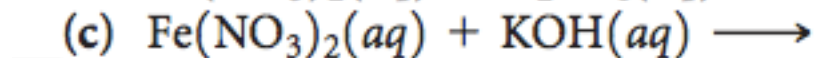
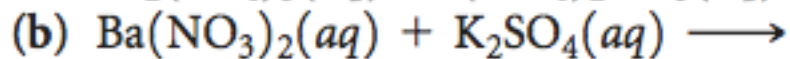
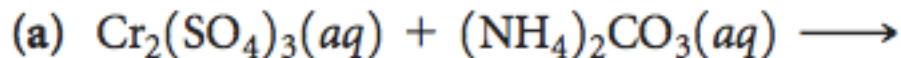
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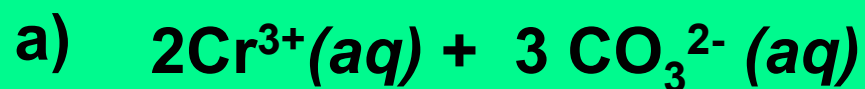
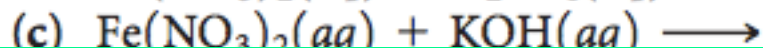
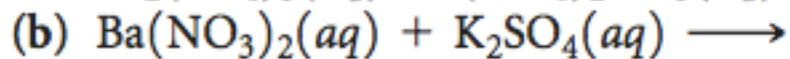
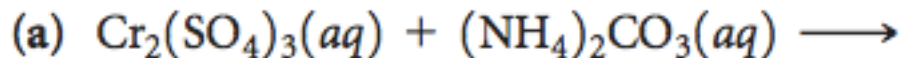


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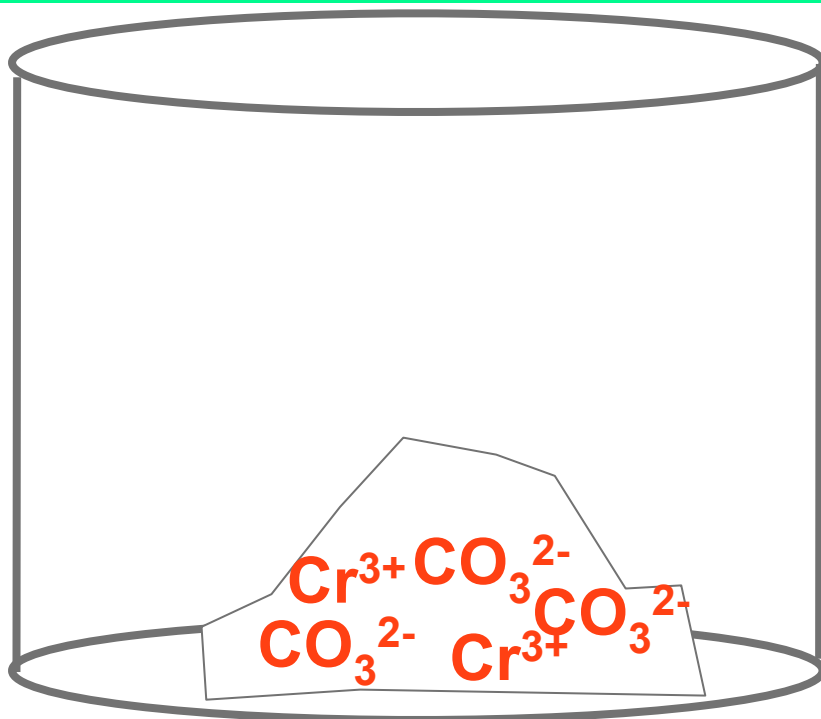


spectator ions

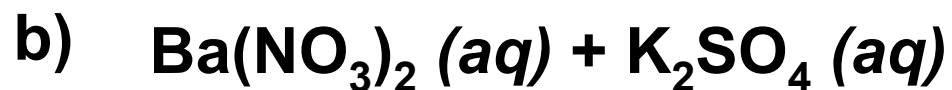
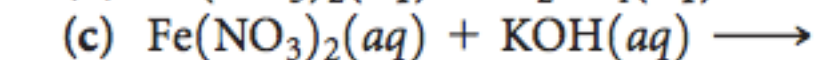
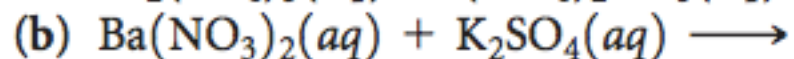
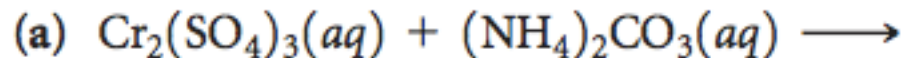
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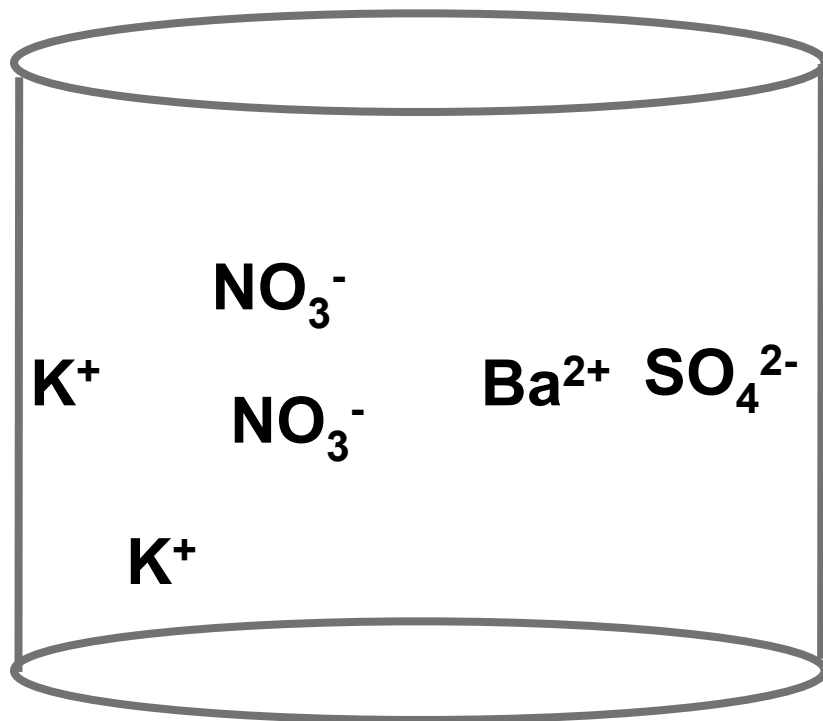
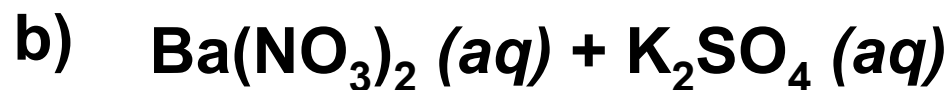
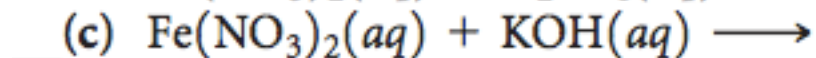
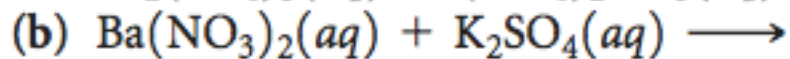
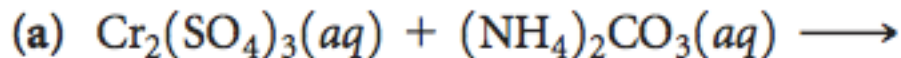
net ionic equation



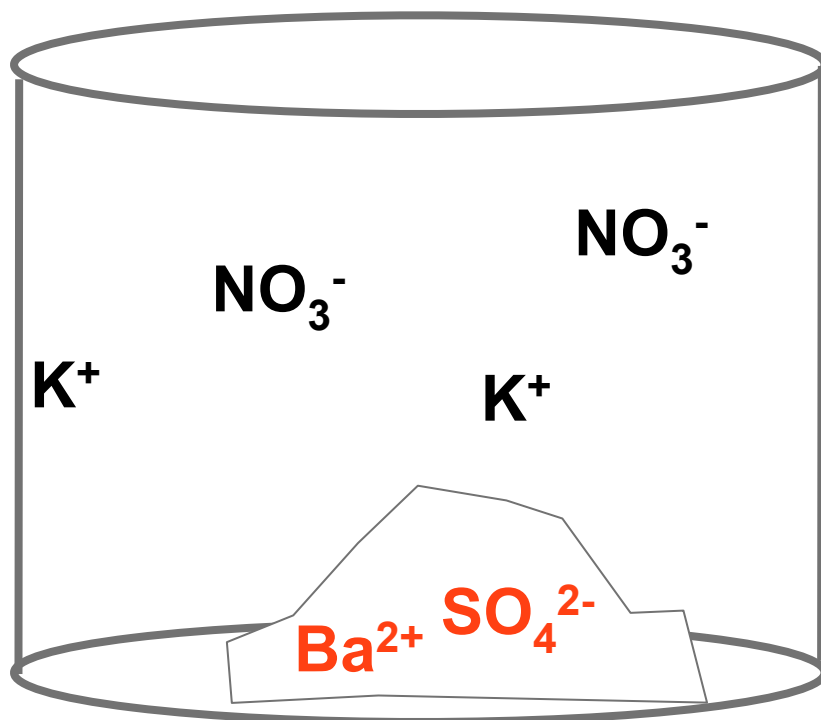
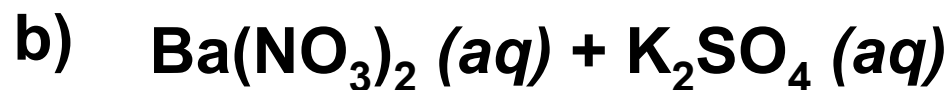
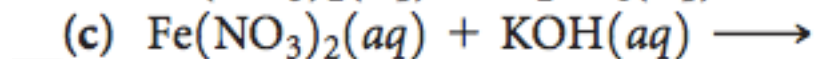
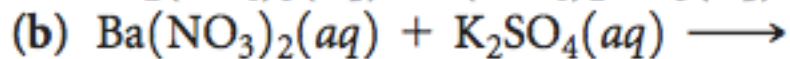
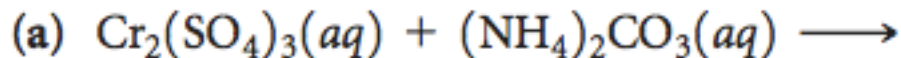
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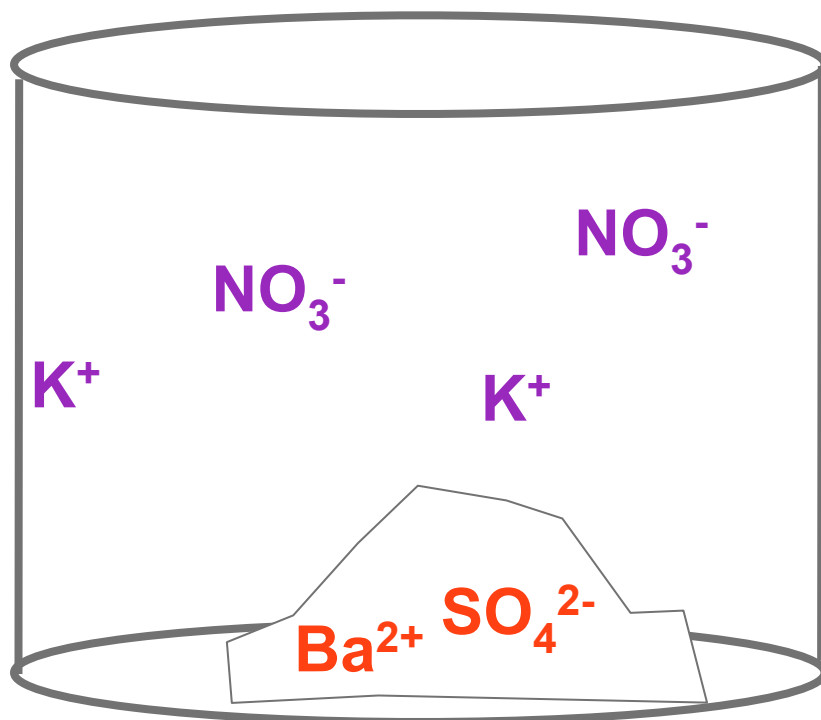
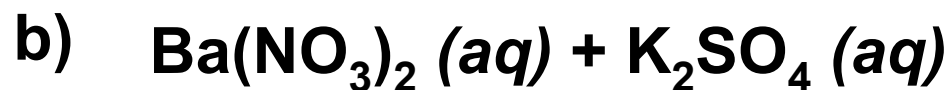
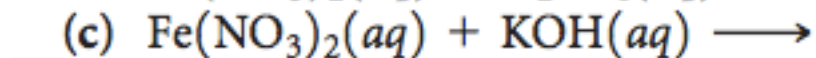
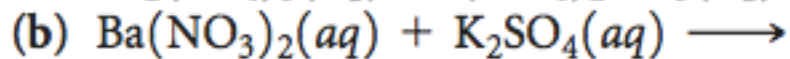
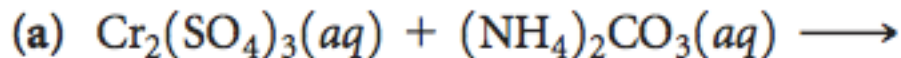
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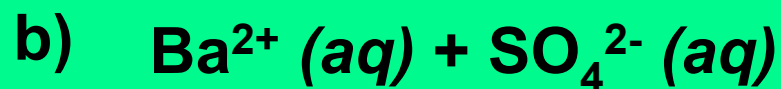
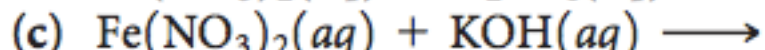
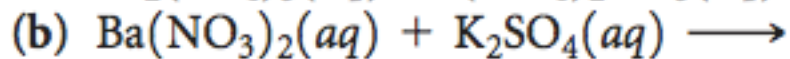
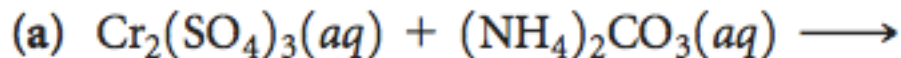


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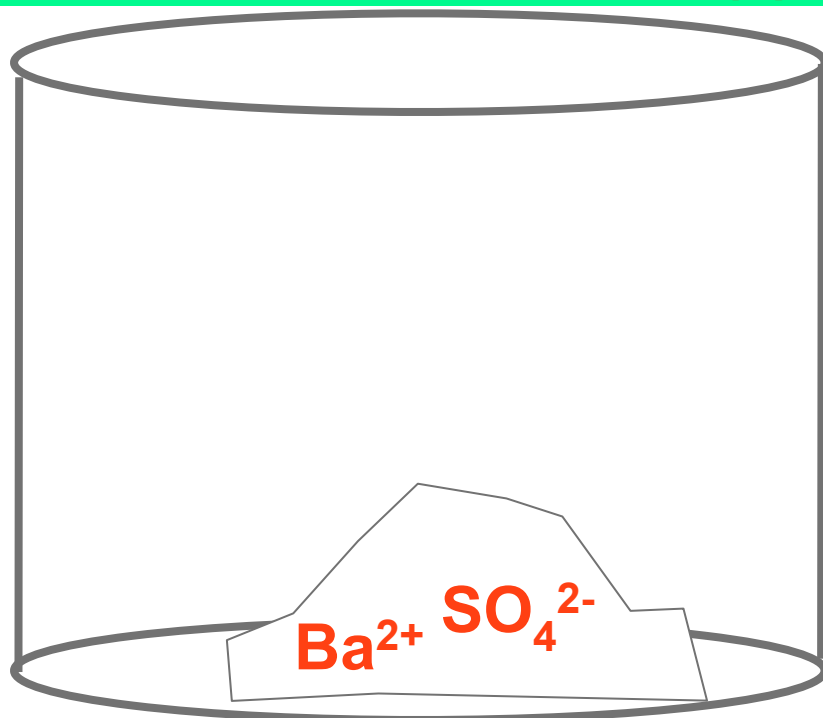


spectator ions

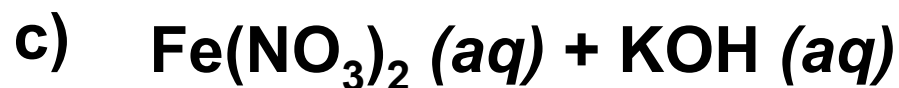
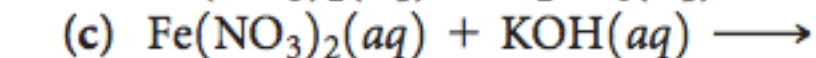
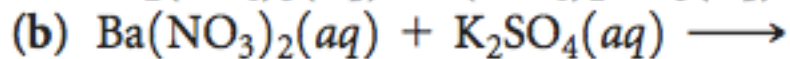
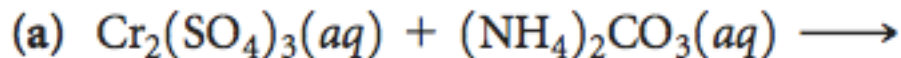
4.24 Write balanced net ionic equations for the reactions that occur in each of the following cases. Identify the spectator ion or ions in each reaction.



net ionic equation



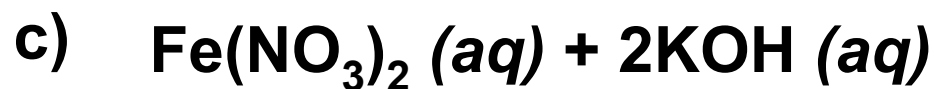
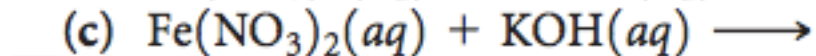
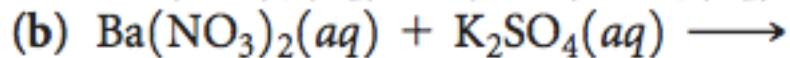
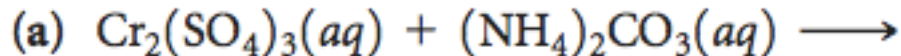
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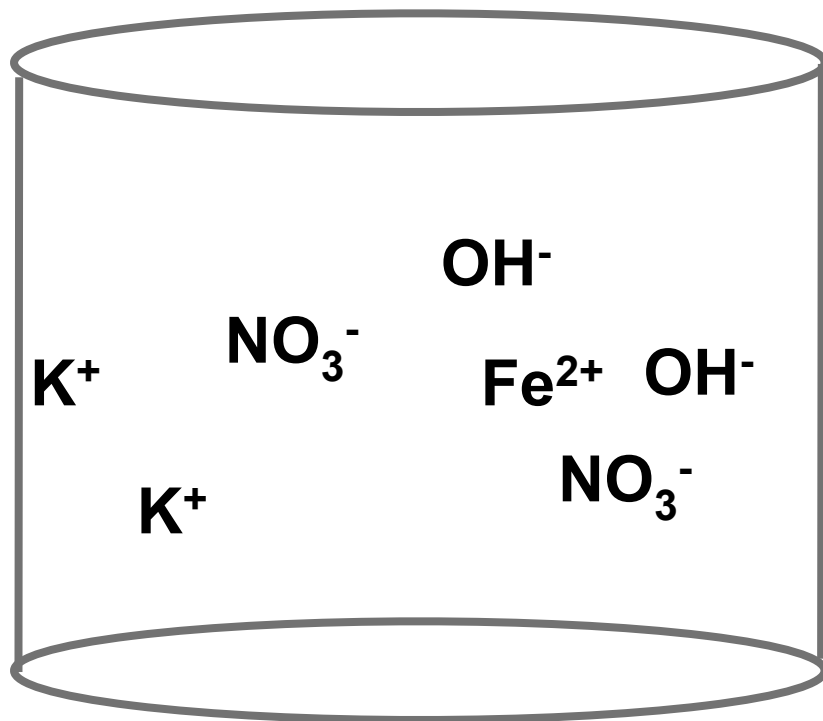
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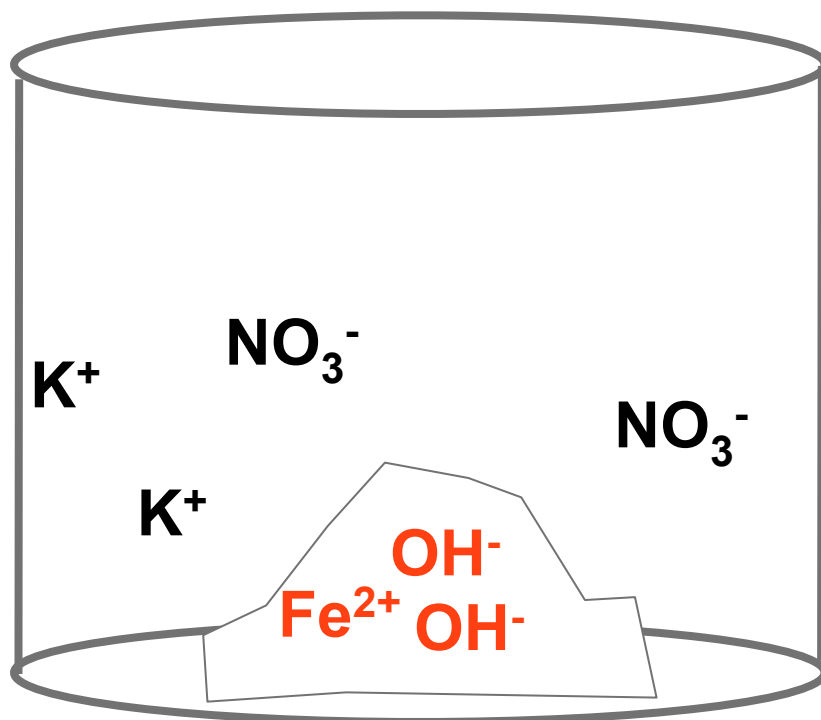
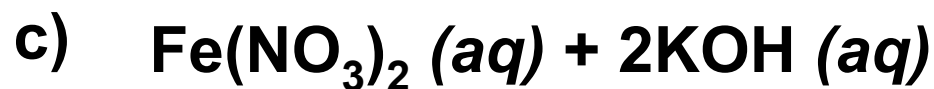
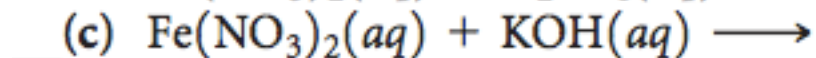
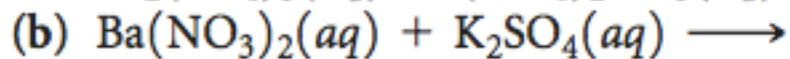
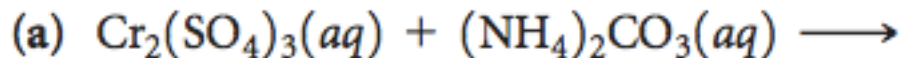
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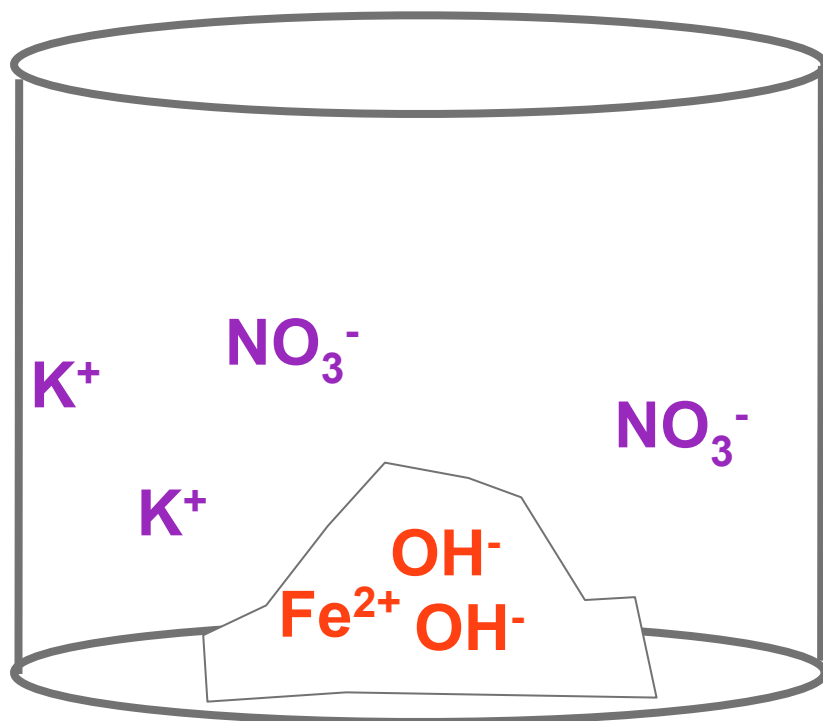
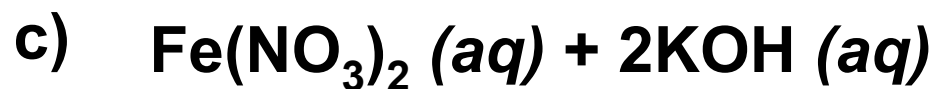
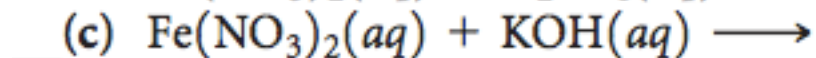
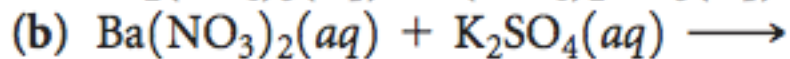
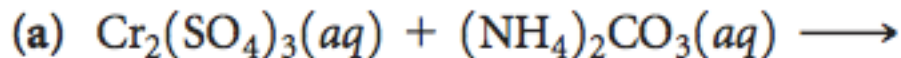
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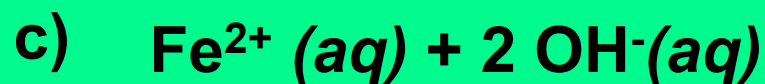
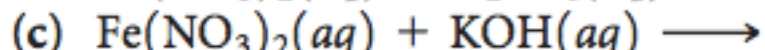
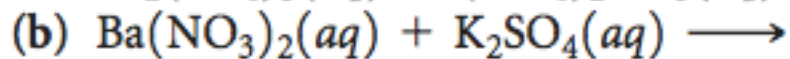
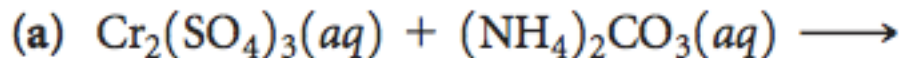


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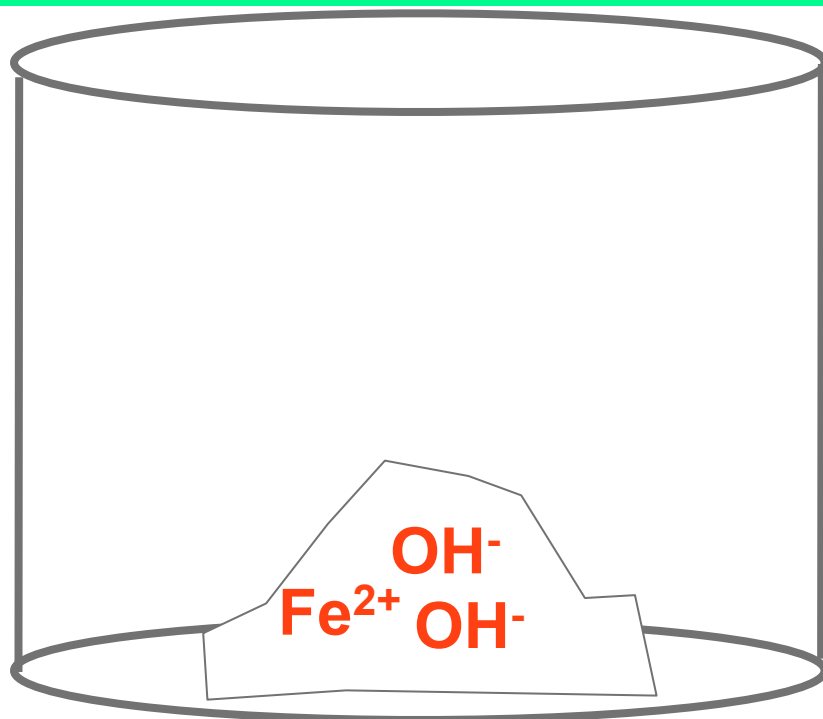


spectator ions

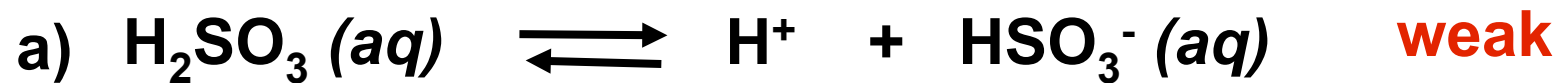
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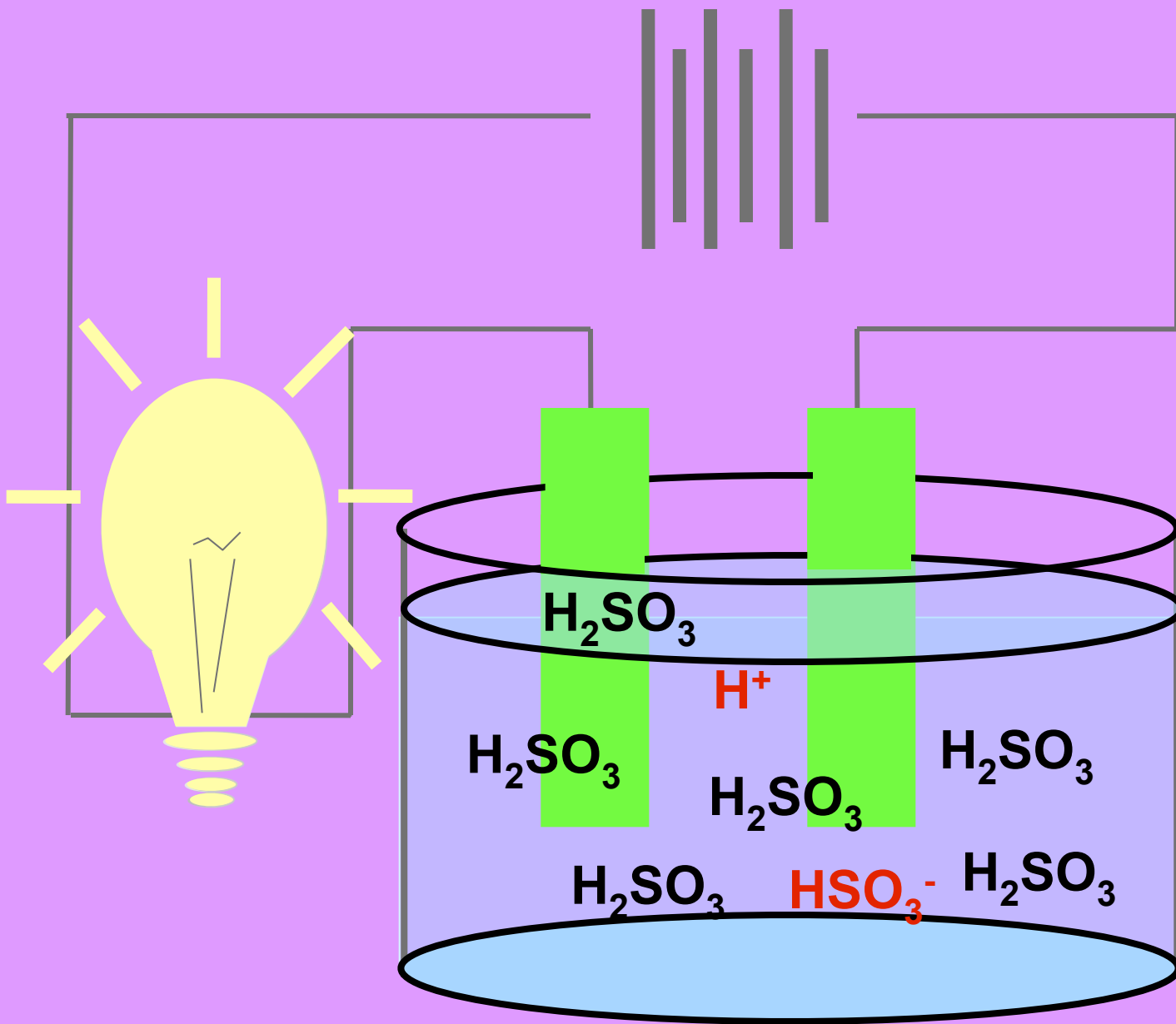


net ionic equation

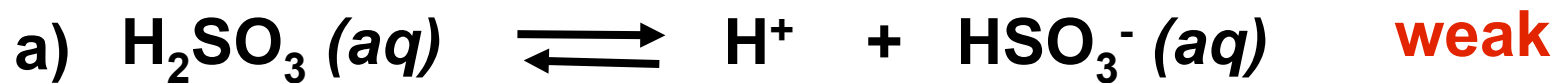


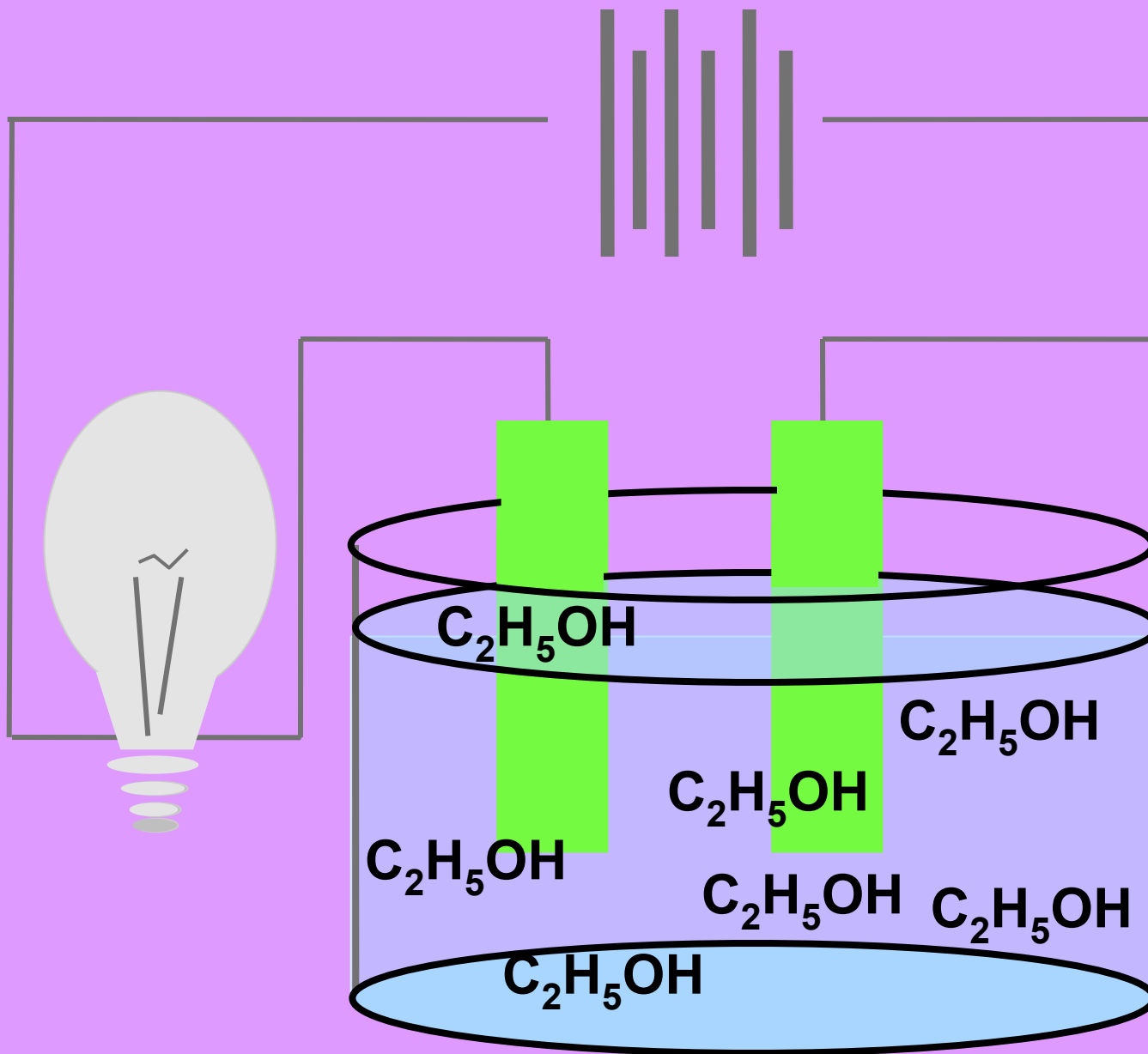
4.37 Classify each of the following substances as a nonelectrolyte, weak electrolyte, or strong electrolyte in water: (a) H_2SO_3 , (b) $\text{C}_2\text{H}_5\text{OH}$ (ethanol), (c) NH_3 , (d) KClO_3 , (e) $\text{Cu}(\text{NO}_3)_2$.



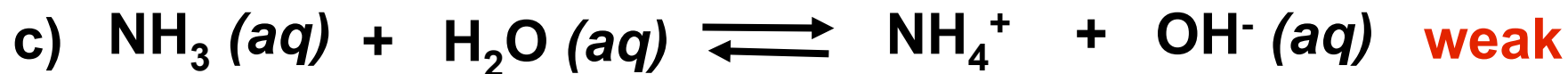
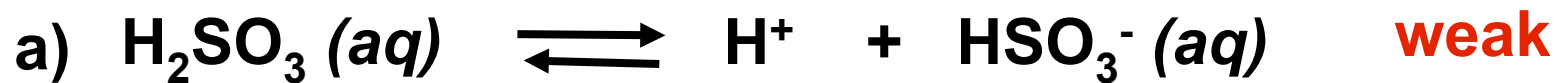


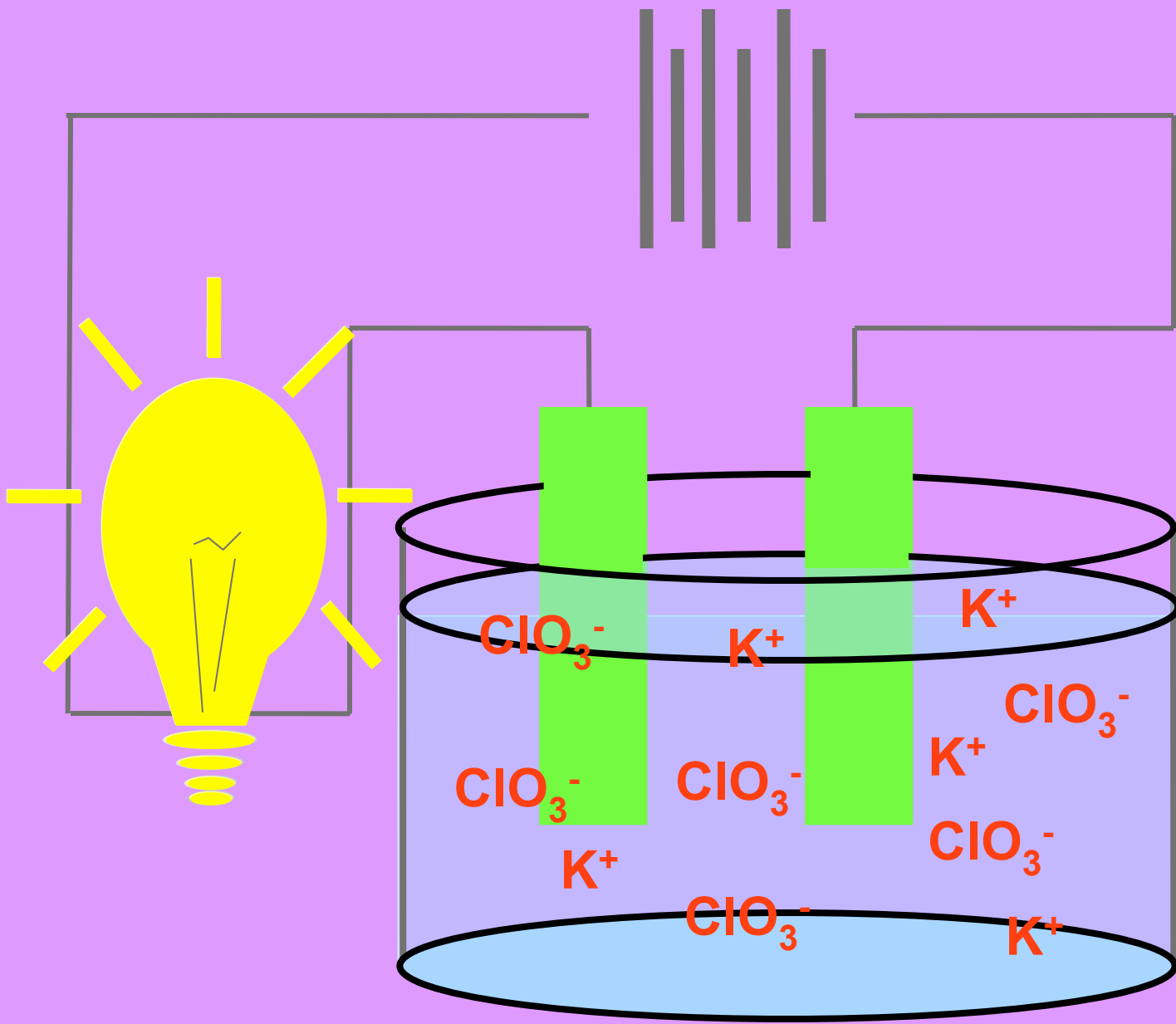
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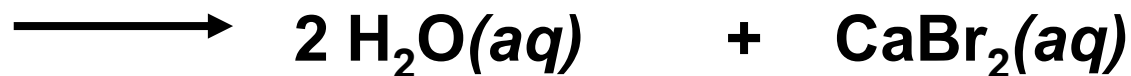
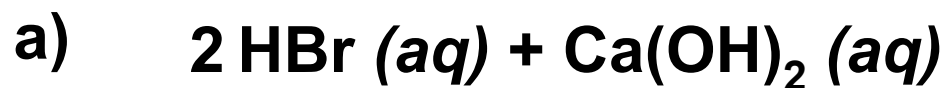
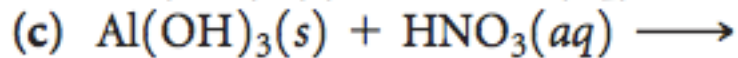
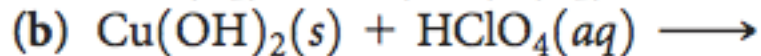
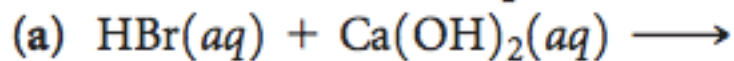


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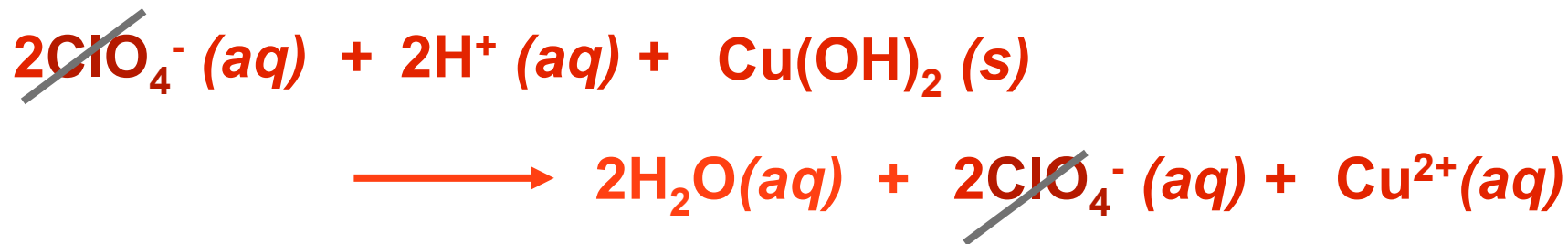
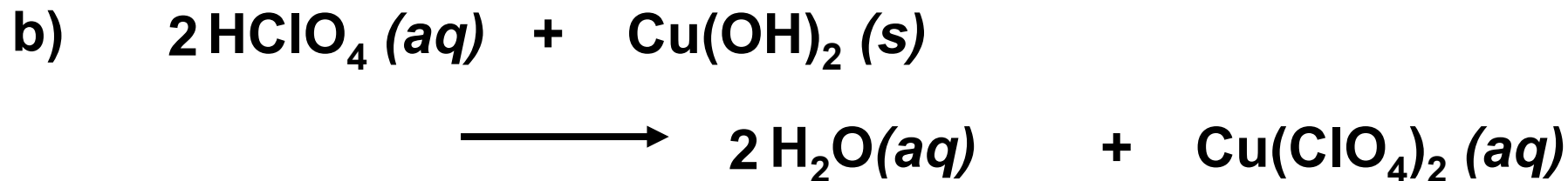
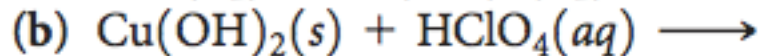
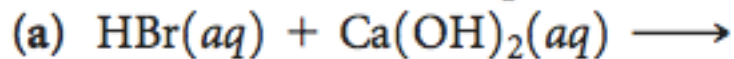


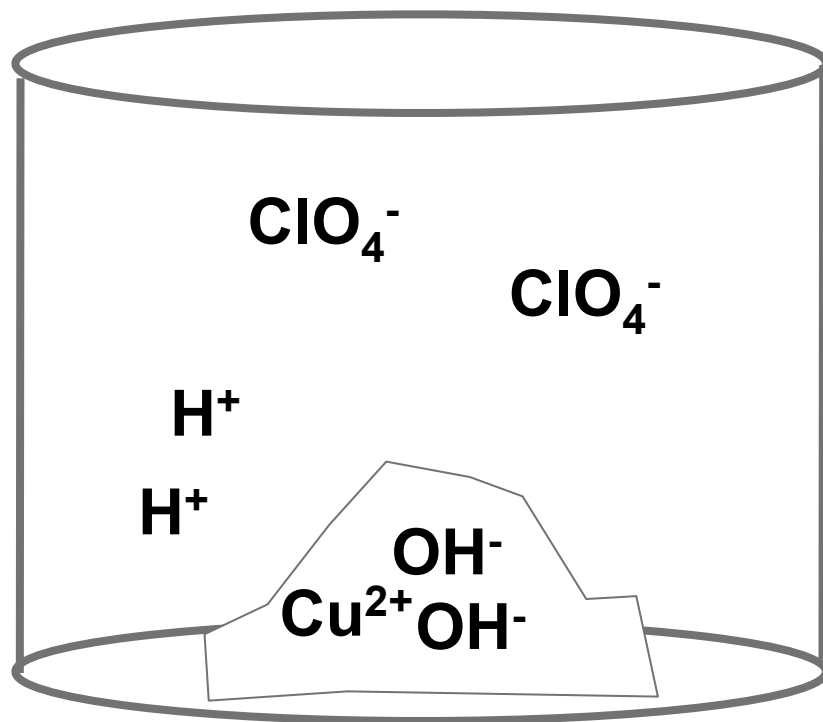


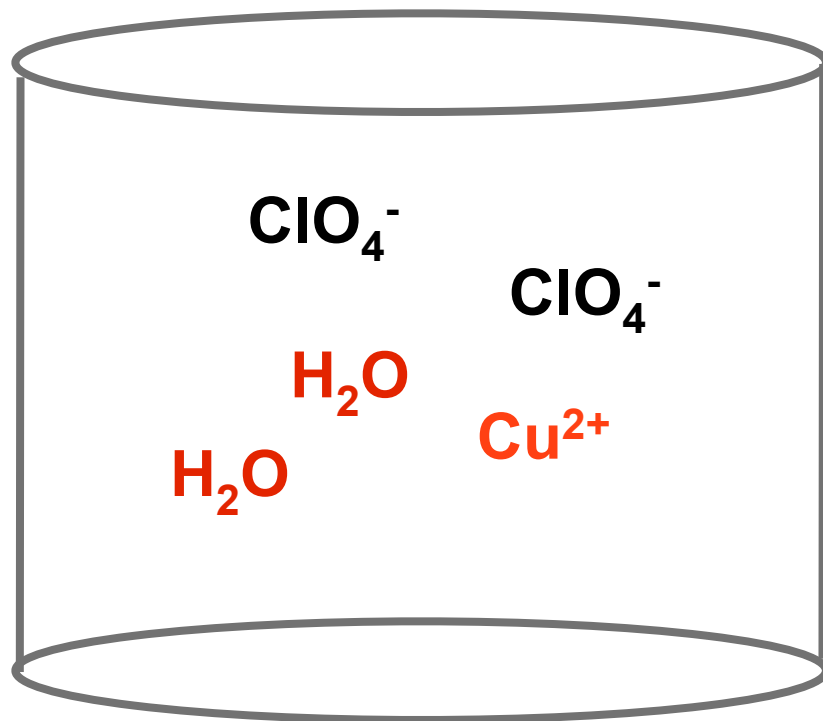
4.39 Complete and balance the following molecular equations, and then write the net ionic equation for each:



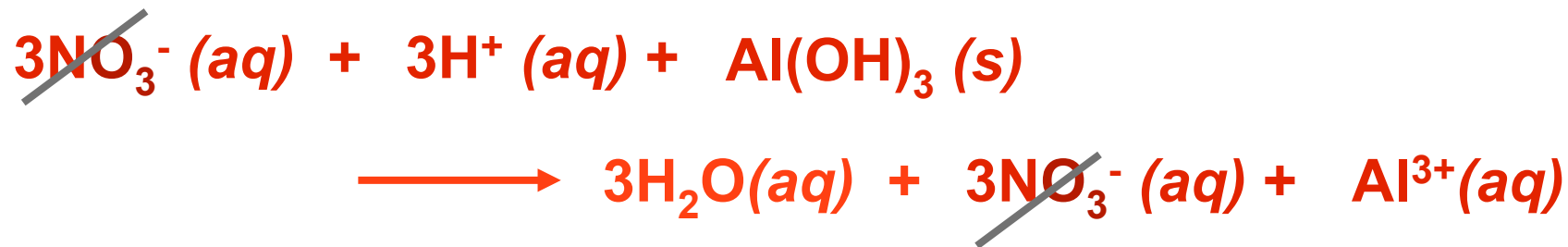
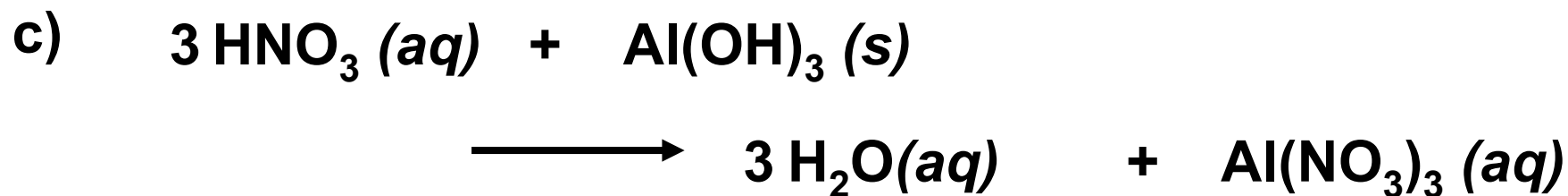
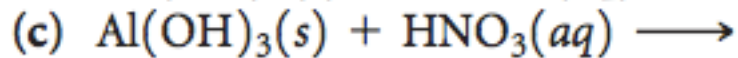
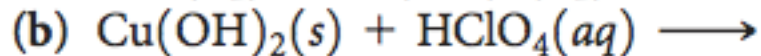
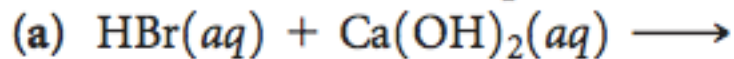
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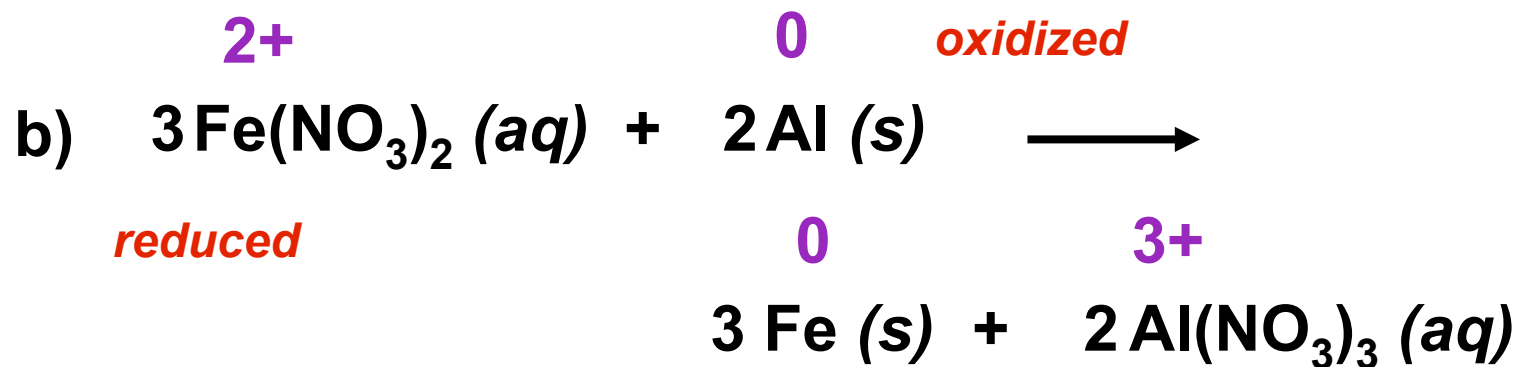
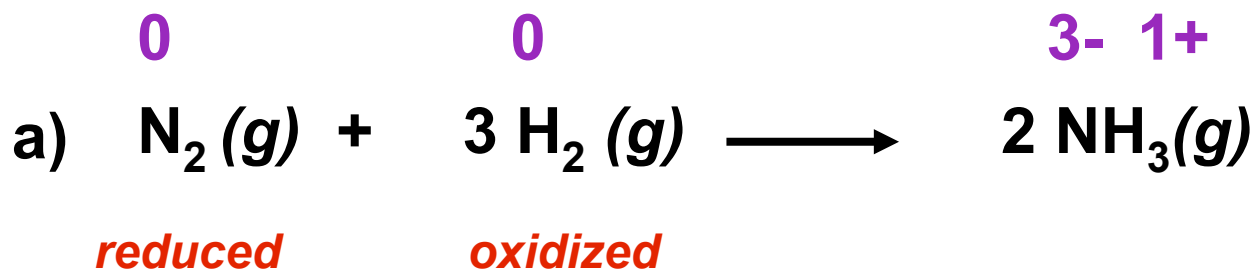
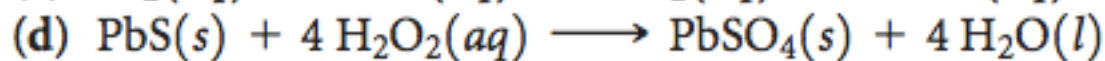
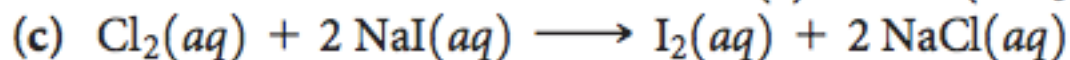
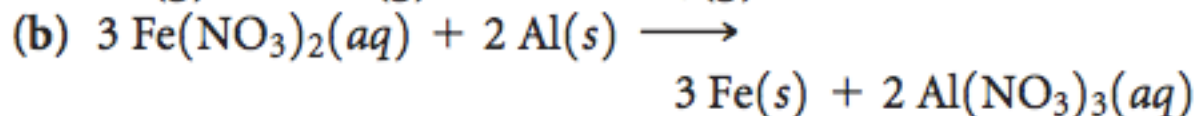
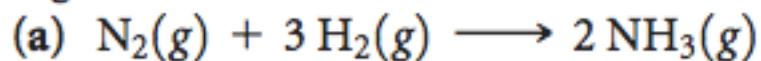




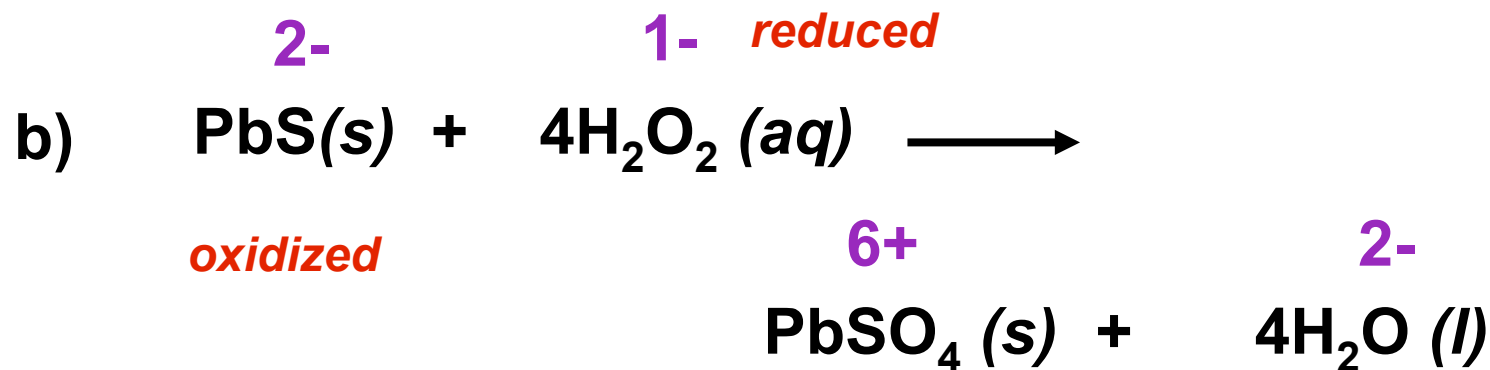
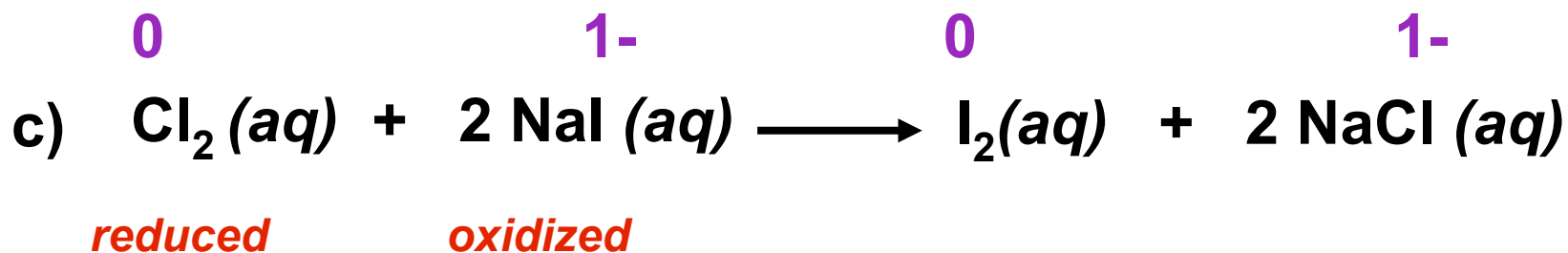
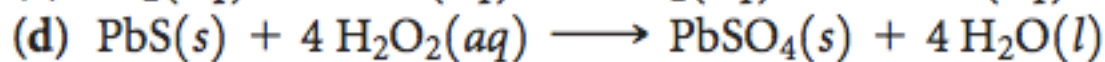
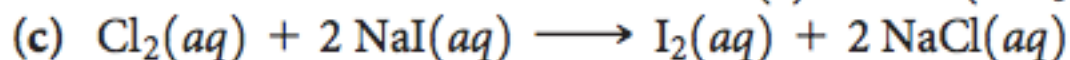
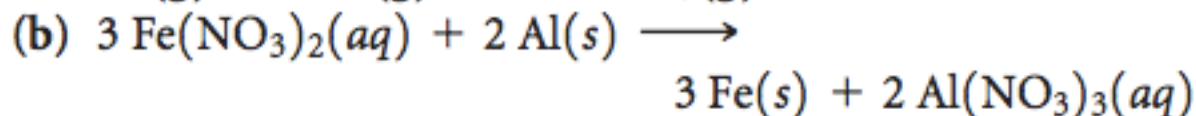
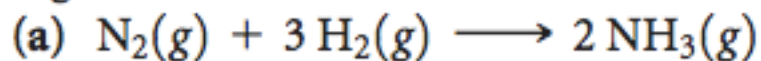
4.39 Complete and balance the following molecular equations, and then write the net ionic equation for each:



4.51 Which element is oxidized and which is reduced in the following reactions?



4.51 Which element is oxidized and which is reduced in the following reactions?



4.55 Using the activity series (Table 4.5), write balanced chemical equations for the following reactions. If no reaction occurs, simply write NR. (a) Iron metal is added to a solution of copper(II) nitrate; (b) zinc metal is added to a solution of magnesium sulfate; (c) hydrobromic acid is added to tin metal; (d) hydrogen gas is bubbled through an aqueous solution of nickel(II) chloride; (e) aluminum metal is added to a solution of cobalt(II) sulfate.

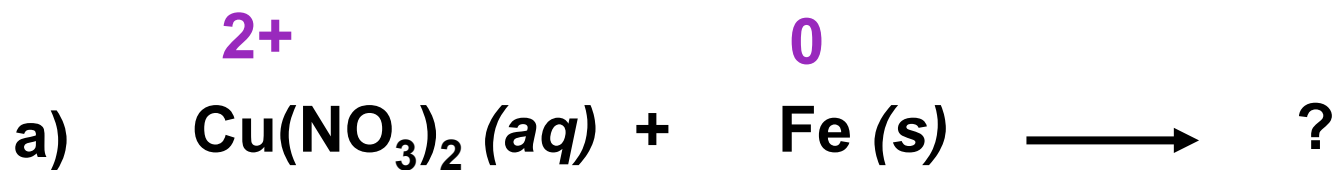


TABLE 4.5 • Activity Series of Metals in Aqueous Solution

Metal		Oxidation Reaction	
Lithium	<i>best reducing agents</i>	$\text{Li}(s) \rightarrow \text{Li}^+(aq) + e^-$	<i>worst oxidizing agents</i>
Potassium		$\text{K}(s) \rightarrow \text{K}^+(aq) + e^-$	
Barium		$\text{Ba}(s) \rightarrow \text{Ba}^{2+}(aq) + 2e^-$	
Calcium		$\text{Ca}(s) \rightarrow \text{Ca}^{2+}(aq) + 2e^-$	
Sodium		$\text{Na}(s) \rightarrow \text{Na}^+(aq) + e^-$	
Magnesium		$\text{Mg}(s) \rightarrow \text{Mg}^{2+}(aq) + 2e^-$	
Aluminum		$\text{Al}(s) \rightarrow \text{Al}^{3+}(aq) + 3e^-$	
Manganese		$\text{Mn}(s) \rightarrow \text{Mn}^{2+}(aq) + 2e^-$	
Zinc		$\text{Zn}(s) \rightarrow \text{Zn}^{2+}(aq) + 2e^-$	
Chromium		$\text{Cr}(s) \rightarrow \text{Cr}^{3+}(aq) + 3e^-$	
Iron	$\text{Fe}(s) \rightarrow \text{Fe}^{2+}(aq) + 2e^-$	<i>Ease of oxidation increases</i>	
Cobalt	$\text{Co}(s) \rightarrow \text{Co}^{2+}(aq) + 2e^-$		
Nickel	$\text{Ni}(s) \rightarrow \text{Ni}^{2+}(aq) + 2e^-$		
Tin	$\text{Sn}(s) \rightarrow \text{Sn}^{2+}(aq) + 2e^-$		
Lead	$\text{Pb}(s) \rightarrow \text{Pb}^{2+}(aq) + 2e^-$		
Hydrogen	$\text{H}_2(g) \rightarrow 2\text{H}^+(aq) + 2e^-$		
Copper	$\text{Cu}(s) \rightarrow \text{Cu}^{2+}(aq) + 2e^-$		
Silver	$\text{Ag}(s) \rightarrow \text{Ag}^+(aq) + e^-$		
Mercury	$\text{Hg}(l) \rightarrow \text{Hg}^{2+}(aq) + 2e^-$		
Platinum	$\text{Pt}(s) \rightarrow \text{Pt}^{2+}(aq) + 2e^-$		<i>best oxidizing agents</i>
Gold	$\text{Au}(s) \rightarrow \text{Au}^{3+}(aq) + 3e^-$		

TABLE 4.5 • Activity Series of Metals in Aqueous Solution

Metal	Oxidation Reaction
Lithium	$\text{Li}(s) \longrightarrow \text{Li}^+(aq) + e^-$
Potassium	$\text{K}(s) \longrightarrow \text{K}^+(aq) + e^-$
Barium	$\text{Ba}(s) \longrightarrow \text{Ba}^{2+}(aq) + 2e^-$
Calcium	$\text{Ca}(s) \longrightarrow \text{Ca}^{2+}(aq) + 2e^-$
Sodium	$\text{Na}(s) \longrightarrow \text{Na}^+(aq) + e^-$
Magnesium	$\text{Mg}(s) \longrightarrow \text{Mg}^{2+}(aq) + 2e^-$
Aluminum	$\text{Al}(s) \longrightarrow \text{Al}^{3+}(aq) + 3e^-$
Manganese	$\text{Mn}(s) \longrightarrow \text{Mn}^{2+}(aq) + 2e^-$
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Mercury	$\text{Hg}(l) \longrightarrow \text{Hg}^{2+}(aq) + 2e^-$
Platinum	$\text{Pt}(s) \longrightarrow \text{Pt}^{2+}(aq) + 2e^-$
Gold	$\text{Au}(s) \longrightarrow \text{Au}^{3+}(aq) + 3e^-$

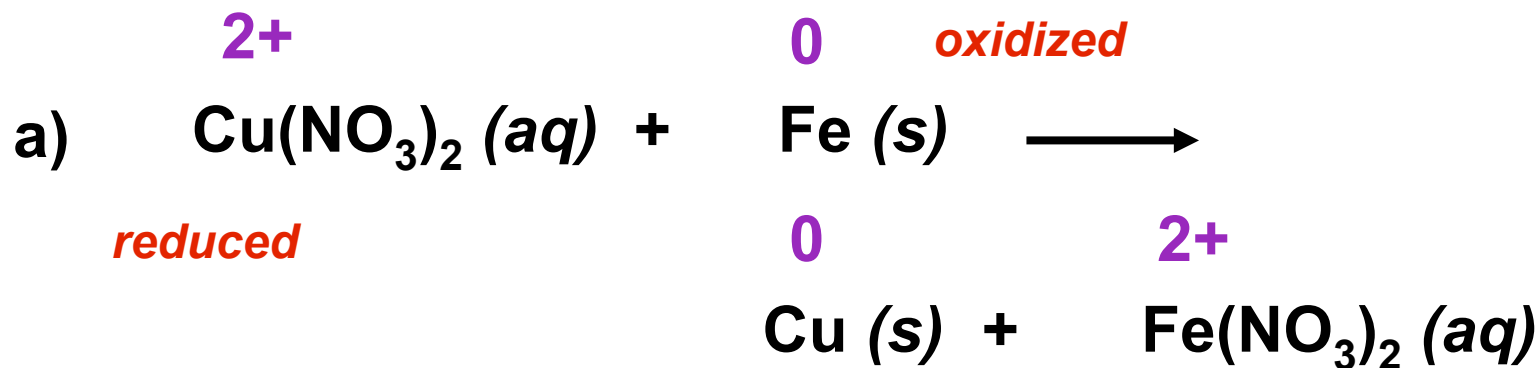
best reducing agents

reducing agents will give up electrons to oxidizing agents lying below it on the chart

Ease of oxidation

best oxidizing agents

4.55 Using the activity series (Table 4.5), write balanced chemical equations for the following reactions. If no reaction occurs, simply write NR. (a) Iron metal is added to a solution of copper(II) nitrate; (b) zinc metal is added to a solution of magnesium sulfate; (c) hydrobromic acid is added to tin metal; (d) hydrogen gas is bubbled through an aqueous solution of nickel(II) chloride; (e) aluminum metal is added to a solution of cobalt(II) sulfate.



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TABLE 4.5 • Activity Series of Metals in Aqueous Solution

Metal	Oxidation Reaction
Lithium	$\text{Li}(s) \longrightarrow \text{Li}^+(aq) + e^-$
Potassium	$\text{K}(s) \longrightarrow \text{K}^+(aq) + e^-$
Barium	$\text{Ba}(s) \longrightarrow \text{Ba}^{2+}(aq) + 2e^-$
Calcium	$\text{Ca}(s) \longrightarrow \text{Ca}^{2+}(aq) + 2e^-$
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Mercury	$\text{Hg}(l) \longrightarrow \text{Hg}^{2+}(aq) + 2e^-$
Platinum	$\text{Pt}(s) \longrightarrow \text{Pt}^{2+}(aq) + 2e^-$
Gold	$\text{Au}(s) \longrightarrow \text{Au}^{3+}(aq) + 3e^-$

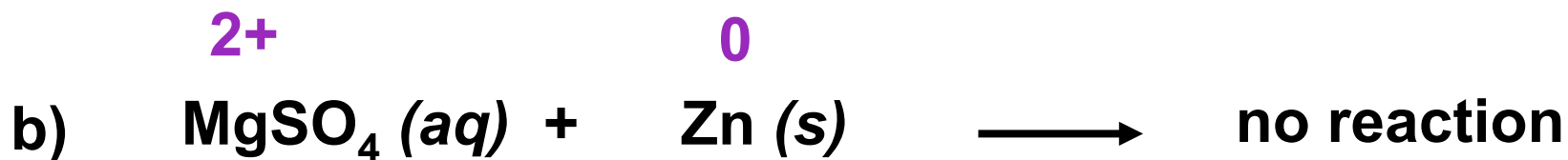
best reducing agents

reducing agents will give up electrons to oxidizing agents lying below it on the chart

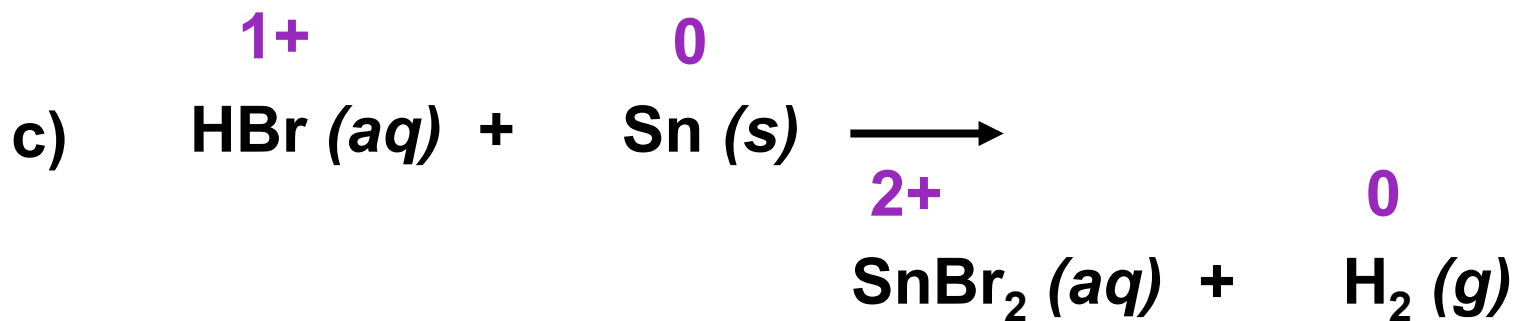
Ease of oxidation

best oxidizing agents

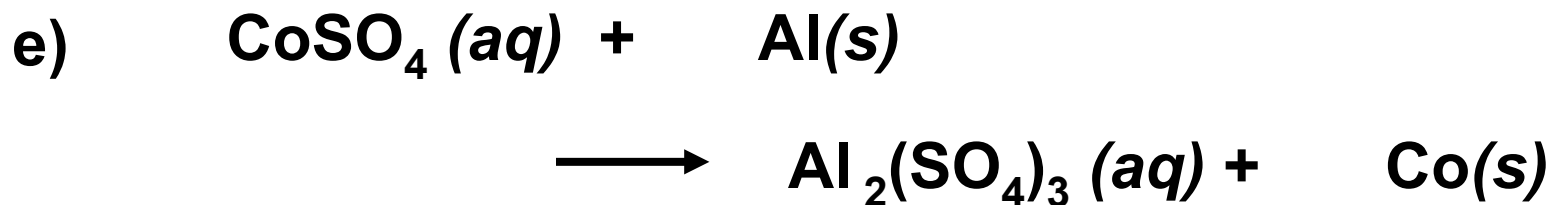
4.55 Using the activity series (Table 4.5), write balanced chemical equations for the following reactions. If no reaction occurs, simply write NR. (a) Iron metal is added to a solution of copper(II) nitrate; (b) zinc metal is added to a solution of magnesium sulfate; (c) hydrobromic acid is added to tin metal; (d) hydrogen gas is bubbled through an aqueous solution of nickel(II) chloride; (e) aluminum metal is added to a solution of cobalt(II) sulfate.



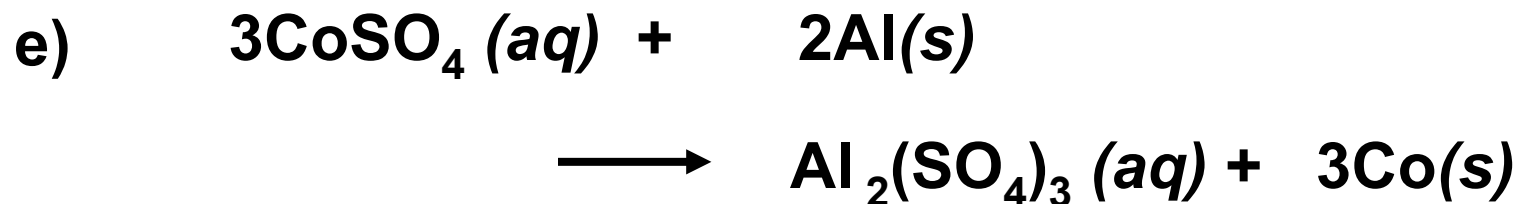
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- 4.61** (a) Calculate the molarity of a solution that contains 0.175 mol ZnCl_2 in exactly 150 mL of solution. (b) How many moles of HCl are present in 35.0 mL of a 4.50 M solution of nitric acid? (c) How many milliliters of 6.00 M NaOH solution are needed to provide 0.325 mol of NaOH?

a)

$$\frac{0.175 \text{ mol ZnCl}_2}{150 \text{ ml}} \times \frac{1000 \text{ ml}}{1 \text{ L}}$$

$$= 1.17 \text{ mol/L ZnCl}_2$$

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b)

$$0.035 \cancel{\text{ L}} \text{ HNO}_3 \times \frac{4.50 \text{ mol HNO}_3}{\cancel{1 \text{ L}}} = 0.158 \text{ mol HNO}_3$$

- 4.61** (a) Calculate the molarity of a solution that contains 0.175 mol ZnCl_2 in exactly 150 mL of solution. (b) How many moles of HCl are present in 35.0 mL of a 4.50 M solution of nitric acid? (c) How many milliliters of 6.00 M NaOH solution are needed to provide 0.325 mol of NaOH?

c)

$$0.325 \text{ mol } \cancel{\text{NaOH}} \times \frac{\cancel{1 \text{ L}}}{6.00 \text{ mol } \cancel{\text{HNO}_3}} \times \frac{1000 \text{ ml}}{\cancel{1 \text{ L}}} = 0.158 \text{ mol HNO}_3$$

4.69 (a) Which will have the highest concentration of potassium ion: 0.20 M KCl, 0.15 M K₂CrO₄, or 0.080 M K₃PO₄? (b) Which will contain the greater number of moles of potassium ion: 30.0 mL of 0.15 M K₂CrO₄ or 25.0 mL of 0.080 M K₃PO₄?

a)

$$\frac{0.20 \text{ mol } \cancel{\text{KCl}}}{1 \text{ L}} \times \frac{1 \text{ mol K}^+}{1 \text{ mol } \cancel{\text{KCl}}} = \frac{0.20 \text{ mol K}^+}{1 \text{ L}}$$

$$\frac{0.15 \text{ mol } \cancel{\text{K}_2\text{CrO}_4}}{1 \text{ L}} \times \frac{2 \text{ mol K}^+}{1 \text{ mol } \cancel{\text{K}_2\text{CrO}_4}} = \frac{0.30 \text{ mol K}^+}{1 \text{ L}}$$

$$\frac{0.080 \text{ mol } \cancel{\text{K}_3\text{PO}_4}}{1 \text{ L}} \times \frac{3 \text{ mol K}^+}{1 \text{ mol } \cancel{\text{K}_3\text{PO}_4}} = \frac{0.24 \text{ mol K}^+}{1 \text{ L}}$$

4.69 (a) Which will have the highest concentration of potassium ion: 0.20 M KCl, 0.15 M K_2CrO_4 , or 0.080 M K_3PO_4 ? (b) Which will contain the greater number of moles of potassium ion: 30.0 mL of 0.15 M K_2CrO_4 or 25.0 mL of 0.080 M K_3PO_4 ?

b)

$$\begin{aligned} & \cancel{30.0 \text{ ml } K_2CrO_4} \times \frac{\cancel{1 \text{ L}}}{\cancel{1000 \text{ ml}}} \times \frac{\cancel{0.15 \text{ mol } K_2CrO_4}}{\cancel{1 \text{ L}}} \\ & \times \frac{2 \text{ mol } K^+}{\cancel{1 \text{ mol } K_2CrO_4}} = 9.00 \times 10^{-3} \text{ mol } K^+ \end{aligned}$$

$$\begin{aligned} & \cancel{25.0 \text{ ml } K_3PO_4} \times \frac{\cancel{1 \text{ L}}}{\cancel{1000 \text{ ml}}} \times \frac{\cancel{0.080 \text{ mol } K_3PO_4}}{\cancel{1 \text{ L}}} \\ & \times \frac{3 \text{ mol } K^+}{\cancel{1 \text{ mol } K_3PO_4}} = 6.00 \times 10^{-3} \text{ mol } K^+ \end{aligned}$$

4.73 (a) You have a stock solution of 14.8 M NH₃. How many milliliters of this solution should you dilute to make 1000.0 mL of 0.250 M NH₃? (b) If you take a 10.0-mL portion of the stock solution and dilute it to a total volume of 0.500 L, what will be the concentration of the final solution?

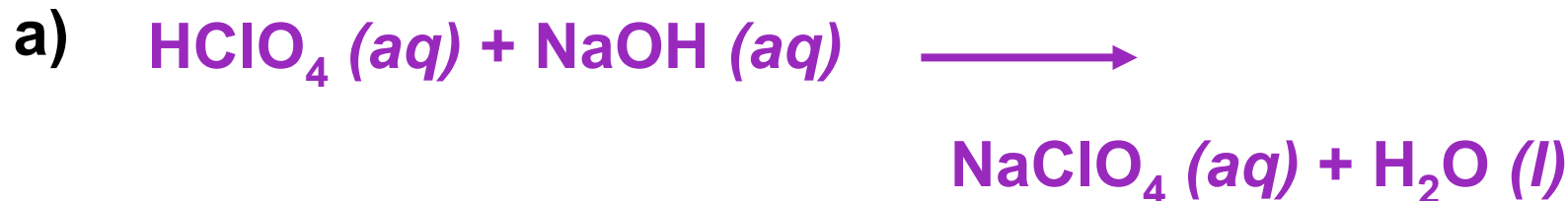
$$M_1V_1 = M_2V_2$$

$$(14.8 \text{ M NH}_3) (V_1) = (0.25 \text{ M NH}_3) (1 \text{ L})$$

$$V_1 = \frac{(0.25 \text{ M NH}_3) (1 \text{ L})}{(14.8 \text{ M NH}_3)}$$

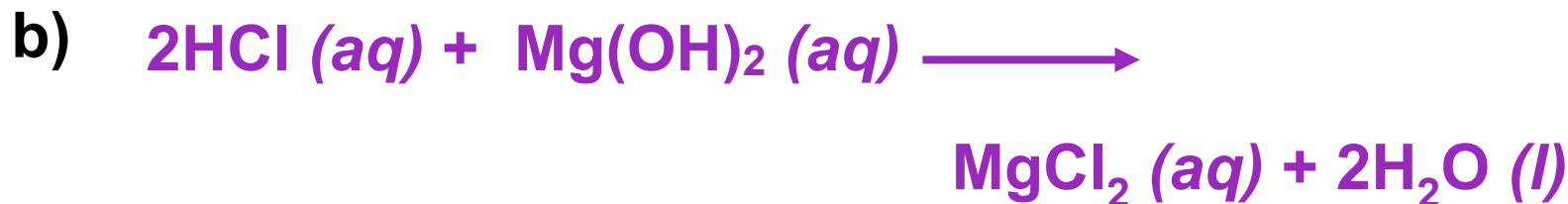
$$V_1 = 1.69 \times 10^{-2} \text{ L} \times \frac{1000 \text{ ml}}{1 \text{ L}} = 16.9 \text{ mL}$$

4.81 (a) What volume of 0.115 M HClO₄ solution is needed to neutralize 50.00 mL of 0.0875 M NaOH? (b) What volume of 0.128 M HCl is needed to neutralize 2.87 g of Mg(OH)₂?



$$\begin{aligned}
 & 50 \text{ mL NaOH} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.0875 \text{ mol NaOH}}{1 \text{ L}} \\
 & \times \frac{1 \text{ mol HClO}_4}{1 \text{ mol NaOH}} \times \frac{1 \text{ L}}{0.115 \text{ mol HClO}_4} \times \frac{1000 \text{ mL}}{1 \text{ L}} \\
 & = 38.0 \text{ mL HClO}_4 \text{ needed}
 \end{aligned}$$

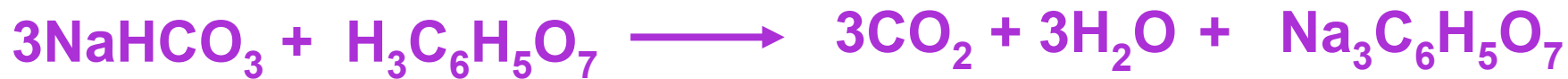
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$$\begin{aligned}
 & \cancel{2.87\text{g}} \text{ Mg}(\text{OH})_2 \times \frac{\cancel{1 \text{ mol}}}{\cancel{58.3 \text{ g}}} \times \frac{\cancel{2 \text{ mol HCl}}}{\cancel{1 \text{ mol Mg}(\text{OH})_2}} \\
 & \times \frac{\cancel{1 \text{ L}}}{\cancel{0.128 \text{ mol NaOH}}} \times \frac{1000 \text{ mL}}{\cancel{1 \text{ L}}} \\
 & = \mathbf{769 \text{ mL HClO}_4 \text{ needed}}
 \end{aligned}$$

4.81 (a) What volume of 0.115 M HClO_4 solution is needed to neutralize 50.00 mL of 0.0875 M NaOH ? (b) What volume of 0.128 M HCl is needed to neutralize 2.87 g of Mg(OH)_2 ? (c) If 25.8 mL of AgNO_3 is needed to precipitate all the Cl^- ions in a 785-mg sample of KCl (forming AgCl), what is the molarity of the AgNO_3 solution? (d) If 45.3 mL of 0.108 M HCl solution is needed to neutralize a solution of KOH , how many grams of KOH must be present in the solution?

Problem #77



a)

$$1\text{g NaHCO}_3 \times \frac{1\text{ mol}}{84\text{ g NaHCO}_3} = 1.19 \times 10^{-2}\text{ mol NaHCO}_3$$

limiting

$$1\text{g H}_3\text{C}_6\text{H}_5\text{O}_7 \times \frac{1\text{ mol}}{192\text{ g H}_3\text{C}_6\text{H}_5\text{O}_7} = 5.21 \times 10^{-2}\text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7$$

available

$$1.19 \times 10^{-2}\text{ mol NaHCO}_3 \times \frac{1\text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7}{3\text{ mol NaHCO}_3} =$$

$$3.97 \times 10^{-3}\text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7$$

needed