

CHEMISTRY I – CH-1211

EXTRA PRACTICE

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Exam 2 Review: Mole and Percent Composition

1. Which one of the samples contains the most particles?

- A. 1 mol CO₂(g)
- B. 1 mol UF₆(g)
- C. 1 mol CH₃COCH₃(l)
- D. 1 mol He(g)
- E. all contain the same number of particles

E. Since there is 1 mole of each sample, each sample contains 6.022×10^{23} particles.

sec02-q0033-01.tex

Keyword:number of entities; moles

2. Which one of the samples has the largest mass?

- A. 1 mol CO₂(g)
- B. 1 mol UF₆(g)
- C. 1 mol CH₃COCH₃(l)
- D. 1 mol He(g)
- E. all have the same mass

B. Since each sample contains the same number of particles, identify the particle with the largest mass. UF₆ has the largest mass and therefore, the 1 mole sample has the largest mass.

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Keyword:number of entities; moles

3. What is the molar mass (in g mol⁻¹ to four significant figures) of Al₂(SO₄)₃ · 18 H₂O?

A: 666.5 g mol⁻¹

$$\begin{aligned}M[\text{Al}_2(\text{SO}_4)_3 \cdot 18 \text{H}_2\text{O}] &= [2 A_r^\circ(\text{Al}) + 3 A_r^\circ(\text{S}) + 30 A_r^\circ(\text{O}) + 36 A_r^\circ(\text{H})] M_u \\&= [2 (26.98) + 3 (32.06) + 30 (16.00) + 36 (1.01)] \left(\frac{\text{g}}{\text{mol}} \right) \\&= 666.46 \text{ g mol}^{-1} = 666.5 \text{ g mol}^{-1}\end{aligned}$$

sec02-q0028-01.tex

Keyword:molar mass

4. What is the molar mass (in g mmol^{-1} to three significant figures) of $(\text{NH}_4)_2\text{HPO}_4$?

A: $0.132 \text{ g mmol}^{-1}$

$$\begin{aligned} M[(\text{NH}_4)_2\text{HPO}_4] &= [2 A_r^\circ(\text{N}) + 9 A_r^\circ(\text{H}) + A_r^\circ(\text{P}) + 4 A_r^\circ(\text{O})] M_u \\ &= [2(14.01) + 9(1.01) + (30.97) + 4(16.00)] \left(\frac{\text{g}}{\text{mol}}\right) \left(\frac{\text{mol}}{10^3 \text{ mmol}}\right) \\ &= 0.13208 \text{ g mmol}^{-1} = 0.132 \text{ g mmol}^{-1} \end{aligned}$$

sec02-q0029-01.tex

Keyword:molar mass

5. How many atoms are present in a 0.268 mol sample of CH_3OH ?

A: 9.68×10^{23}

$$\begin{aligned} N(X) &= n(\text{CH}_3\text{OH}) r(X, \text{CH}_3\text{OH}) N_A \\ &= 0.268 \text{ mol CH}_3\text{OH} \left(\frac{6 \text{ mol X}}{\text{mol CH}_3\text{OH}}\right) \left(\frac{6.022 \times 10^{23} \text{ X}}{\text{mol X}}\right) \\ &= 9.6833 \times 10^{23} = 9.68 \times 10^{23} \end{aligned}$$

sec02-q0030-01.tex

Keyword:number of entities; moles

6. How many aluminum atoms are there in a 3.50 g sample of Al_2O_3 ?

A: 4.13×10^{22}

$$\begin{aligned} N(\text{Al}) &= m(\text{Al}_2\text{O}_3) M(\text{Al}_2\text{O}_3)^{-1} r(\text{Al}, \text{Al}_2\text{O}_3) N_A \\ &= 3.50 \text{ g Al}_2\text{O}_3 \left(\frac{\text{mol Al}_2\text{O}_3}{101.96 \text{ g}}\right) \left(\frac{2 \text{ mol Al}}{\text{mol Al}_2\text{O}_3}\right) \left(\frac{6.022 \times 10^{23} \text{ Al}}{\text{mol Al}}\right) \\ &= 4.1343 \times 10^{22} = 4.13 \times 10^{22} \end{aligned}$$

sec02-q0031-01.tex

Keyword:number of entities; moles

7. Which one of the samples contains the most atoms?

- A. 1 mol $\text{CO}_2(\text{g})$
- B. 1 mol $\text{UF}_6(\text{g})$
- C. 1 mol $\text{CH}_3\text{COCH}_3(\text{l})$
- D. 1 mol $\text{He}(\text{g})$
- E. all contain the same number of atoms

C

$$\begin{aligned}\mathbf{A} : N(X) &= n(\text{CO}_2) r(X, \text{CO}_2) N_A \\ &= 1 \text{ mol CO}_2 \left(\frac{3 \text{ mol X}}{\text{mol CO}_2} \right) \left(\frac{N_0}{\text{mol}} \right) \\ &= 4 N_0\end{aligned}$$

$$\begin{aligned}\mathbf{B} : N(X) &= n(\text{UF}_6) r(X, \text{UF}_6) N_A \\ &= 1 \text{ mol UF}_6 \left(\frac{7 \text{ mol X}}{\text{mol UF}_6} \right) \left(\frac{N_0}{\text{mol}} \right) \\ &= 7 N_0\end{aligned}$$

$$\begin{aligned}\mathbf{C} : N(X) &= n(\text{CH}_3\text{COCH}_3) r(X, \text{CH}_3\text{COCH}_3) N_A \\ &= 1 \text{ mol CH}_3\text{COCH}_3 \left(\frac{10 \text{ mol X}}{\text{mol CH}_3\text{COCH}_3} \right) \left(\frac{N_0}{\text{mol}} \right) \\ &= 10 N_0\end{aligned}$$

$$\begin{aligned}\mathbf{D} : N(X) &= n(\text{He}) N_A \\ &= 1 \text{ mol X} \left(\frac{N_0}{\text{mol}} \right) \\ &= N_0\end{aligned}$$

sec02-q0032-01.tex

Keyword:number of entities; moles

8. Guanidine, $\text{HNC}(\text{NH}_2)_2$, is a fertilizer. What is the percent by mass (to one decimal place) of nitrogen in the fertilizer?

A: 71.1%

$$\begin{aligned}
 w(\text{N})\% &= w(\text{N}) \times 100\% \\
 &= \left\{ \frac{3m(\text{N})}{m(\text{HNC}(\text{NH}_2)_2)} \right\} \times 100\% \\
 &= \left\{ \frac{3A_r^\circ(\text{N})}{[5A_r^\circ(\text{H})] + [3A_r^\circ(\text{N})] + A_r^\circ(\text{C})} \right\} \times 100\% \\
 &= \left\{ \frac{3(14.01)}{(5 \times 1.01) + (3 \times 14.01) + 12.01} \right\} \times 100\% \\
 &= \left(\frac{42.03}{59.09} \right) \times 100\% \\
 &= 71.128\% = 71.1\%
 \end{aligned}$$

sec02-q0035-01.tex

Keyword: percent by mass

9. Determine the percent by mass (to one decimal place) of Mg in chlorophyll ($\text{C}_{55}\text{H}_{72}\text{MgN}_4\text{O}_5$), the green pigment in plant cells.

A: 2.7%

$$\begin{aligned}
 w(\text{Mg})\% &= w(\text{Mg}) \times 100\% \\
 &= \left\{ \frac{m(\text{Mg})}{m(\text{chlorophyll})} \right\} \times 100\% \\
 &= \left\{ \frac{A_r^\circ(\text{Mg})}{[55 \times A_r^\circ(\text{C})] + [72 \times A_r^\circ(\text{H})] + A_r^\circ(\text{Mg}) + [4 \times A_r^\circ(\text{N})] + [5 \times A_r^\circ(\text{O})]} \right\} \times 100\% \\
 &= \left\{ \frac{24.31}{(55 \times 12.01) + (72 \times 1.01) + 24.31 + (4 \times 14.01) + (5 \times 16.00)} \right\} \times 100\% \\
 &= \left\{ \frac{24.31}{893.62} \right\} \times 100\% \\
 &= 2.720\% = 2.7\%
 \end{aligned}$$

sec02-q0047-01.tex

Keyword: percent composition by mass

10. The mineral spodumene has the formula $\text{LiAlSi}_2\text{O}_6$. What is the mass (in g to two decimal places) of lithium in a 438 g sample?

A: 16.3 g

$$\begin{aligned}m(\text{Li}) &= w(\text{Li}) m(\text{sample}) \\&= \left(\frac{m(\text{Li})}{m(\text{LiAlSi}_2\text{O}_6)} \right) m(\text{sample}) \\&= \left(\frac{A_r^\circ(\text{Li})}{A_r^\circ(\text{Li}) + A_r^\circ(\text{Al}) + [2A_r^\circ(\text{Si})] + [6A_r^\circ(\text{O})]} \right) m(\text{sample}) \\&= \left(\frac{6.94}{186.1} \right) 438 \text{ g} \\&= 16.\bar{3}33 \text{ g} = 16.3 \text{ g}\end{aligned}$$

sec02-q0048-01.tex

Keyword:mass fraction

11. Analysis of a sample of a covalent compound showed that it contained 14.4 % hydrogen and 85.6 % carbon by mass. What is the empirical formula for the compound?

A: CH₂

Here I choose the mass of the sample to be exactly 100 g.

$$\begin{aligned}
 w(\text{H})\% &= w(\text{H}) \times 100 \% \\
 &= m(\text{H}) m(\text{sample})^{-1} \times 100 \% \\
 &= n(\text{H}) M(\text{H}) m(\text{sample})^{-1} \times 100 \% \longrightarrow \\
 n(\text{H}) &= \left(\frac{w(\text{H})\%}{100 \%} \right) m(\text{sample}) M(\text{H})^{-1} \\
 &= \left(\frac{14.4 \%}{100 \%} \right) \left(\frac{100 \text{ g}}{1} \right) \left(\frac{\text{mol}}{1.01 \text{ g}} \right) \\
 &= 14.257 \text{ mol H}
 \end{aligned}$$

$$\begin{aligned}
 w(\text{C})\% &= w(\text{C}) \times 100 \% \\
 &= m(\text{C}) m(\text{sample})^{-1} \times 100 \% \\
 &= n(\text{C}) M(\text{C}) m(\text{sample})^{-1} \times 100 \% \longrightarrow \\
 n(\text{C}) &= w(\text{C}) m(\text{sample}) M(\text{C})^{-1} \\
 &= \left(\frac{w(\text{C})\%}{100 \%} \right) m(\text{sample}) M(\text{C})^{-1} \\
 &= \left(\frac{85.6 \%}{100 \%} \right) \left(\frac{100 \text{ g}}{1} \right) \left(\frac{\text{mol}}{12.01 \text{ g}} \right) \\
 &= 7.127 \text{ mol C}
 \end{aligned}$$

$$\begin{aligned}
 r(\text{H}, \text{C}) &= n(\text{H}) n(\text{C})^{-1} \\
 &= \frac{14.257 \text{ mol H}}{7.127 \text{ mol C}} \\
 &= \frac{2.00 \text{ mol H}}{1 \text{ mol C}}
 \end{aligned}$$



sec02-q0036-01.tex

Keyword:percent composition by mass; empirical formula

12. How many moles (in normalized scientific notation) of Cs are contained in 595 kg of Cs?

A: 4.48×10^3 mol

$$\begin{aligned}n(\text{Cs}) &= m(\text{Cs}) M(\text{Cs})^{-1} \\&= 595 \text{ kg} \left(\frac{10^3 \text{ g}}{\text{kg}} \right) \left(\frac{\text{mol}}{132.91 \text{ g}} \right) \\&= 4476.7 \text{ mol} \\&= 4.48 \times 10^3 \text{ mol}\end{aligned}$$

sec02-q0040-01.tex

Keyword: moles

13. What is the mass (in g) of 2.6×10^{22} chlorine atoms?

A: 1.5 g

$$\begin{aligned}m(\text{Cl}) &= n(\text{Cl}) M(\text{Cl}) \\&= N(\text{Cl}) N_A^{-1} M(\text{Cl}) \\&= 2.6 \times 10^{22} \text{ Cl} \left(\frac{\text{mol}}{6.022 \times 10^{23} \text{ Cl}} \right) \left(\frac{35.45 \text{ g}}{\text{mol}} \right) \\&= 1.530 \text{ g} \\&= 1.5 \text{ g}\end{aligned}$$

sec02-q0042-01.tex

Keyword: moles

14. How many iron atoms are contained in 354 g of iron?

A: 3.82×10^{24} atoms

$$\begin{aligned}N(\text{Fe}) &= n(\text{Fe}) M(\text{Fe}) \\&= m(\text{Fe}) M(\text{Fe})^{-1} N_A \\&= 354 \text{ g} \left(\frac{\text{mol}}{55.85 \text{ g}} \right) \left(\frac{6.022 \times 10^{23} \text{ Fe}}{\text{mol}} \right) \\&= 3.8169 \times 10^{24} \text{ Fe} \\&= 3.82 \times 10^{24} \text{ Fe}\end{aligned}$$

sec02-q0043-01.tex

Keyword: moles; number of entities

15. What is the mass (in ng) of 2.33×10^{20} oxygen atoms?

A: 6.19×10^6 ng

$$\begin{aligned}
 m(\text{O}) &= n(\text{O}) M(\text{O}) \\
 &= N(\text{O}) N_{\text{A}}^{-1} M(\text{O}) \\
 &= 2.33 \times 10^{20} \text{ O} \left(\frac{\text{mol}}{6.022 \times 10^{23} \text{ O}} \right) \left(\frac{16.00 \text{ g}}{\text{mol}} \right) \left(\frac{10^9 \text{ ng}}{\text{g}} \right) \\
 &= 6.1906 \times 10^6 \text{ ng} \\
 &= 6.19 \times 10^6 \text{ ng}
 \end{aligned}$$

sec02-q0044-01.tex

Keyword: moles; number of entities

16. What is the mass (in g) of 2.0×10^{24} Hg atoms?

A: 6.7×10^2 g

$$\begin{aligned}
 m(\text{Hg}) &= n(\text{Hg}) M(\text{Hg}) \\
 &= N(\text{Hg}) N_{\text{A}}^{-1} M(\text{Hg}) \\
 &= 2.0 \times 10^{24} \text{ Hg} \left(\frac{\text{mol}}{6.022 \times 10^{23} \text{ Hg}} \right) \left(\frac{200.59 \text{ g}}{\text{mol}} \right) \\
 &= 6.661 \times 10^2 \text{ g} \\
 &= 6.7 \times 10^2 \text{ g}
 \end{aligned}$$

sec02-q0045-01.tex

Keyword: moles; number of entities

17. A sample of a compound containing only carbon and oxygen decomposes and produces 24.5 g of carbon and 32.59 g of oxygen. Determine the sample by considering percent composition by mass.

- A. CO
- B. CO₂
- C. CO₃
- D. C₃O₂
- E. C₂O

A

Total mass of sample:

$$m(\text{sample}) = 24.5 \text{ g} + 32.59 \text{ g} = 57.09 \text{ g}$$

Mass percent of C and O in sample:

$$\begin{aligned} w(\text{C})\% &= w(\text{C}) \times 100 \% \\ &= \frac{m(\text{C})}{m(\text{sample})} \times 100 \% \\ &= \frac{24.5 \text{ g}}{57.09 \text{ g}} \times 100 \% \\ &= 42.914 \% \end{aligned}$$

$$\begin{aligned} w(\text{O})\% &= w(\text{O}) \times 100 \% \\ &= \frac{m(\text{O})}{m(\text{sample})} \times 100 \% \\ &= \frac{32.59 \text{ g}}{57.09 \text{ g}} \times 100 \% \\ &= 57.0853 \% \end{aligned}$$

Mass percent of C and O in CO:

$$\begin{aligned} w(\text{C})\% &= w(\text{C}) \times 100 \% \\ &= \frac{A_r^\circ(\text{C})}{A_r^\circ(\text{CO})} \times 100 \% \\ &= \frac{12.01}{28.01} \times 100 \% \\ &= 42.8775 \% \end{aligned}$$

$$\begin{aligned} w(\text{O})\% &= w(\text{O}) \times 100 \% \\ &= \frac{A_r^\circ(\text{O})}{A_r^\circ(\text{CO})} \times 100 \% \\ &= \frac{16.00}{28.01} \times 100 \% \\ &= 57.1224 \% \end{aligned}$$

The mass percent of C and O in the sample closely match the mass percent of C and O in CO. The other options give significantly different mass percent compositions.

sec02-q0004-01.tex

Keyword:percent composition by mass

18. The mineral spodumene has the formula $\text{LiAlSi}_2\text{O}_6$. How many lithium atoms are present in a 105 g sample?

A: 3.40×10^{23}

$$\begin{aligned}
 N(\text{Li}) &= n(\text{Li}) N_A \\
 &= m(\text{Li}) M(\text{Li})^{-1} N_A \\
 &= w(\text{Li}) m(\text{sample}) M(\text{Li})^{-1} N_A \\
 &= \left(\frac{m(\text{Li})}{m(\text{LiAlSi}_2\text{O}_6)} \right) m(\text{sample}) M(\text{Li})^{-1} N_A \\
 &= \left(\frac{A_r^\circ(\text{Li})}{A_r^\circ(\text{Li}) + A_r^\circ(\text{Al}) + [2 A_r^\circ(\text{Si})] + [6 A_r^\circ(\text{O})]} \right) m(\text{sample}) M(\text{Li})^{-1} N_A \\
 &= \left(\frac{6.94}{6.94 + 26.98 + [2 \times 28.09] + [6 \times 16.00]} \right) \left(\frac{105 \text{ g}}{\text{mol}} \right) \left(\frac{\text{mol}}{6.94 \text{ g}} \right) \left(\frac{6.022 \times 10^{23}}{\text{mol}} \right) \\
 &= \left(\frac{6.94}{186.10} \right) \left(\frac{105 \text{ g}}{\text{mol}} \right) \left(\frac{\text{mol}}{6.94 \text{ g}} \right) \left(\frac{6.022 \times 10^{23}}{\text{mol}} \right) \\
 &= 3.3976 \times 10^{23} \\
 &= 3.40 \times 10^{23}
 \end{aligned}$$

sec02-q0054-01.tex

Keyword:number of particles

19. Which of the following statements are correct for sorbic acid, $\text{C}_6\text{H}_8\text{O}_2$, an inhibitor of mold and yeast?

- I. It has a C:H:O mass ratio of 3:4:1
- II. It has the same mass percent composition as $\text{C}_3\text{H}_4\text{O}$
- III. It has the same empirical formula as $\text{C}_{12}\text{H}_{16}\text{O}_4$
- IV. The highest percentage, by mass, is that of H
- V. It is an alcohol

- A. III and IV
- B. II and III
- C. I, II, III, IV, and V
- D. II, III, and V
- E. II, III, IV, and V

B

sec02-q0055-01.tex

Keyword:percent by mass; empirical formula

20. Find the mass (in g) of 500 atoms of iron.

A: 5×10^{-20}

$$\begin{aligned}m(\text{Fe}) &= n(\text{Fe}) M(\text{Fe}) \\&= N(\text{Fe}) N_{\text{A}}^{-1} M(\text{Fe}) \\&= 500 \text{ Fe} \left(\frac{\text{mol}}{6.022 \times 10^{23} \text{ Fe}} \right) \left(\frac{55.85 \text{ g}}{\text{mol}} \right) \\&= 4.63 \times 10^{-20} \text{ g} \\&= 5 \times 10^{-20} \text{ g}\end{aligned}$$

sec02-q0060-01.tex

Keyword: moles; number of particles

21. How much Fe (in mol and number of atoms) are in 125.0 g of Fe?

A: 2.238 mol; 1.347×10^{24} atoms

$$\begin{aligned}n(\text{Fe}) &= m(\text{Fe}) M(\text{Fe})^{-1} \\&= 125.0 \text{ g} \left(\frac{\text{mol}}{55.85 \text{ g}} \right) \\&= 2.23813 \text{ mol} \\&= 2.238 \text{ mol}\end{aligned}$$
$$\begin{aligned}N(\text{Fe}) &= n(\text{Fe}) N_{\text{A}} \\&= 2.23813 \text{ mol} \left(\frac{6.022 \times 10^{23} \text{ Fe}}{\text{mol}} \right) \\&= 1.34780 \times 10^{24} \\&= 1.347 \times 10^{24}\end{aligned}$$

sec02-q0061-01.tex

Keyword: moles; number of particles

22. Freon-12 (CCl_2F_2) is used as a refrigerant in air conditioners and as a propellant in aerosol cans. What is the number of freon-12 molecules and what is the mass (in mg) of Cl in a 5.56 mg sample of freon-12?

A: 2.77×10^{19} molecules; 3.26 mg

$$\begin{aligned}
 N(\text{CCl}_2\text{F}_2) &= n(\text{CCl}_2\text{F}_2) N_A \\
 &= m(\text{CCl}_2\text{F}_2) M(\text{CCl}_2\text{F}_2)^{-1} N_A \\
 &= 5.56 \text{ mg} \left(\frac{\text{g}}{10^3 \text{ mg}} \right) \left(\frac{\text{mol}}{120.91 \text{ g}} \right) \left(\frac{6.022 \times 10^{23}}{\text{mol}} \right) \\
 &= 2.7691 \times 10^{19} \text{ CCl}_2\text{F}_2 \\
 &= 2.77 \times 10^{19} \text{ CCl}_2\text{F}_2 \\
 m(\text{Cl}) &= n(\text{Cl}) M(\text{Cl}) \\
 &= N(\text{CCl}_2\text{F}_2) r(\text{Cl}, \text{CCl}_2\text{F}_2) N_A^{-1} M(\text{Cl}) \\
 &= 2.7691 \times 10^{19} \text{ CCl}_2\text{F}_2 \left(\frac{2 \text{ Cl}}{1 \text{ CCl}_2\text{F}_2} \right) \left(\frac{\text{mol}}{6.022 \times 10^{23} \text{ Cl}} \right) \left(\frac{35.45 \text{ g}}{\text{mol}} \right) \left(\frac{10^3 \text{ mg}}{\text{g}} \right) \\
 &= 3.2601 \text{ mg} \\
 &= 3.26 \text{ mg}
 \end{aligned}$$

sec02-q0062-01.tex

Keyword: moles; number of particles

23. *Prevacid* ($C_{16}H_{14}F_3N_3O_2S$) is used to treat gastroesophageal reflux disease (GERD). Determine each of the following:

- A. the molar mass (in g mol^{-1}) of *Prevacid*
- B. the mass (in g) of fluorine in a 0.75 mol sample of *Prevacid*
- C. the number of C atoms in a 0.75 mol sample of *Prevacid*
- D. the mass (in g) of 4.25×10^{21} molecules of *Prevacid*

A: $369.36 \text{ g mol}^{-1}$; 43 g; 7.2×10^{24} ; 2.61 g

Let *Prevacid* be "PA".

A:

$$\begin{aligned} M(\text{PA}) &= \left\{ [16 A_r^\circ(\text{C})] + [14 A_r^\circ(\text{H})] + [3 A_r^\circ(\text{F})] + [3 A_r^\circ(\text{N})] + [2 A_r^\circ(\text{O})] + A_r^\circ(\text{S}) \right\} M_u \\ &= \left\{ [16 \times 12.01] + [14 \times 1.01] + [3 \times 19.00] + [3 \times 14.01] + [2 \times 16.00] + 32.06 \right\} \left(\frac{\text{g}}{\text{mol}} \right) \\ &= 369.39 \text{ g mol}^{-1} \end{aligned}$$

B:

$$\begin{aligned} m(\text{F}) &= n(\text{F}) M(\text{F}) \\ &= n(\text{PA}) r(\text{F, PA}) M(\text{F}) \\ &= 0.75 \text{ mol PA} \left(\frac{3 \text{ mol F}}{\text{mol PA}} \right) \left(\frac{19.00 \text{ g}}{\text{mol F}} \right) \\ &= 42.75 \text{ g} = 43 \text{ g} \end{aligned}$$

C:

$$\begin{aligned} N(\text{C}) &= n(\text{C}) N_A \\ &= n(\text{PA}) r(\text{C, PA}) N_A \\ &= 0.75 \text{ mol PA} \left(\frac{16 \text{ mol C}}{\text{mol PA}} \right) \left(\frac{6.022 \times 10^{23} \text{ C}}{\text{mol}} \right) \\ &= 7.226 \times 10^{24} = 7.2 \times 10^{24} \end{aligned}$$

D:

$$\begin{aligned} m(\text{PA}) &= n(\text{PA}) M(\text{PA}) \\ &= N(\text{PA}) N_A^{-1} M(\text{PA}) \\ &= 4.25 \times 10^{21} \text{ PA} \left(\frac{\text{mol}}{6.022 \times 10^{23} \text{ PA}} \right) \left(\frac{369.39 \text{ g}}{\text{mol}} \right) \\ &= 2.6069 \text{ g} = 2.61 \text{ g} \end{aligned}$$

sec02-q0063-01.tex

Keyword: moles; number of particles

24. Find the percent composition by mass (to one decimal place) of each element in $\text{YBa}_2\text{Cu}_3\text{O}_7$.

A: Y: 13.3 %; Ba: 41.2 %; Cu: 28.6 %; O: 16.8 %

$$\begin{aligned}M(\text{YBa}_2\text{Cu}_3\text{O}_7) &= \left\{ A_r^\circ(\text{Y}) + [2 A_r^\circ(\text{Ba})] + [3 A_r^\circ(\text{Cu})] + [7 A_r^\circ(\text{O})] \right\} M_u \\&= \left\{ 88.91 + [2 \times 137.33] + [3 \times 63.55] + [7 \times 16.00] \right\} \left(\frac{\text{g}}{\text{mol}} \right) \\&= 666.22 \text{ g mol}^{-1}\end{aligned}$$

$$\begin{aligned}w(\text{Y})\% &= w(\text{Y}) \times 100 \% \\&= \left(\frac{A_r^\circ(\text{Y})}{A_r^\circ(\text{YBa}_2\text{Cu}_3\text{O}_7)} \right) \times 100 \% \\&= \left(\frac{88.91}{666.22} \right) \times 100 \% \\&= 13.345 \% \\&= 13.3 \%\end{aligned}$$

$$\begin{aligned}w(\text{Ba})\% &= w(\text{Ba}) \times 100 \% \\&= \left(\frac{2 A_r^\circ(\text{Ba})}{A_r^\circ(\text{YBa}_2\text{Cu}_3\text{O}_7)} \right) \times 100 \% \\&= \left(\frac{2 \times 137.33}{666.22} \right) \times 100 \% \\&= 41.226 \% \\&= 41.2 \%\end{aligned}$$

$$\begin{aligned}w(\text{Cu})\% &= w(\text{Cu}) \times 100 \% \\&= \left(\frac{3 A_r^\circ(\text{Cu})}{A_r^\circ(\text{YBa}_2\text{Cu}_3\text{O}_7)} \right) \times 100 \% \\&= \left(\frac{3 \times 63.55}{666.22} \right) \times 100 \% \\&= 28.616 \% \\&= 28.6 \%\end{aligned}$$

$$\begin{aligned}w(\text{O})\% &= w(\text{O}) \times 100 \% \\&= \left(\frac{7 A_r^\circ(\text{O})}{A_r^\circ(\text{YBa}_2\text{Cu}_3\text{O}_7)} \right) \times 100 \% \\&= \left(\frac{7 \times 16.00}{666.22} \right) \times 100 \% \\&= 16.811 \% \\&= 16.8 \%\end{aligned}$$

sec02-q0064-01.tex

Keyword:percent composition by mass

25. Hemoglobin is a protein that transports oxygen in mammals. Hemoglobin is 0.347 % Fe (by mass). Each hemoglobin molecule contains 4 Fe atoms. What is the molar mass (in g mol^{-1} in standard notation) of hemoglobin?

A: $64,400 \text{ g mol}^{-1}$

$$\begin{aligned}w(\text{Fe})\% &= w(\text{Fe}) \times 100 \% \\&= \left(\frac{m(\text{Fe})}{m(\text{hemoglobin})} \right) \times 100 \% \\&= \frac{4 A_r^\circ(\text{Fe}) M_u}{M(\text{hemoglobin})} \times 100 \% \longrightarrow \\M(\text{hemoglobin}) &= \frac{4 A_r^\circ(\text{Fe}) M_u}{\left(\frac{w(\text{Fe})\%}{100 \%} \right)} \\&= \frac{4 (55.85) \left(\frac{\text{g}}{\text{mol}} \right)}{\left(\frac{0.347 \%}{100 \%} \right)} \\&= 64\,380.4 \text{ g mol}^{-1} = 64\,400 \text{ g mol}^{-1}\end{aligned}$$

sec02-q0065-01.tex

Keyword:percent composition by mass

26. A compound that only contains carbon, hydrogen, and oxygen is 48.64 % C and 8.16 % H (by mass). What is the empirical formula of this substance?

A: $C_3H_6O_2$

Assume an exact 100 g sample.

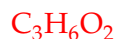
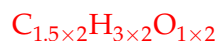
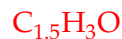
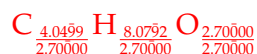
Find the moles of C, H, and O in an exact 100 g sample.

$$\begin{aligned} n(\text{C}) &= w(\text{C}) m(\text{sample}) M(\text{C})^{-1} \\ &= \left(\frac{w(\text{C})\%}{100\%} \right) m(\text{sample}) M(\text{C})^{-1} \\ &= \left(\frac{48.64\% \text{ C}}{100\%} \right) \left(\frac{100 \text{ g}}{1} \right) \left(\frac{\text{mol}}{12.01 \text{ g}} \right) \\ &= 4.04995 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{H}) &= w(\text{H}) m(\text{sample}) M(\text{H})^{-1} \\ &= \left(\frac{w(\text{H})\%}{100\%} \right) m(\text{sample}) M(\text{H})^{-1} \\ &= \left(\frac{8.16\% \text{ H}}{100\%} \right) \left(\frac{100 \text{ g}}{1} \right) \left(\frac{\text{mol}}{1.01 \text{ g}} \right) \\ &= 8.07920 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{O}) &= w(\text{O}) m(\text{sample}) M(\text{O})^{-1} \\ &= \left(\frac{w(\text{O})\%}{100\%} \right) m(\text{sample}) M(\text{O})^{-1} \\ &= \left(\frac{[100 - (48.64 + 8.16)] \% \text{ O}}{100\%} \right) \left(\frac{100 \text{ g}}{1} \right) \left(\frac{\text{mol}}{16.00 \text{ g}} \right) \\ &= 2.70000 \text{ mol} \end{aligned}$$

Find the mole ratio of C, H, and O to a smallest whole number ratio by dividing by the smallest mole number and multiplying by an integer (here the integer is 2).



sec02-q0066-01.tex

Keyword: percent composition by mass; empirical formula

27. Consider four individual samples of phosphine (PH_3), water, hydrogen sulfide, and hydrogen fluoride, each with a mass of 121 g. Rank the compounds from the least to the greatest number of hydrogen atoms contained in each sample.

A: $\text{HF} < \text{H}_2\text{S} < \text{PH}_3 < \text{H}_2\text{O}$

PH_3

$$\begin{aligned} N(\text{H}) &= n(\text{H}) N_{\text{A}} \\ &= m(\text{PH}_3) M(\text{PH}_3)^{-1} r(\text{H}, \text{PH}_3) N_{\text{A}} \\ &= 121 \text{ g PH}_3 \left(\frac{\text{mol PH}_3}{34.00 \text{ g}} \right) \left(\frac{3 \text{ mol H}}{\text{mol PH}_3} \right) \left(\frac{6.022 \times 10^{23} \text{ H}}{\text{mol H}} \right) \\ &= 6.4293 \times 10^{24} \text{ H} = 6.43 \times 10^{24} \text{ H} \end{aligned}$$

H_2O

$$\begin{aligned} N(\text{H}) &= n(\text{H}) N_{\text{A}} \\ &= m(\text{H}_2\text{O}) M(\text{H}_2\text{O})^{-1} r(\text{H}, \text{H}_2\text{O}) N_{\text{A}} \\ &= 121 \text{ g H}_2\text{O} \left(\frac{\text{mol H}_2\text{O}}{18.02 \text{ g}} \right) \left(\frac{2 \text{ mol H}}{\text{mol H}_2\text{O}} \right) \left(\frac{6.022 \times 10^{23} \text{ H}}{\text{mol H}} \right) \\ &= 8.0872 \times 10^{24} \text{ H} = 8.09 \times 10^{24} \text{ H} \end{aligned}$$

H_2S

$$\begin{aligned} N(\text{H}) &= n(\text{H}) N_{\text{A}} \\ &= m(\text{H}_2\text{S}) M(\text{H}_2\text{S})^{-1} r(\text{H}, \text{H}_2\text{S}) N_{\text{A}} \\ &= 121 \text{ g H}_2\text{S} \left(\frac{\text{mol H}_2\text{S}}{34.08 \text{ g}} \right) \left(\frac{2 \text{ mol H}}{\text{mol H}_2\text{S}} \right) \left(\frac{6.022 \times 10^{23} \text{ H}}{\text{mol H}} \right) \\ &= 4.2761 \times 10^{24} \text{ H} = 4.28 \times 10^{24} \text{ H} \end{aligned}$$

HF

$$\begin{aligned} N(\text{H}) &= n(\text{H}) N_{\text{A}} \\ &= m(\text{HF}) M(\text{HF})^{-1} r(\text{H}, \text{HF}) N_{\text{A}} \\ &= 121 \text{ g HF} \left(\frac{\text{mol HF}}{20.01 \text{ g}} \right) \left(\frac{1 \text{ mol H}}{\text{mol HF}} \right) \left(\frac{6.022 \times 10^{23} \text{ H}}{\text{mol H}} \right) \\ &= 3.6414 \times 10^{24} \text{ H} = 3.64 \times 10^{24} \text{ H} \end{aligned}$$

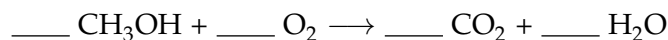
$\text{HF} < \text{H}_2\text{S} < \text{PH}_3 < \text{H}_2\text{O}$

sec02-q0067-01.tex

Keyword: moles; number of particles

Exam 2 Review: Balancing Equations and Solubility

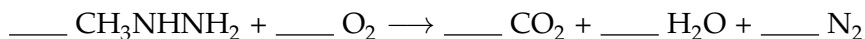
1. Write a balanced equation for the following reaction by placing appropriate stoichiometric coefficients.



sec03-q0001-01.tex

Keyword:balancing equations

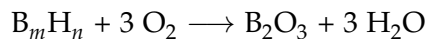
2. Write a balanced equation for the following reaction by placing appropriate stoichiometric coefficients.



sec03-q0002-01.tex

Keyword:balancing equations

3. What values for m and n are required to balance the equation with the given stoichiometric coefficients?



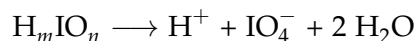
$$m = 2, n = 6$$



sec03-q0003-01.tex

Keyword:balancing equations

4. What values for m and n are required to balance the equation with the given stoichiometric coefficients?



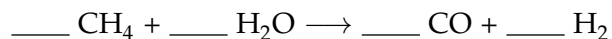
$$m = 5, n = 6$$



sec03-q0004-01.tex

Keyword:balancing equations

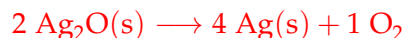
5. Write a balanced equation for the following reaction by placing appropriate stoichiometric coefficients. Include a coefficient of "1" where appropriate for the purpose of this exercise.



sec03-q0005-01.tex

Keyword:balancing equations

6. Solid silver oxide decomposes at high temperatures to yield metallic silver and oxygen gas. Balance the following reaction. Include a coefficient of "1" where appropriate for the purpose of this exercise.



sec03-q0006-01.tex

Keyword:balancing equations

7. Chemical equations must be balanced because the resulting coefficients allow us to predict (select all that apply).
- A. the amount of product that can form from a given amount of reactant.
 - B. whether the reaction requires a catalyst or not
 - C. how much of one reactant is required to react with a given amount of another
 - D. how much reactants are required to form a given amount of products
 - E. whether the given reaction is possible or not

A, C, D

sec03-q0007-01.tex

Keyword:balancing equations

8. Select the appropriately balanced equation for the following reaction.

aqueous silver sulfate + aqueous barium iodide \longrightarrow solid barium sulfate + solid silver iodide

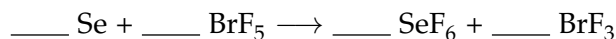
- A. $\text{Ag}_2\text{SO}_4 + \text{BaI}_2 \longrightarrow \text{BaSO}_4 + \text{AgI}$
- B. $\text{Ag}_2\text{SO}_4(\text{l}) + \text{BaI}_2(\text{l}) \longrightarrow \text{BaSO}_4(\text{s}) + 2 \text{AgI}(\text{s})$
- C. $\text{Ag}_2\text{SO}_4(\text{aq}) + \text{BaI}_2(\text{aq}) \longrightarrow \text{BaSO}_4(\text{s}) + 2 \text{AgI}(\text{s})$
- D. $\text{AgSO}_4(\text{aq}) + \text{BaI}(\text{aq}) \longrightarrow \text{BaSO}_4(\text{s}) + 2 \text{AgI}(\text{s})$
- E. $\text{AgSO}_4(\text{l}) + 2 \text{BaI}(\text{l}) \longrightarrow \text{Ba}_2\text{SO}_4(\text{s}) + 2 \text{AgI}_2(\text{s})$

C

sec03-q0008-01.tex

Keyword:nomenclature; balancing equations

9. Write a balanced equation for the following reaction by placing appropriate stoichiometric coefficients. Include a coefficient of "1" where appropriate for the purpose of this exercise.



sec03-q0009-01.tex

Keyword:balancing equations

10. Classify each of the following (all that apply) as a

- I. strong electrolyte
- II. weak electrolyte
- III. nonelectrolyte
- IV. strong acid
- V. strong base

- VI. weak acid
- VII. weak base
- VIII. ionic compound
- IX. organic compound

- A. HBr
- B. ammonium carbonate
- C. NaClO₄
- D. ethanol
- E. acetic acid
- F. NH₃

- A. I, IV
- B. I, VIII
- C. I, VIII
- D. III, IX
- E. II, VI
- F. II, VII

sec03-q0010-01.tex

Keyword:electrolytes

11. Which of the following compounds are insoluble in water? Select all that apply.

- A. CoCO₃
- B. Cu₃(PO₄)₂
- C. AgNO₃
- D. Na₂S
- E. AgI

A, B, E

sec03-q0012-01.tex

Keyword:solubility rules

12. Which of the following combinations will form a precipitate? Select all that apply.

- A. $\text{SrCl}_2(\text{aq}) + \text{Na}_2\text{S}(\text{aq})$
- B. $\text{KCl}(\text{aq}) + \text{CaS}(\text{aq})$
- C. $\text{Hg}(\text{NO}_3)_2(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})$
- D. $\text{Ba}(\text{NO}_3)_2(\text{aq}) + \text{KOH}(\text{aq})$
- E. $\text{NaOH}(\text{aq}) + \text{FeCl}_3(\text{aq})$

A, C, E

- A. $\text{SrCl}_2(\text{aq}) + \text{Na}_2\text{S}(\text{aq}) \longrightarrow \text{SrS}(\text{s}) + 2 \text{NaCl}(\text{aq})$
- B. $2 \text{KCl}(\text{aq}) + \text{CaS}(\text{aq}) \longrightarrow \text{K}_2\text{S}(\text{aq}) + \text{CaCl}_2(\text{aq})$
- C. $\text{Hg}(\text{NO}_3)_2(\text{aq}) + 2 \text{Na}_3\text{PO}_4(\text{aq}) \longrightarrow \text{Hg}_3(\text{PO}_4)_2(\text{s}) + 6 \text{NaNO}_3(\text{aq})$
- D. $\text{Ba}(\text{NO}_3)_2(\text{aq}) + \text{KOH}(\text{aq}) \longrightarrow \text{Ba}(\text{OH})_2(\text{aq}) + 2 \text{KNO}_3(\text{aq})$
- E. $\text{NaOH}(\text{aq}) + \text{FeCl}_3(\text{aq}) \longrightarrow \text{Fe}(\text{OH})_3(\text{s}) + 3 \text{NaCl}(\text{aq})$

sec03-q0013-01.tex

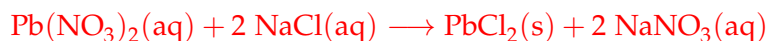
Keyword:solubility rules; precipitation

13. Lead(II) nitrate reacts with sodium chloride. Choose the net ionic equation for the reaction.

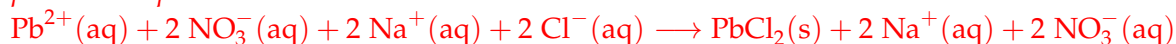
- A. $\text{Pb}^{2+}(\text{aq}) + \text{Cl}^{-}(\text{aq}) \longrightarrow \text{PbCl}(\text{s})$
- B. $\text{Pb}^{2+}(\text{aq}) + \text{NO}_3^{-}(\text{aq}) + \text{Na}^{+}(\text{aq}) + \text{Cl}^{-}(\text{aq}) \longrightarrow \text{PbCl}(\text{s}) + \text{NaNO}_3(\text{aq})$
- C. $\text{PbNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \longrightarrow \text{PbCl}(\text{s}) + \text{NaNO}_3(\text{aq})$
- D. $\text{Pb}^{2+}(\text{aq}) + 2 \text{Cl}^{-}(\text{aq}) \longrightarrow \text{PbCl}_2(\text{s})$

D

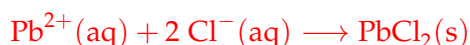
Molecular equation



Complete ionic equation



Net ionic equation



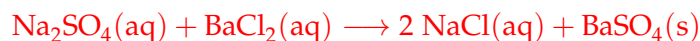
sec03-q0014-01.tex

Keyword:solubility rules; precipitation; net ionic equation

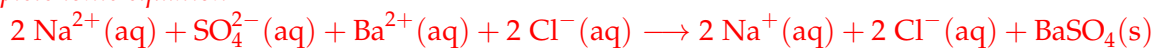
14. Aqueous solutions of sodium sulfate and barium chloride react. What is the sum of the coefficients from the balanced net ionic equation?

3

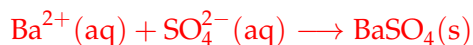
Molecular equation



Complete ionic equation



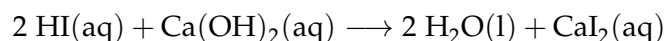
Net ionic equation



sec03-q0015-01.tex

Keyword:solubility rules; precipitation; net ionic equation; balancing equations

15. Answer the questions for the following reaction.



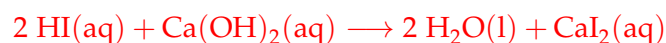
- A. Is the acid strong or weak?
 B. Is the base strong or weak?
 C. What is the net ionic equation for the reaction?

A. strong

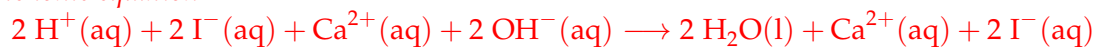
B. strong

C. $\text{H}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$

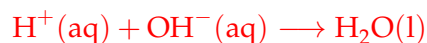
Molecular equation



Complete ionic equation



Net ionic equation



sec03-q0016-01.tex

Keyword:acid-base reaction; net ionic equation; balancing equations

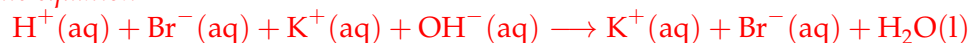
16. A reaction between hydrobromic acid and potassium hydroxide occurs. What is the sum of the coefficients from the balanced net ionic equation?

3

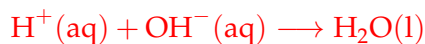
Molecular equation



Complete ionic equation



Net ionic equation



sec03-q0017-01.tex

Keyword:acid-base reaction; net ionic equation; balancing equations

17. Which is the spectator ion in the reaction between potassium carbonate and calcium iodide? Select all that apply.

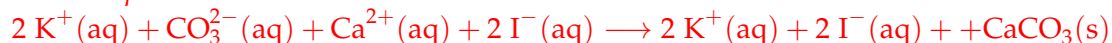
- A. $\text{K}^+(\text{aq})$
- B. $\text{CO}_3^{2-}(\text{aq})$
- C. $\text{Ca}^{2+}(\text{aq})$
- D. $\text{I}^-(\text{aq})$

A, D

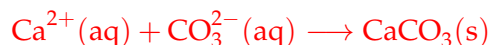
Molecular equation



Complete ionic equation



Net ionic equation



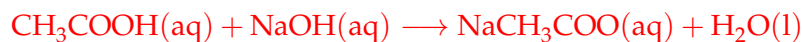
sec03-q0018-01.tex

Keyword:solubility rules; precipitation; net ionic equation; balancing equations

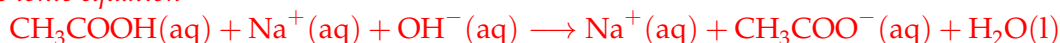
18. What is the sum of the coefficients of the net ionic equation for aqueous sodium hydroxide neutralized by aqueous acetic acid?

4

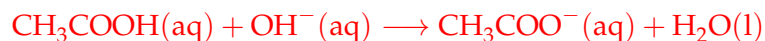
Molecular equation



Complete ionic equation



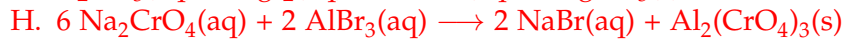
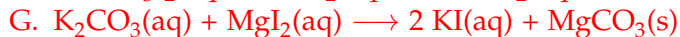
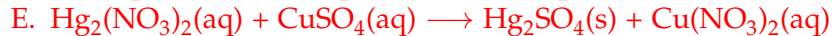
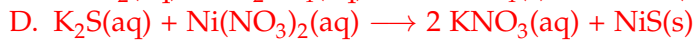
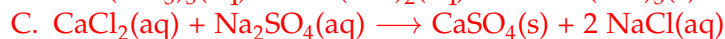
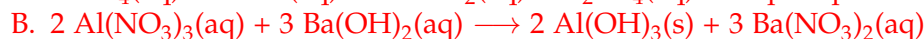
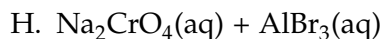
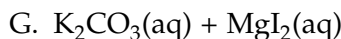
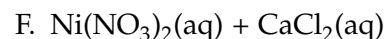
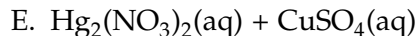
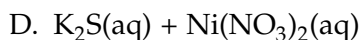
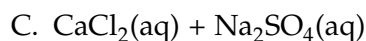
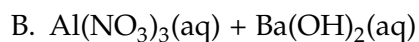
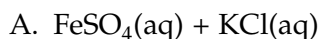
Net ionic equation



sec03-q0019-01.tex

Keyword:acid-base reaction; net ionic equation; balancing equations

19. Balance each reaction complete with phase labels.



sec03-q0020-01.tex

Keyword:solubility rules; double-displacement reaction; balancing equations

20. Which of the following substances are soluble in water? Select all that apply.

- A. aluminum nitrate
- B. magnesium chloride
- C. rubidium sulfate
- D. nickel(II) hydroxide
- E. lead(II) sulfide
- F. barium hydroxide
- G. iron(III) phosphate

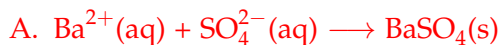
A, B, C, F

sec03-q0021-01.tex

Keyword:solubility rules

21. Write the net ionic equations for the following reactions:

- A. ammonium sulfate and barium nitrate
- B. lead(II) nitrate and sodium chloride
- C. sodium phosphate and potassium nitrate
- D. sodium bromide and rubidium chloride
- E. copper(II) chloride and sodium hydroxide



C. none (all ions are spectators)

D. none (all ions are spectators)



sec03-q0022-01.tex

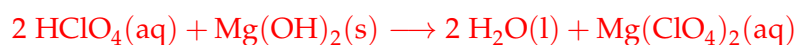
Keyword:net ionic equation; balancing equations; solubility rules

22. Write the balanced molecular equation, complete ionic equation, and net ionic equation for the following acid-base reactions.

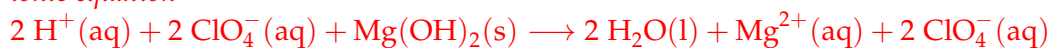
- A. $\text{HClO}_4(\text{aq}) + \text{Mg}(\text{OH})_2(\text{s})$
 B. $\text{HCN}(\text{aq}) + \text{NaOH}(\text{aq})$
 C. $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq})$

A:

Molecular equation



Complete ionic equation

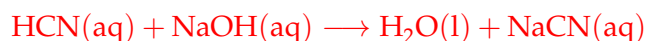


Net ionic equation

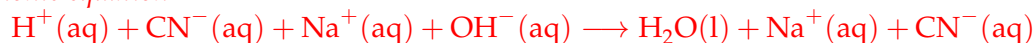


B:

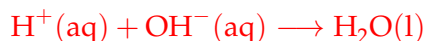
Molecular equation



Complete ionic equation



Net ionic equation

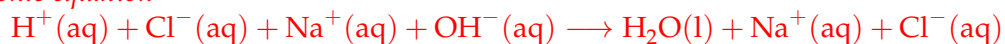


C:

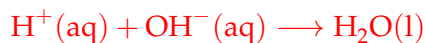
Molecular equation



Complete ionic equation



Net ionic equation



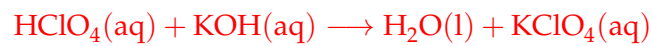
sec03-q0023-01.tex

Keyword:acid-base reaction; net ionic equation

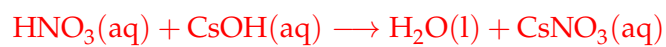
23. Write a balanced chemical equation between an acid and a base that would have the following salt appear as a product.

- A. potassium perchlorate
- B. cesium nitrate
- C. calcium iodide

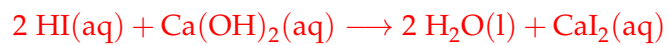
A:



B:



C:



sec03-q0024-01.tex

Keyword:acid-base reaction; salts

Exam 2 Review: Oxidation-Reduction

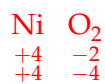
1. Assign oxidation states for all atoms in each of the following compounds.

- A. KMnO_4
- B. NiO_2
- C. $\text{Na}_4\text{Fe}(\text{OH})_6$
- D. $(\text{NH}_4)_2\text{HPO}_4$
- E. P_4O_6

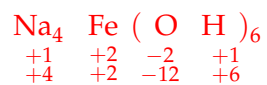
A:



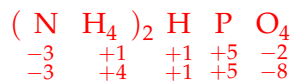
B:



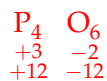
C:



D:



E:



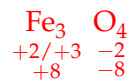
sec03-q0025-01.tex

Keyword:oxidation state

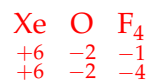
2. Assign oxidation states for all atoms in each of the following compounds.

- A. Fe_3O_4
- B. XeOF_4
- C. SF_4
- D. CO
- E. $\text{C}_6\text{H}_{12}\text{O}_6$

A:



B:



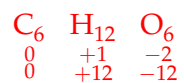
C:



D:



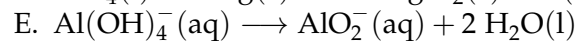
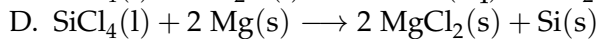
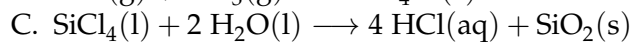
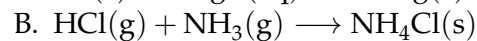
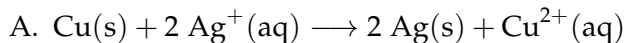
E:



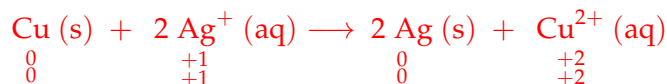
sec03-q0026-01.tex

Keyword:oxidation state

3. Specify which reactions are redox reactions and identify the oxidizing agent, reducing agent, the substance being oxidized, and the substance being reduced.



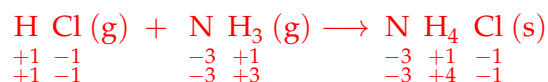
A:



Oxidizing agent: $\text{Ag}^+(\text{aq})$; Reducing agent: Cu(s)

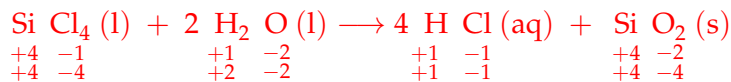
Substance oxidized: Cu(s) ; Substance reduced: $\text{Ag}^+(\text{aq})$

B:



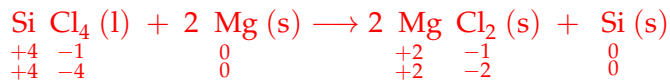
Not a redox reaction.

C:



Not a redox reaction.

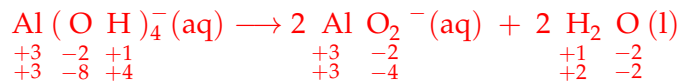
D:



Oxidizing agent: $\text{SiCl}_4(\text{l})$; Reducing agent: Mg(s)

Substance oxidized: Mg(s) ; Substance reduced: $\text{SiCl}_4(\text{l})$

E:

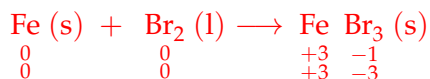
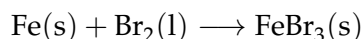


Not a redox reaction.

sec03-q0027-01.tex

Keyword:oxidation state

4. Determine the half-reactions, the amount (in mol) of electrons transferred, and the overall balanced reaction (with phase labels) for the following redox reaction.



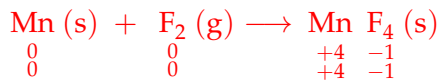
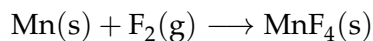
Fe undergoes oxidation and Br₂ undergoes reduction.



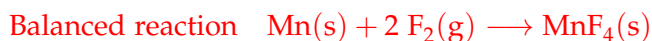
sec03-q0028-01.tex

Keyword:oxidation state; oxidation-reduction reaction; balancing equations

5. Determine the half-reactions, the amount (in mol) of electrons transferred, and the overall balanced reaction (with phase labels) for the following redox reaction.



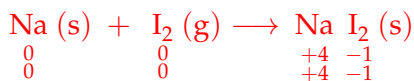
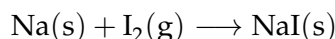
Mn undergoes oxidation and F₂ undergoes reduction.



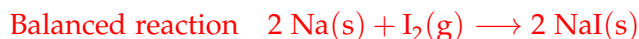
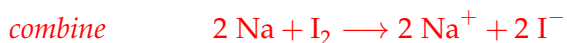
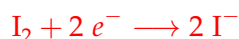
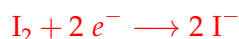
sec03-q0029-01.tex

Keyword:oxidation state; oxidation-reduction reaction; balancing equations

6. Determine the half-reactions, the amount (in mol) of electrons transferred, and the overall balanced reaction (with phase labels) for the following redox reaction.



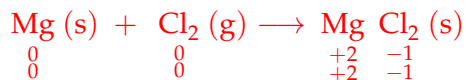
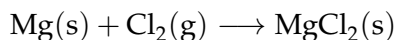
Na undergoes oxidation and I₂ undergoes reduction.



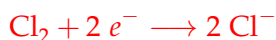
sec03-q0030-01.tex

Keyword:oxidation state; oxidation-reduction reaction; balancing equations

7. Determine the half-reactions, the amount (in mol) of electrons transferred, and the overall balanced reaction (with phase labels) for the following redox reaction.



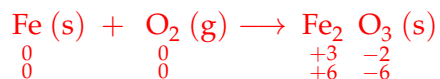
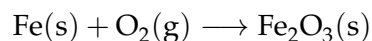
Mg undergoes oxidation and Cl₂ undergoes reduction.



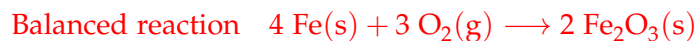
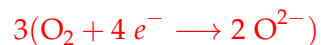
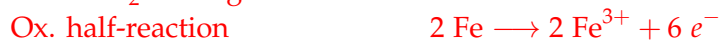
sec03-q0031-01.tex

Keyword:oxidation state; oxidation-reduction reaction; balancing equations

8. Determine the half-reactions, the amount (in mol) of electrons transferred, and the overall balanced reaction (with phase labels) for the following redox reaction.



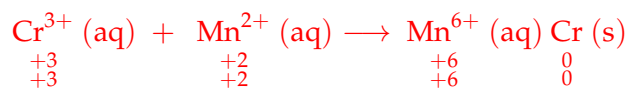
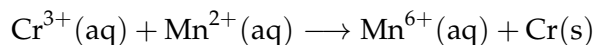
Fe undergoes oxidation and O₂ undergoes reduction.



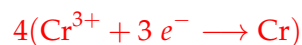
sec03-q0032-01.tex

Keyword:oxidation state; oxidation-reduction reaction; balancing equations

9. Determine the half-reactions, the amount (in mol) of electrons transferred, and the overall balanced reaction (with phase labels) for the following redox reaction.



Mn^{2+} undergoes oxidation and Cr^{3+} undergoes reduction.



sec03-q0033-01.tex

Keyword:oxidation state; oxidation-reduction reaction; balancing equations

Exam 2 Review: Stoichiometry and Molarity

1. Balance the following equation.



Additionally, consider a 4.260×10^3 mg sample of impure silver oxide that, when completely decomposes, yields 283 mg of $\text{O}_2\text{(g)}$. Assuming that the silver oxide is the only source of oxygen, what is the mass percent of silver oxide in the sample?

A: 96.2 %

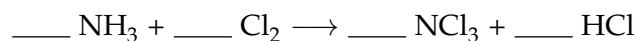


$$\begin{aligned} w(\text{Ag}_2\text{O})\% &= w(\text{Ag}_2\text{O}) \times 100 \% \\ &= \left\{ m(\text{Ag}_2\text{O}) m(\text{sample})^{-1} \right\} \times 100 \% \\ &= \left\{ n(\text{Ag}_2\text{O}) M(\text{Ag}_2\text{O}) m(\text{sample})^{-1} \right\} \times 100 \% \\ &= \left\{ n(\text{O}_2) r(\text{Ag}_2\text{O}, \text{O}_2) M(\text{Ag}_2\text{O}) m(\text{sample})^{-1} \right\} \times 100 \% \\ &= \left\{ m(\text{O}_2) M(\text{O}_2)^{-1} r(\text{Ag}_2\text{O}, \text{O}_2) M(\text{Ag}_2\text{O}) m(\text{sample})^{-1} \right\} \times 100 \% \\ &= \left\{ 283 \text{ mg O}_2 \left(\frac{\text{g}}{10^3 \text{ mg}} \right) \left(\frac{\text{mol O}_2}{32.00 \text{ g O}_2} \right) \left(\frac{2 \text{ mol Ag}_2\text{O}}{\text{mol O}_2} \right) \left(\frac{231.74 \text{ g}}{\text{mol Ag}_2\text{O}} \right) \right. \\ &\quad \left. \left[4.260 \times 10^3 \text{ mg sample} \left(\frac{\text{g}}{10^3 \text{ mg}} \right) \right]^{-1} \right\} \times 100 \% \\ &= \left(\frac{4.0989 \text{ g Ag}_2\text{O}}{4.260 \text{ g sample}} \right) \times 100 \% \\ &= 96.218 \% = 96.2 \% \end{aligned}$$

sec04-q0001-01.tex

Keyword:balancing equations; stoichiometry; percent composition by mass

2. Balance the following equation.



Additionally, what mass (in g) of HCl is produced if 1.27 g of NH₃ reacts with 4.53 g of Cl₂?

A: 2.33 g



$$\begin{aligned} m(\text{HCl}) &= n(\text{HCl}) M(\text{HCl}) \\ &= m(\text{NH}_3) M(\text{NH}_3)^{-1} r(\text{HCl}, \text{NH}_3) M(\text{HCl}) \\ &= 1.27 \text{ g NH}_3 \left(\frac{\text{mol NH}_3}{17.04 \text{ g}} \right) \left(\frac{3 \text{ mol HCl}}{\text{mol NH}_3} \right) \left(\frac{36.46 \text{ g}}{\text{mol HCl}} \right) \\ &= 8.1521 \text{ g} = 8.15 \text{ g} \end{aligned}$$

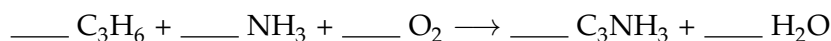
$$\begin{aligned} m(\text{HCl}) &= n(\text{HCl}) M(\text{HCl}) \\ &= m(\text{Cl}_2) M(\text{Cl}_2)^{-1} r(\text{HCl}, \text{Cl}_2) M(\text{HCl}) \\ &= 4.53 \text{ g Cl}_2 \left(\frac{\text{mol Cl}_2}{70.90 \text{ g}} \right) \left(\frac{3 \text{ mol HCl}}{3 \text{ mol Cl}_2} \right) \left(\frac{36.46 \text{ g}}{\text{mol HCl}} \right) \\ &= 2.3295 \text{ g} = 2.33 \text{ g} \end{aligned}$$

Cl₂ is the limiting reactant. 2.33 g of HCl is produced.

sec04-q0002-01.tex

Keyword:balancing equations; stoichiometry; limiting reactant

3. Balance the following equation.

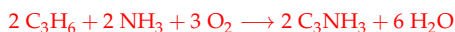


Additionally, determine the following:

- What is the limiting reactant if 4.25 g of C_3H_6 reacts with 3.14 g of NH_3 and 6.12 g of O_2 ?
- What mass (in g) of C_3NH_3 can theoretically be produced given the information in A?
- What mass (in g) of C_3NH_3 , NH_3 , and O_2 would theoretically be leftover given the information in A?
- If 1.94 g of C_3NH_3 was produced in an experiment, what is the percent yield?

A: C_3H_6 ; 5.36 g; 0 g, 1.42 g, and 1.27 g; 36.2 %

A. C_3H_6 is limiting.



$$\begin{aligned} n(\text{C}_3\text{NH}_3) &= n(\text{C}_3\text{H}_6) r(\text{C}_3\text{NH}_3, \text{C}_3\text{H}_6) \\ &= m(\text{C}_3\text{H}_6) M(\text{C}_3\text{H}_6)^{-1} r(\text{C}_3\text{NH}_3, \text{C}_3\text{H}_6) \\ &= 4.25 \text{ g C}_3\text{H}_6 \left(\frac{\text{mol C}_3\text{H}_6}{42.09 \text{ g}} \right) \left(\frac{2 \text{ mol C}_3\text{NH}_3}{2 \text{ mol C}_3\text{H}_6} \right) \\ &= 0.10097 \text{ mol} \longrightarrow m(\text{C}_3\text{NH}_3) = 0.10097 \text{ mol} \left(\frac{53.06 \text{ g}}{\text{mol C}_3\text{NH}_3} \right) = 5.3576 \text{ g} = 5.36 \text{ g} \end{aligned}$$

$$\begin{aligned} n(\text{C}_3\text{NH}_3) &= n(\text{NH}_3) r(\text{C}_3\text{NH}_3, \text{NH}_3) \\ &= m(\text{NH}_3) M(\text{NH}_3)^{-1} r(\text{C}_3\text{NH}_3, \text{NH}_3) \\ &= 3.14 \text{ g NH}_3 \left(\frac{\text{mol NH}_3}{17.04 \text{ g}} \right) \left(\frac{2 \text{ mol C}_3\text{NH}_3}{2 \text{ mol NH}_3} \right) \\ &= 0.18427 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{C}_3\text{NH}_3) &= m(\text{O}_2) r(\text{C}_3\text{NH}_3, \text{O}_2) \\ &= m(\text{O}_2) M(\text{O}_2)^{-1} r(\text{C}_3\text{NH}_3, \text{O}_2) \\ &= 6.12 \text{ g O}_2 \left(\frac{\text{mol O}_2}{32.00 \text{ g}} \right) \left(\frac{2 \text{ mol C}_3\text{NH}_3}{3 \text{ mol O}_2} \right) \\ &= 0.12750 \text{ mol} \end{aligned}$$

B. 5.36 g of C_3NH_3 can be produced (see work in A).

C.

$$\begin{aligned} m(\text{C}_3\text{H}_6)_{\text{leftover}} &= m(\text{C}_3\text{H}_6)_{\text{initial}} - m(\text{C}_3\text{H}_6)_{\text{reacted}} \\ &= m(\text{C}_3\text{H}_6)_{\text{initial}} - [n(\text{C}_3\text{NH}_3) r(\text{C}_3\text{H}_6, \text{C}_3\text{NH}_3) M(\text{C}_3\text{H}_6)] \\ &= 4.25 \text{ g C}_3\text{H}_6 - \left[0.10097 \text{ mol C}_3\text{NH}_3 \left(\frac{2 \text{ mol NH}_3}{2 \text{ mol C}_3\text{NH}_3} \right) \left(\frac{42.09 \text{ g}}{\text{mol C}_3\text{H}_6} \right) \right] \\ &= 4.25 \text{ g} - 4.2498 \text{ g} = 0 \text{ g} \end{aligned}$$

$$\begin{aligned} m(\text{NH}_3)_{\text{leftover}} &= m(\text{NH}_3)_{\text{initial}} - m(\text{NH}_3)_{\text{reacted}} \\ &= m(\text{NH}_3)_{\text{initial}} - [n(\text{C}_3\text{NH}_3) r(\text{NH}_3, \text{C}_3\text{NH}_3) M(\text{NH}_3)] \\ &= 3.14 \text{ g NH}_3 - \left[0.10097 \text{ mol C}_3\text{NH}_3 \left(\frac{2 \text{ mol NH}_3}{2 \text{ mol C}_3\text{NH}_3} \right) \left(\frac{17.04 \text{ g}}{\text{mol NH}_3} \right) \right] \\ &= 3.14 \text{ g} - 1.7205 \text{ g} = 1.4194 \text{ g} = 1.42 \text{ g} \end{aligned}$$

$$\begin{aligned} m(\text{O}_2)_{\text{leftover}} &= m(\text{O}_2)_{\text{initial}} - m(\text{O}_2)_{\text{reacted}} \\ &= m(\text{O}_2)_{\text{initial}} - [n(\text{C}_3\text{NH}_3) r(\text{O}_2, \text{C}_3\text{NH}_3) M(\text{O}_2)] \\ &= 6.12 \text{ g O}_2 - \left[0.10097 \text{ mol C}_3\text{NH}_3 \left(\frac{3 \text{ mol O}_2}{2 \text{ mol C}_3\text{NH}_3} \right) \left(\frac{32.00 \text{ g}}{\text{mol O}_2} \right) \right] \\ &= 6.12 \text{ g} - 4.8465 \text{ g} = 1.2734 \text{ g} = 1.27 \text{ g} \end{aligned}$$

D.

$$\% \text{ yield} = \left(\frac{m(\text{actual})}{m(\text{theoretical})} \right) 100 \% = \left(\frac{1.94 \text{ g}}{5.3586 \text{ g}} \right) 100 \% = 36.203 \% = 36.2 \%$$

4. Balance the following reaction.



Additionally, determine the following:

- A. What volume (in mL) of $\text{C}_6\text{H}_5\text{NO}_2$ ($\rho = 1.20 \text{ g mL}^{-1}$) must be allowed to react with an excess of $\text{C}_6\text{H}_{14}\text{O}_4$ to produce 6.21 g of $(\text{C}_6\text{H}_5\text{N})_2$ if the percent yield is 83.7 %?
- B. If 0.17 L of $\text{C}_6\text{H}_5\text{NO}_2$ ($\rho = 1.20 \text{ g mL}^{-1}$) and 0.52 L $\text{C}_6\text{H}_{14}\text{O}_4$ ($\rho = 1.12 \text{ g mL}^{-1}$) react to yield 64.4 g of $(\text{C}_6\text{H}_5\text{N})_2$, what is the limiting reactant and what is the percent yield of the reaction?

A: 8.35 mL; $\text{C}_6\text{H}_5\text{NO}_2$; 43 %



A.

$$\begin{aligned} V(\text{C}_6\text{H}_5\text{NO}_2) &= m(\text{C}_6\text{H}_5\text{NO}_2) \rho(\text{C}_6\text{H}_5\text{NO}_2)^{-1} \\ &= m[(\text{C}_6\text{H}_5\text{N})_2] M[(\text{C}_6\text{H}_5\text{N})_2]^{-1} r[\text{C}_6\text{H}_5\text{NO}_2, (\text{C}_6\text{H}_5\text{N})_2] M(\text{C}_6\text{H}_5\text{NO}_2) \rho(\text{C}_6\text{H}_5\text{NO}_2)^{-1} \\ &= 7.42 \text{ g } (\text{C}_6\text{H}_5\text{N})_2 \left(\frac{\text{mol } (\text{C}_6\text{H}_5\text{N})_2}{182.24 \text{ g}} \right) \left(\frac{2 \text{ mol } \text{C}_6\text{H}_5\text{NO}_2}{\text{mol } (\text{C}_6\text{H}_5\text{N})_2} \right) \left(\frac{123.12 \text{ g}}{\text{mol } \text{C}_6\text{H}_5\text{NO}_2} \right) \\ &\quad \left(\frac{\text{mL}}{1.20 \text{ g } \text{C}_6\text{H}_5\text{NO}_2} \right) \\ &= 8.3548 \text{ mL} \\ &= 8.35 \text{ mL} \end{aligned}$$

B.

$$\begin{aligned} m[(\text{C}_6\text{H}_5\text{N})_2] &= n[(\text{C}_6\text{H}_5\text{N})_2] M[(\text{C}_6\text{H}_5\text{N})_2] \\ &= V(\text{C}_6\text{H}_5\text{NO}_2) \rho(\text{C}_6\text{H}_5\text{NO}_2) M(\text{C}_6\text{H}_5\text{NO}_2)^{-1} r[(\text{C}_6\text{H}_5\text{N})_2, \text{C}_6\text{H}_5\text{NO}_2] M[(\text{C}_6\text{H}_5\text{N})_2] \\ &= 0.17 \text{ L } \text{C}_6\text{H}_5\text{NO}_2 \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \left(\frac{1.20 \text{ g } \text{C}_6\text{H}_5\text{NO}_2}{\text{mL}} \right) \left(\frac{\text{mol } \text{C}_6\text{H}_5\text{NO}_2}{123.12 \text{ g}} \right) \\ &\quad \left(\frac{\text{mol } (\text{C}_6\text{H}_5\text{N})_2}{2 \text{ mol } \text{C}_6\text{H}_5\text{NO}_2} \right) \left(\frac{182.24 \text{ g}}{\text{mol } (\text{C}_6\text{H}_5\text{N})_2} \right) \\ &= 150.9 \text{ g} = 150 \text{ g} \end{aligned}$$

$$\begin{aligned} m[(\text{C}_6\text{H}_5\text{N})_2] &= n[(\text{C}_6\text{H}_5\text{N})_2] M[(\text{C}_6\text{H}_5\text{N})_2] \\ &= V(\text{C}_6\text{H}_{14}\text{O}_4) \rho(\text{C}_6\text{H}_{14}\text{O}_4) M(\text{C}_6\text{H}_{14}\text{O}_4)^{-1} r[(\text{C}_6\text{H}_5\text{N})_2, \text{C}_6\text{H}_{14}\text{O}_4] M[(\text{C}_6\text{H}_5\text{N})_2] \\ &= 0.52 \text{ L } \text{C}_6\text{H}_{14}\text{O}_4 \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \left(\frac{1.12 \text{ g } \text{C}_6\text{H}_{14}\text{O}_4}{\text{mL}} \right) \left(\frac{\text{mol } \text{C}_6\text{H}_{14}\text{O}_4}{150.20 \text{ g}} \right) \\ &\quad \left(\frac{\text{mol } (\text{C}_6\text{H}_5\text{N})_2}{4 \text{ mol } \text{C}_6\text{H}_{14}\text{O}_4} \right) \left(\frac{182.24 \text{ g}}{\text{mol } (\text{C}_6\text{H}_5\text{N})_2} \right) \\ &= 176.6 \text{ g} = 180 \text{ g} \end{aligned}$$

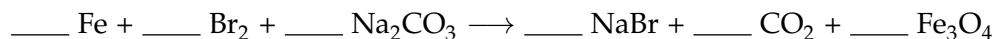
$\text{C}_6\text{H}_5\text{NO}_2$ is the limiting reactant.

$$\% \text{ yield} = \left(\frac{m[(\text{C}_6\text{H}_5\text{N})_2]_{\text{actual}}}{m[(\text{C}_6\text{H}_5\text{N})_2]_{\text{theoretical}}} \right) 100 \% = \left(\frac{64.4 \text{ g}}{150.9 \text{ g}} \right) 100 \% = 42.67 \% = 43 \%$$

sec04-q0004-01.tex

Keyword:balancing equations; limiting reactant; percent yield; stoichiometry

5. Balance the following reaction.



Additionally, an alloy contains 84.2 % Fe and 15.8 % Ni (by mass). A 6.41 g sample of the alloy reacts with 8.30 g Na_2CO_3 with excess Br_2 .

A. What mass (in g) of Fe_3O_4 can be produced?

B. What mass (in g) of Fe_3O_4 is produced if the percent yield of the reaction is 94.3 %?

A: 4.53 g; 4.27 g



A.

$$\begin{aligned} m(\text{Fe}_3\text{O}_4) &= n(\text{Fe}_3\text{O}_4) M(\text{Fe}_3\text{O}_4) \\ &= n(\text{Fe}) r(\text{Fe}_3\text{O}_4, \text{Fe}) M(\text{Fe}_3\text{O}_4) \\ &= m(\text{sample}) w(\text{sample}) M(\text{Fe})^{-1} r(\text{Fe}_3\text{O}_4, \text{Fe}) M(\text{Fe}_3\text{O}_4) \\ &= 6.41 \text{ g sample} \left(\frac{84.2 \% \text{ Fe}}{100 \% \text{ sample}} \right) \left(\frac{\text{mol Fe}}{55.85 \text{ g}} \right) \left(\frac{\text{mol Fe}_3\text{O}_4}{3 \text{ mol Fe}} \right) \left(\frac{231.55 \text{ g}}{\text{mol Fe}_3\text{O}_4} \right) \\ &= 7.4588 \text{ g} = 7.46 \text{ g} \end{aligned}$$

$$\begin{aligned} m(\text{Fe}_3\text{O}_4) &= n(\text{Fe}_3\text{O}_4) M(\text{Fe}_3\text{O}_4) \\ &= n(\text{Na}_2\text{CO}_3) r(\text{Fe}_3\text{O}_4, \text{Na}_2\text{CO}_3) M(\text{Fe}_3\text{O}_4) \\ &= m(\text{Na}_2\text{CO}_3) M(\text{Na}_2\text{CO}_3)^{-1} r(\text{Fe}_3\text{O}_4, \text{Na}_2\text{CO}_3) M(\text{Fe}_3\text{O}_4) \\ &= 8.30 \text{ g Na}_2\text{CO}_3 \left(\frac{\text{mol Na}_2\text{CO}_3}{105.99 \text{ g}} \right) \left(\frac{\text{mol Fe}_3\text{O}_4}{4 \text{ mol Fe}} \right) \left(\frac{231.55 \text{ g}}{\text{mol Fe}_3\text{O}_4} \right) \\ &= 4.5331 \text{ g} = 4.53 \text{ g} \end{aligned}$$

Na_2CO_3 is the limiting reactant. 4.53 g of Fe_3O_4 can be produced.

B.

$$\begin{aligned} \% \text{ yield} &= \left(\frac{m(\text{Fe}_3\text{O}_4)_{\text{actual}}}{m(\text{Fe}_3\text{O}_4)_{\text{theoretical}}} \right) 100 \% \longrightarrow \\ m(\text{Fe}_3\text{O}_4)_{\text{actual}} &= \left(\frac{\% \text{ yield}}{100 \%} \right) m(\text{Fe}_3\text{O}_4)_{\text{theoretical}} \\ &= \left(\frac{94.3 \%}{100 \%} \right) 4.5331 \text{ g} \\ &= 4.2747 \text{ g} = 4.27 \text{ g} \end{aligned}$$

sec04-q0005-01.tex

Keyword:balancing equations; limiting reactant; percent yield; stoichiometry

6. A mixture contained no fluorine compound except methyl fluoroacetate, $\text{FCH}_2\text{COOCH}_3$ ($M(\text{FCH}_2\text{COOCH}_3) = 92.08 \text{ g mol}^{-1}$). When chemically treated, all the fluorine was converted to CaF_2 ($M(\text{CaF}_2) = 78.08 \text{ g mol}^{-1}$). The mass of CaF_2 obtained was 20.1 g. Find the mass (in g) of methyl fluoroacetate in the original mixture.

A: 47.4 g

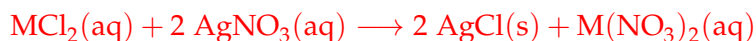
$$\begin{aligned}
 m(\text{FCH}_2\text{COOCH}_3) &= n(\text{FCH}_2\text{COOCH}_3) M(\text{FCH}_2\text{COOCH}_3) \\
 &= m(\text{CaF}_2) M(\text{CaF}_2)^{-1} r(\text{F}^-, \text{CaF}_2) r(\text{FCH}_2\text{COOCH}_3, \text{F}^-) M(\text{FCH}_2\text{COOCH}_3) \\
 &= 20.1 \text{ g CaF}_2 \left(\frac{\text{mol CaF}_2}{78.08 \text{ g}} \right) \left(\frac{2 \text{ mol F}^-}{\text{mol CaF}_2} \right) \left(\frac{\text{mol FCH}_2\text{COOCH}_3}{\text{mol F}^-} \right) \\
 &\quad \left(\frac{92.08 \text{ g}}{\text{mol FCH}_2\text{COOCH}_3} \right) \\
 &= 47.\bar{4}07 \text{ g} = 47.4 \text{ g}
 \end{aligned}$$

sec04-q0013-01.tex

Keyword:stoichiometry

7. A 1.62 g sample of a metal chloride, MCl_2 , is dissolved in water and treated with excess aqueous silver nitrate. The silver chloride that formed weighed 3.46 g. Calculate the molar mass (in g mol^{-1}) of the metal, M, and identify the metal.

A: 63.3 g mol^{-1} ; Cu



$$\begin{aligned}
 M(\text{M}) &= m(\text{M}) n(\text{M})^{-1} \\
 &= \left\{ m(\text{MCl}_2) n(\text{MCl}_2)^{-1} \right\} - 2 M(\text{Cl}) \\
 &= \left\{ m(\text{MCl}_2) \left[n(\text{AgCl}) r(\text{Cl}^-, \text{AgCl}) r(\text{MCl}_2, \text{Cl}^-) \right]^{-1} \right\} - 2 M(\text{Cl}) \\
 &= \left\{ m(\text{MCl}_2) \left[m(\text{AgCl}) M(\text{AgCl})^{-1} r(\text{Cl}^-, \text{AgCl}) r(\text{MCl}_2, \text{Cl}^-) \right]^{-1} \right\} - 2 M(\text{Cl}) \\
 &= \left\{ 1.62 \text{ g MCl}_2 \left[3.46 \text{ g AgCl} \left(\frac{\text{mol AgCl}}{143.32 \text{ g}} \right) \left(\frac{\text{mol Cl}^-}{\text{mol AgCl}} \right) \left(\frac{\text{mol MCl}_2}{2 \text{ mol Cl}^-} \right) \right]^{-1} \right\} - \left[2 \left(\frac{35.45 \text{ g}}{\text{mol Cl}} \right) \right] \\
 &= \left\{ \frac{1.62 \text{ g MCl}_2}{0.012070 \text{ mol MCl}_2} \right\} - \left[2 \left(\frac{35.45 \text{ g}}{\text{mol Cl}} \right) \right] \\
 &= 63.\bar{3}07 \text{ g} = 63.3 \text{ g}
 \end{aligned}$$

sec04-q0014-01.tex

Keyword:stoichiometry

8. Which solution has the greatest molar concentration of SO_4^{2-} ?

- A. 0.060 M H_2SO_4
- B. 0.27 M MgSO_4
- C. 0.17 M Na_2SO_4
- D. 0.098 M $\text{Al}_2(\text{SO}_4)_3$
- E. 0.22 M CuSO_4

D

- A. 0.06 M
- B. 0.27 M
- C. 0.17 M
- D. 0.29 M
- E. 0.22 M

sec04-q0006-01.tex

Keyword:electrolytes; molarity

9. A solution is prepared by dissolving 4.25 g NaCl, 0.175 g KCl, and 0.183 g CaCl₂ in water. The volume of the solution is 500.0 mL. What is the molar concentration (in mol L⁻¹) of Cl⁻ in the solution?

A: 0.157 M

All ionic compounds are soluble.

NaCl

$$\begin{aligned} n(\text{Cl}^-) &= n(\text{NaCl}) r(\text{Cl}^-, \text{NaCl}) \\ &= m(\text{NaCl}) M(\text{NaCl})^{-1} r(\text{Cl}^-, \text{NaCl}) \\ &= 4.25 \text{ g} \left(\frac{\text{mol NaCl}}{58.44 \text{ g}} \right) \left(\frac{\text{mol Cl}^-}{\text{mol NaCl}} \right) \\ &= 0.072724 \text{ mol} \end{aligned}$$

KCl

$$\begin{aligned} n(\text{Cl}^-) &= n(\text{KCl}) r(\text{Cl}^-, \text{KCl}) \\ &= m(\text{KCl}) M(\text{KCl})^{-1} r(\text{Cl}^-, \text{KCl}) \\ &= 0.175 \text{ g} \left(\frac{\text{mol KCl}}{74.55 \text{ g}} \right) \left(\frac{\text{mol Cl}^-}{\text{mol KCl}} \right) \\ &= 0.0023474 \text{ mol} \end{aligned}$$

CaCl₂

$$\begin{aligned} n(\text{Cl}^-) &= n(\text{CaCl}_2) r(\text{Cl}^-, \text{CaCl}_2) \\ &= m(\text{CaCl}_2) M(\text{CaCl}_2)^{-1} r(\text{Cl}^-, \text{CaCl}_2) \\ &= 0.183 \text{ g} \left(\frac{\text{mol CaCl}_2}{110.98 \text{ g}} \right) \left(\frac{2 \text{ mol Cl}^-}{\text{mol CaCl}_2} \right) \\ &= 0.0032978 \text{ mol} \end{aligned}$$

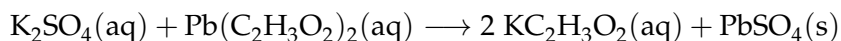
Cl⁻ molar concentration

$$\begin{aligned} c(\text{Cl}^-) &= n(\text{Cl}^-) V(\text{solution})^{-1} \\ &= \left[(0.072724 + 0.0023474 + 0.0032978) \text{ mol} \right] \left[500.0 \text{ mL} \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \right]^{-1} \\ &= 0.15673 \text{ mol L}^{-1} = 0.157 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0007-01.tex

Keyword:electrolytes; molarity

10. In the following reaction, 55.2 mL of potassium sulfate solution was added to excess lead acetate. What is the concentration of K^+ in the potassium sulfate solution if 1.23 g of $PbSO_4$ was produced?



A: 0.147 M

$$\begin{aligned} c(K^+) &= n(K^+) V(\text{solution})^{-1} \\ &= n(K_2SO_4) r(K^+, K_2SO_4) V(\text{solution})^{-1} \\ &= n(PbSO_4) r(K_2SO_4, PbSO_4) r(K^+, K_2SO_4) V(\text{solution})^{-1} \\ &= m(PbSO_4) M(PbSO_4)^{-1} r(K_2SO_4, PbSO_4) r(K^+, K_2SO_4) V(\text{solution})^{-1} \\ &= 1.23 \text{ g } PbSO_4 \left(\frac{\text{mol } PbSO_4}{303.26 \text{ g}} \right) \left(\frac{\text{mol } K_2SO_4}{\text{mol } PbSO_4} \right) \left(\frac{2 \text{ mol } K^+}{\text{mol } K_2SO_4} \right) \left(\frac{1}{55.2 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.15539 \text{ mol L}^{-1} = 0.155 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0008-01.tex

Keyword:electrolytes; molarity; stoichiometry

11. You mix 285.0 mL of 1.20 M aqueous lead(II) nitrate with 300.0 mL of 1.55 M aqueous potassium iodide. Determine the following.

- the molecular equation for this reaction
- the limiting reactant
- the final molar concentration (in mol L⁻¹) of Pb²⁺
- the mass (in g) of lead(II) iodide formed
- the final molar concentration (in mol L⁻¹) of K⁺
- the final molar concentration (in mol L⁻¹) of NO₃⁻

A.



B. KI is limiting.

$$\begin{aligned} c(\text{PbI}_2) &= n(\text{PbI}_2) V(\text{solution})^{-1} \\ &= V(\text{Pb}(\text{NO}_3)_2) c(\text{Pb}(\text{NO}_3)_2) r(\text{PbI}_2, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= 285.0 \text{ mL Pb}(\text{NO}_3)_2 \left(\frac{1.20 \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \right) \left(\frac{\text{mol PbI}_2}{\text{mol Pb}(\text{NO}_3)_2} \right) \left(\frac{1}{(285.0 + 300.0) \text{ mL}} \right) \\ &= 0.58461 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{PbI}_2) &= n(\text{PbI}_2) V(\text{solution})^{-1} \\ &= V(\text{KI}) c(\text{KI}) r(\text{PbI}_2, \text{KI}) V(\text{solution})^{-1} \\ &= 300.0 \text{ mL KI} \left(\frac{1.55 \text{ mol KI}}{\text{L}} \right) \left(\frac{\text{mol PbI}_2}{2 \text{ mol KI}} \right) \left(\frac{1}{(285.0 + 300.0) \text{ mL}} \right) \\ &= 0.39743 \text{ mol L}^{-1} \end{aligned}$$

C.

$$\begin{aligned} c(\text{Pb}^{2+})_{\text{final}} &= n(\text{Pb}^{2+}) V(\text{solution})^{-1} \\ &= \left\{ n(\text{Pb}(\text{NO}_3)_2)_{\text{initial}} - n(\text{Pb}(\text{NO}_3)_2)_{\text{reacted}} \right\} r(\text{Pb}^{2+}, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \left\{ \left[c(\text{Pb}(\text{NO}_3)_2) V(\text{Pb}(\text{NO}_3)_2) \right] - \left[c(\text{PbI}_2) V(\text{solution}) r(\text{PbI}_2, \text{Pb}(\text{NO}_3)_2) \right] \right\} \\ &\quad r(\text{Pb}^{2+}, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \left\{ \left[\left(\frac{1.20 \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \right) \left(\frac{285.0 \text{ mL Pb}(\text{NO}_3)_2}{10^3 \text{ mL}} \right) \right] - \right. \\ &\quad \left. \left[\left(\frac{0.39743 \text{ mol PbI}_2}{\text{L}} \right) \left(\frac{(285.0 \text{ mL} + 300.0) \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Pb}(\text{NO}_3)_2}{\text{mol PbI}_2} \right) \right] \right\} \\ &\quad \left(\frac{\text{mol Pb}^{2+}}{\text{mol Pb}(\text{NO}_3)_2} \right) \left(\frac{1}{(285.0 + 300.0) \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.18718 \text{ mol L}^{-1} = 0.187 \text{ mol L}^{-1} \end{aligned}$$

D.

$$\begin{aligned} m(\text{PbI}_2) &= c(\text{PbI}_2) V(\text{solution}) M(\text{PbI}_2) \\ &= \frac{0.39743 \text{ mol PbI}_2}{\text{L}} \left(\frac{(285.0 + 300.0) \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{461 \text{ g}}{\text{mol PbI}_2} \right) \\ &= 107.18 \text{ g} = 111 \text{ g} \end{aligned}$$

E.

$$\begin{aligned} c(\text{K}^+) &= n(\text{K}^+) V(\text{solution})^{-1} \\ &= n(\text{KI}) r(\text{K}^+, \text{KI}) V(\text{solution})^{-1} \\ &= c(\text{KI}) V(\text{KI}) r(\text{K}^+, \text{KI}) V(\text{solution})^{-1} \\ &= \frac{1.55 \text{ mol KI}}{\text{L}} \left(\frac{300.0 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{2 \text{ mol K}^+}{2 \text{ mol KNO}_3} \right) \left(\frac{1}{(285.0 + 300.0) \text{ mL}} \right) \\ &= 0.79487 \text{ mol L}^{-1} = 0.795 \text{ mol L}^{-1} \end{aligned}$$

F.

$$\begin{aligned} c(\text{NO}_3^-) &= n(\text{NO}_3^-) V(\text{solution})^{-1} \\ &= c(\text{Pb}(\text{NO}_3)_2) V(\text{Pb}(\text{NO}_3)_2) r(\text{NO}_3^-, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \frac{1.20 \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \left(\frac{285.0 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{2 \text{ mol NO}_3^-}{\text{mol Pb}(\text{NO}_3)_2} \right) \left(\frac{1}{(285.0 + 300.0) \text{ mL}} \right) \\ &= 1.1692 \text{ mol L}^{-1} = 1.17 \text{ mol L}^{-1} \end{aligned}$$

12. If all of the chloride in a 4.106 g sample of an unknown metal chloride is precipitated as AgCl with 70.90 mL of 0.2010 M AgNO₃, what is the percentage of chloride in the sample?

A: 12.30 %

$$\begin{aligned}
 w(\text{Cl}^-)\% &= w(\text{Cl}^-) \times 100 \% \\
 &= m(\text{Cl}^-) m(\text{sample})^{-1} \times 100 \% \\
 &= n(\text{Cl}^-) M(\text{Cl}^-) m(\text{sample})^{-1} \times 100 \% \\
 &= n(\text{AgNO}_3) r(\text{Ag}^+, \text{AgNO}_3) r(\text{AgCl}, \text{Ag}^+) r(\text{Cl}^-, \text{Ag}^+) M(\text{Cl}^-) m(\text{sample})^{-1} \times 100 \% \\
 &= c(\text{AgNO}_3) V(\text{AgNO}_3) r(\text{Ag}^+, \text{AgNO}_3) r(\text{AgCl}, \text{Ag}^+) r(\text{Cl}^-, \text{Ag}^+) M(\text{Cl}^-) \\
 &\quad m(\text{sample})^{-1} \times 100 \% \\
 &= \frac{0.2010 \text{ mol AgNO}_3}{\text{L}} \left(\frac{70.90 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Ag}^+}{\text{mol AgNO}_3} \right) \left(\frac{\text{mol AgCl}}{\text{mol Ag}^+} \right) \left(\frac{\text{mol Cl}^-}{\text{mol AgCl}} \right) \\
 &\quad \left(\frac{35.45 \text{ g}}{\text{mol Cl}^-} \right) \left(\frac{1}{4.106 \text{ g}} \right) \times 100 \% \\
 &= 12.3038 \% = 12.30 \%
 \end{aligned}$$

sec04-q0010-01.tex

Keyword:stoichiometry; molarity; percent composition by mass

13. A mixture of BaCl₂ and NaCl is analyzed by precipitating all of the barium as BaSO₄. After the addition of excess Na₂SO₄ to a 3.988 g sample of the mixture, the mass of precipitate collected is 2.113 g. What is the mass percentage of barium chloride in the mixture?

A: 47.27 %

$$\begin{aligned}
 w(\text{BaCl}_2)\% &= w(\text{BaCl}_2) \times 100 \% \\
 &= m(\text{BaCl}_2) m(\text{sample})^{-1} \times 100 \% \\
 &= n(\text{BaCl}_2) M(\text{BaCl}_2) m(\text{sample})^{-1} \times 100 \% \\
 &= n(\text{BaSO}_4) r(\text{BaCl}_2, \text{BaSO}_4) M(\text{BaCl}_2) m(\text{sample})^{-1} \times 100 \% \\
 &= m(\text{BaSO}_4) M(\text{BaSO}_4)^{-1} r(\text{BaCl}_2, \text{BaSO}_4) M(\text{BaCl}_2) m(\text{sample})^{-1} \times 100 \% \\
 &= 2.113 \text{ g BaSO}_4 \left(\frac{\text{mol BaSO}_4}{233.39 \text{ g}} \right) \left(\frac{\text{mol BaCl}_2}{\text{mol BaSO}_4} \right) \left(\frac{208.23 \text{ g}}{\text{mol BaCl}_2} \right) \left(\frac{1}{3.988 \text{ g}} \right) \times 100 \% \\
 &= 47.2721 \% = 47.27 \%
 \end{aligned}$$

sec04-q0011-01.tex

Keyword:stoichiometry; molarity; percent composition by mass

14. A 3.00 g sample of an alloy containing only Pb and Sn was dissolved in nitric acid. Sulfuric acid was added to this solution, which precipitated 1.90 g of PbSO_4 . Assuming that all of the lead was precipitated, what is the percentage of Sn in the sample? ($M(\text{PbSO}_4) = 303.26 \text{ g mol}^{-1}$)

A: 56.7 %



$$\begin{aligned} w(\text{Sn})\% &= w(\text{Sn}) \times 100 \% \\ &= m(\text{Sn}) m(\text{sample})^{-1} \times 100 \% \\ &= \left\{ m(\text{sample}) - m(\text{Pb}^{2+}) \right\} m(\text{sample})^{-1} \times 100 \% \\ &= \left\{ m(\text{sample}) - \left[n(\text{Pb}^{2+}) M(\text{Pb}^{2+}) \right] \right\} m(\text{sample})^{-1} \times 100 \% \\ &= \left\{ m(\text{sample}) - \left[n(\text{PbSO}_4) r(\text{Pb}^{2+}, \text{PbSO}_4) M(\text{Pb}^{2+}) \right] \right\} m(\text{sample})^{-1} \times 100 \% \\ &= \left\{ m(\text{sample}) - \left[m(\text{PbSO}_4) M(\text{PbSO}_4)^{-1} r(\text{Pb}^{2+}, \text{PbSO}_4) M(\text{Pb}^{2+}) \right] \right\} \\ &\quad m(\text{sample})^{-1} \times 100 \% \\ &= \left\{ 3.00 \text{ g sample} - \left[1.90 \text{ g PbSO}_4 \left(\frac{\text{mol PbSO}_4}{303.26 \text{ g}} \right) \left(\frac{\text{mol Pb}^{2+}}{\text{mol PbSO}_4} \right) \left(\frac{207.2 \text{ g}}{\text{mol Pb}^{2+}} \right) \right] \right\} \\ &\quad \left(\frac{1}{3.00 \text{ g sample}} \right) \times 100 \% \\ &= 56.728 \% = 56.7 \% \end{aligned}$$

sec04-q0012-01.tex

Keyword:stoichiometry; molarity; percent composition by mass

15. You have 76.0 mL of a 2.50 M aqueous solution of Na_2CrO_4 and 125 mL of a 2.16 M aqueous solution of AgNO_3 . Calculate the molar concentration (in mol L^{-1}) of CrO_4^{2-} after the two solutions are mixed together.

A: 0.274 M



Find the limiting reactant

$$\begin{aligned} n(\text{Ag}_2\text{CrO}_4) &= n(\text{Na}_2\text{CrO}_4) r(\text{Ag}_2\text{CrO}_4, \text{Na}_2\text{CrO}_4) \\ &= c(\text{Na}_2\text{CrO}_4) V(\text{Na}_2\text{CrO}_4) r(\text{Ag}_2\text{CrO}_4, \text{Na}_2\text{CrO}_4) \\ &= \frac{2.50 \text{ mol Na}_2\text{CrO}_4}{\text{L}} \left(\frac{76.0 \text{ mL Na}_2\text{CrO}_4}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Ag}_2\text{CrO}_4}{\text{mol Na}_2\text{CrO}_4} \right) \\ &= 0.19000 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Ag}_2\text{CrO}_4) &= n(\text{AgNO}_3) r(\text{Ag}_2\text{CrO}_4, \text{AgNO}_3) \\ &= c(\text{AgNO}_3) V(\text{AgNO}_3) r(\text{Ag}_2\text{CrO}_4, \text{AgNO}_3) \\ &= \frac{2.16 \text{ mol AgNO}_3}{\text{L}} \left(\frac{125 \text{ mL AgNO}_3}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Ag}_2\text{CrO}_4}{2 \text{ mol AgNO}_3} \right) \\ &= 0.13500 \text{ mol} \end{aligned}$$

AgNO_3 is limiting

$$\begin{aligned} c(\text{CrO}_4^{2-}) &= n(\text{CrO}_4^{2-}) V(\text{solution})^{-1} \\ &= n(\text{Na}_2\text{CrO}_4)_{\text{leftover}} r(\text{CrO}_4^{2-}, \text{Na}_2\text{CrO}_4) V(\text{solution})^{-1} \\ &= \left\{ n(\text{Na}_2\text{CrO}_4)_{\text{initial}} - n(\text{Na}_2\text{CrO}_4)_{\text{reacted}} \right\} r(\text{CrO}_4^{2-}, \text{Na}_2\text{CrO}_4) V(\text{solution})^{-1} \\ &= \left\{ \left[V(\text{Na}_2\text{CrO}_4) c(\text{Na}_2\text{CrO}_4) \right] - \left[n(\text{Ag}_2\text{CrO}_4)_{\text{formed}} r(\text{Na}_2\text{CrO}_4, \text{Ag}_2\text{CrO}_4) \right] \right\} \\ &\quad r(\text{CrO}_4^{2-}, \text{AgNO}_3) V(\text{solution})^{-1} \\ &= \left\{ \left[76.0 \text{ mL Na}_2\text{CrO}_4 \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{2.50 \text{ mol Na}_2\text{CrO}_4}{\text{L}} \right) \right] - \right. \\ &\quad \left. \left[0.13500 \text{ mol Ag}_2\text{CrO}_4 \left(\frac{\text{mol Na}_2\text{CrO}_4}{\text{mol Ag}_2\text{CrO}_4} \right) \right] \right\} \\ &\quad \left(\frac{\text{mol CrO}_4^{2-}}{\text{mol Na}_2\text{CrO}_4} \right) \left(\frac{1}{(76.0 + 125) \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.27363 \text{ mol L}^{-1} \\ &= 0.274 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0015-01.tex

Keyword:balancing equations; stoichiometry; molarity; solubility rules; limiting reactant

16. You have a 75.0 mL 2.50 M aqueous Na_2CrO_4 solution and 125 mL 2.29 M aqueous AgNO_3 solution. What is the molar concentration (in mol L^{-1}) of Ag^+ after the two solutions are mixed together?

A: 0 M



Find the limiting reactant

$$\begin{aligned} n(\text{Ag}_2\text{CrO}_4) &= n(\text{Na}_2\text{CrO}_4) r(\text{Ag}_2\text{CrO}_4, \text{Na}_2\text{CrO}_4) \\ &= V(\text{Na}_2\text{CrO}_4) c(\text{Na}_2\text{CrO}_4) r(\text{Ag}_2\text{CrO}_4, \text{Na}_2\text{CrO}_4) \\ &= 75.0 \text{ mL Na}_2\text{CrO}_4 \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{2.50 \text{ mol Na}_2\text{CrO}_4}{\text{L}} \right) \left(\frac{\text{mol Ag}_2\text{CrO}_4}{\text{mol Na}_2\text{CrO}_4} \right) \\ &= 0.18750 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Ag}_2\text{CrO}_4) &= n(\text{AgNO}_3) r(\text{Ag}_2\text{CrO}_4, \text{AgNO}_3) \\ &= V(\text{AgNO}_3) c(\text{AgNO}_3) r(\text{Ag}_2\text{CrO}_4, \text{AgNO}_3) \\ &= 125 \text{ mL AgNO}_3 \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{2.29 \text{ mol AgNO}_3}{\text{L}} \right) \left(\frac{\text{mol Ag}_2\text{CrO}_4}{2 \text{ mol AgNO}_3} \right) \\ &= 0.14312 \text{ mol} \end{aligned}$$

AgNO_3 is limiting; therefore, all Ag^+ is converted to $\text{Ag}_2\text{CrO}_4(\text{s})$.

$$c(\text{Ag}^+) = 0 \text{ mol L}^{-1}$$

sec04-q0016-01.tex

Keyword:balancing equations; stoichiometry; molarity; solubility rules; limiting reactant

17. You have 75.0 mL of a 2.50 M aqueous solution of Na_2CrO_4 and 125 mL of a 2.24 M aqueous solution of AgNO_3 . Calculate the molar concentration (in mol L^{-1}) of NO_3^- after the two solutions are mixed together.

A: 1.40 M



Find the limiting reactant

$$\begin{aligned} n(\text{Ag}_2\text{CrO}_4) &= n(\text{Na}_2\text{CrO}_4) r(\text{Ag}_2\text{CrO}_4, \text{Na}_2\text{CrO}_4) \\ &= V(\text{Na}_2\text{CrO}_4) c(\text{Na}_2\text{CrO}_4) r(\text{Ag}_2\text{CrO}_4, \text{Na}_2\text{CrO}_4) \\ &= 75.0 \text{ mL Na}_2\text{CrO}_4 \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{2.50 \text{ mol Na}_2\text{CrO}_4}{\text{L}} \right) \left(\frac{\text{mol Ag}_2\text{CrO}_4}{\text{mol Na}_2\text{CrO}_4} \right) \\ &= 0.18750 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Ag}_2\text{CrO}_4) &= n(\text{AgNO}_3) r(\text{Ag}_2\text{CrO}_4, \text{AgNO}_3) \\ &= V(\text{AgNO}_3) c(\text{AgNO}_3) r(\text{Ag}_2\text{CrO}_4, \text{AgNO}_3) \\ &= 125 \text{ mL AgNO}_3 \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{2.24 \text{ mol AgNO}_3}{\text{L}} \right) \left(\frac{\text{mol Ag}_2\text{CrO}_4}{2 \text{ mol AgNO}_3} \right) \\ &= 0.14000 \text{ mol} \end{aligned}$$

AgNO_3 is limiting.

$$\begin{aligned} c(\text{NO}_3^-) &= n(\text{NO}_3^-) V(\text{solution})^{-1} \\ &= n(\text{AgNO}_3) r(\text{NO}_3^-, \text{AgNO}_3) V(\text{solution})^{-1} \\ &= n(\text{Ag}_2\text{CrO}_4) r(\text{AgNO}_3, \text{Ag}_2\text{CrO}_4) r(\text{NO}_3^-, \text{AgNO}_3) V(\text{solution})^{-1} \\ &= 0.14000 \text{ mol} \left(\frac{2 \text{ mol AgNO}_3}{\text{mol Ag}_2\text{CrO}_4} \right) \left(\frac{\text{mol NO}_3^-}{\text{mol AgNO}_3} \right) \left(\frac{1}{(75.0 + 125) \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 1.4000 \text{ mol L}^{-1} = 1.40 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0017-01.tex

Keyword:balancing equations; stoichiometry; molarity; solubility rules; limiting reactant

18. Combine a 55 mL 1.00 M aqueous silver nitrate solution with a 25 mL 0.55 M silver chloride solution. What mass (in g) of silver chloride is produced?

A: 2.0 g



Find the limiting reactant

$$\begin{aligned}n(\text{AgCl}) &= n(\text{AgNO}_3) r(\text{AgCl}, \text{AgNO}_3) \\&= V(\text{AgNO}_3) c(\text{AgNO}_3) r(\text{AgCl}, \text{AgNO}_3) \\&= 55 \text{ mL AgNO}_3 \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{1.00 \text{ mol AgNO}_3}{\text{L}} \right) \left(\frac{\text{mol AgCl}}{\text{mol AgNO}_3} \right) \\&= 0.05500 \text{ mol}\end{aligned}$$

$$\begin{aligned}n(\text{AgCl}) &= n(\text{NaCl}) r(\text{AgCl}, \text{NaCl}) \\&= V(\text{NaCl}) c(\text{NaCl}) r(\text{AgCl}, \text{NaCl}) \\&= 25 \text{ mL NaCl} \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{0.55 \text{ mol NaCl}}{\text{L}} \right) \left(\frac{\text{mol AgCl}}{\text{mol NaCl}} \right) \\&= 0.01375 \text{ mol}\end{aligned}$$

NaCl is limiting

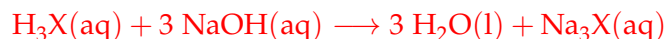
$$\begin{aligned}m(\text{AgCl}) &= n(\text{AgCl}) M(\text{AgCl})^{-1} \\&= 0.01375 \text{ mol} \left(\frac{143.32 \text{ g}}{\text{mol AgCl}} \right) \\&= 1.970 \text{ g} = 2.0 \text{ g}\end{aligned}$$

sec04-q0018-01.tex

Keyword:balancing equations; stoichiometry; molarity; solubility rules; precipitation; limiting reactant

19. A 0.307 g sample of an unknown triprotic acid is completely neutralized using a 35.2 mL 0.106 M aqueous NaOH solution. What is the molar mass (in g mol^{-1}) of the acid?

A: 247 g mol^{-1}



$$\begin{aligned} M(\text{H}_3\text{X}) &= m(\text{H}_3\text{X}) n(\text{H}_3\text{X})^{-1} \\ &= m(\text{H}_3\text{X}) \left[n(\text{NaOH}) r(\text{H}_3\text{X}, \text{NaOH}) \right]^{-1} \\ &= m(\text{H}_3\text{X}) \left[c(\text{NaOH}) V(\text{solution}) r(\text{H}_3\text{X}, \text{NaOH}) \right]^{-1} \\ &= 0.307 \text{ g H}_3\text{X} \left[\left(\frac{0.106 \text{ mol NaOH}}{\text{L}} \right) \left(\frac{35.2 \text{ mL}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol H}_3\text{X}}{3 \text{ mol NaOH}} \right) \right]^{-1} \\ &= 246.83 \text{ g mol}^{-1} = 247 \text{ g mol}^{-1} \end{aligned}$$

sec04-q0019-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

20. A 0.685 g sample of an unknown diprotic acid requires a 42.57 mL 0.111 M aqueous NaOH solution to be completely neutralized. What is the molar mass (in g mol^{-1}) of the acid?

A: 290. g mol^{-1}



$$\begin{aligned} M(\text{H}_2\text{X}) &= m(\text{H}_2\text{X}) n(\text{H}_2\text{X})^{-1} \\ &= m(\text{H}_2\text{X}) \left[n(\text{NaOH}) r(\text{H}_2\text{X}, \text{NaOH}) \right]^{-1} \\ &= m(\text{H}_2\text{X}) \left[c(\text{NaOH}) V(\text{solution}) r(\text{H}_2\text{X}, \text{NaOH}) \right]^{-1} \\ &= 0.685 \text{ g H}_2\text{X} \left[\left(\frac{0.111 \text{ mol NaOH}}{\text{L}} \right) \left(\frac{42.57 \text{ mL}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol H}_2\text{X}}{2 \text{ mol NaOH}} \right) \right]^{-1} \\ &= 289.93 \text{ g mol}^{-1} = 290. \text{ g mol}^{-1} \end{aligned}$$

sec04-q0020-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

21. What mass (in g) of NaOH is required to completely react with a 25.0 mL 2.2 M aqueous H₂SO₄ solution?

A: 4.4 g



$$\begin{aligned} m(\text{NaOH}) &= n(\text{NaOH}) M(\text{NaOH}) \\ &= n(\text{H}_2\text{SO}_4) r(\text{NaOH}, \text{H}_2\text{SO}_4) M(\text{NaOH}) \\ &= c(\text{H}_2\text{SO}_4) V(\text{H}_2\text{SO}_4) r(\text{NaOH}, \text{H}_2\text{SO}_4) M(\text{NaOH}) \\ &= \frac{2.2 \text{ mol H}_2\text{SO}_4}{\text{L}} \left(\frac{25.0 \text{ mL H}_2\text{SO}_4}{10^3 \text{ mL}} \right) \left(\frac{2 \text{ mol NaOH}}{\text{mol H}_2\text{SO}_4} \right) \left(\frac{40.00 \text{ g}}{\text{mol NaOH}} \right) \\ &= 4.400 \text{ g} = 4.4 \text{ g} \end{aligned}$$

sec04-q0021-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

22. What volume (in mL) of a 5.00 M hydrofluoric acid solution will completely react with 4.05 g of calcium hydroxide?

A: 21.9 mL



$$\begin{aligned} V(\text{HF}) &= n(\text{HF}) c(\text{HF})^{-1} \\ &= n(\text{Ca}(\text{OH})_2) r(\text{HF}, \text{Ca}(\text{OH})_2) c(\text{HF})^{-1} \\ &= m(\text{Ca}(\text{OH})_2) M(\text{Ca}(\text{OH})_2)^{-1} r(\text{HF}, \text{Ca}(\text{OH})_2) c(\text{HF})^{-1} \\ &= 4.05 \text{ g Ca}(\text{OH})_2 \left(\frac{\text{mol Ca}(\text{OH})_2}{74.10 \text{ g}} \right) \left(\frac{2 \text{ mol HF}}{\text{mol Ca}(\text{OH})_2} \right) \left(\frac{\text{L}}{5.00 \text{ mol HF}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 21.862 \text{ mL} = 21.9 \text{ mL} \end{aligned}$$

sec04-q0022-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

23. Sulfamic acid (HSO_3NH_2) is a strong monoprotic acid that can be used to standardize a strong base. A 0.179 g sample of HSO_3NH_2 is required to completely neutralize a 19.4 mL aqueous KOH solution. What is the molar concentration (in mol L^{-1}) of the KOH solution?

A: 0.0950 M



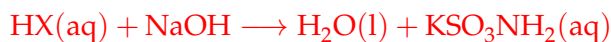
$$\begin{aligned} c(\text{KOH}) &= n(\text{KOH}) V(\text{KOH})^{-1} \\ &= n(\text{HSO}_3\text{NH}_2) r(\text{KOH}, \text{HSO}_3\text{NH}_2) V(\text{KOH})^{-1} \\ &= m(\text{HSO}_3\text{NH}_2) M(\text{HSO}_3\text{NH}_2)^{-1} r(\text{KOH}, \text{HSO}_3\text{NH}_2) V(\text{KOH})^{-1} \\ &= 0.179 \text{ g HSO}_3\text{NH}_2 \left(\frac{\text{mol HSO}_3\text{NH}_2}{97.10 \text{ g}} \right) \left(\frac{\text{mol KOH}}{\text{mol HSO}_3\text{NH}_2} \right) \left(\frac{1}{19.4 \text{ mL KOH}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.095023 \text{ mol L}^{-1} = 0.0950 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0023-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

24. A student weighs out 0.556 g of KHP ($M(\text{KHP}) = 204.22 \text{ g mol}^{-1}$) and puts it into 36.78 mL of a stock NaOH solution. If that was enough to neutralize the NaOH, what is the concentration of the stock NaOH solution? KHP is a monoprotic acid.

A: 0.0740 M



$$\begin{aligned} c(\text{NaOH}) &= n(\text{NaOH}) V(\text{NaOH})^{-1} \\ &= n(\text{HX}) r(\text{NaOH}, \text{HX}) V(\text{NaOH})^{-1} \\ &= m(\text{HX}) M(\text{HX})^{-1} r(\text{NaOH}, \text{HX}) V(\text{NaOH})^{-1} \\ &= 0.556 \text{ g HX} \left(\frac{\text{mol HX}}{204.22 \text{ g}} \right) \left(\frac{\text{mol NaOH}}{\text{mol HX}} \right) \left(\frac{1}{36.78 \text{ mL NaOH}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.074022 \text{ mol L}^{-1} = 0.0740 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0024-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

25. A 2.80 g sample of phosphoric acid is added to a 150.0 mL 1.00 M sodium hydroxide solution to give a 151.489 mL mixture and the acid is completely neutralized. Determine the following:

- A. $[\text{Na}^+]$ (in mol L^{-1})
 B. $[\text{PO}_4^{3-}]$ (in mol L^{-1})
 C. $[\text{OH}^-]$ (in mol L^{-1})

A: 1.00 M; 0.189 M; 0.424 M



Determine the limiting reagent.

$$\begin{aligned} n(\text{Na}_3\text{PO}_4) &= n(\text{H}_3\text{PO}_4) r(\text{Na}_3\text{PO}_4, \text{H}_3\text{PO}_4) \\ &= m(\text{H}_3\text{PO}_4) M(\text{H}_3\text{PO}_4)^{-1} r(\text{Na}_3\text{PO}_4) \\ &= 2.80 \text{ g H}_3\text{PO}_4 \left(\frac{\text{mol H}_3\text{PO}_4}{98.00 \text{ g}} \right) \left(\frac{\text{mol Na}_3\text{PO}_4}{\text{mol H}_3\text{PO}_4} \right) \\ &= 0.028571 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Na}_3\text{PO}_4) &= n(\text{NaOH}) r(\text{Na}_3\text{PO}_4, \text{NaOH}) \\ &= c(\text{NaOH}) V(\text{NaOH}) r(\text{Na}_3\text{PO}_4, \text{NaOH}) \\ &= \frac{1.00 \text{ mol NaOH}}{\text{L}} \left(\frac{150.0 \text{ mL NaOH}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Na}_3\text{PO}_4}{3 \text{ mol NaOH}} \right) \\ &= 0.050000 \text{ mol} \end{aligned}$$

H_3PO_4 is limiting.

A. Since NaOH and Na_3PO_3 are strong electrolytes, the Na^+ concentration is equal to the initial NaOH(aq) concentration. $[\text{Na}^+] = 1.00 \text{ mol L}^{-1}$

B.

$$\begin{aligned} c(\text{PO}_4^{3-}) &= n(\text{PO}_4^{3-}) V(\text{solution})^{-1} \\ &= n(\text{Na}_3\text{PO}_4) r(\text{PO}_4^{3-}, \text{Na}_3\text{PO}_4) V(\text{solution})^{-1} \\ &= 0.028571 \text{ mol Na}_3\text{PO}_4 \left(\frac{\text{mol PO}_4^{3-}}{\text{mol Na}_3\text{PO}_4} \right) \left(\frac{1}{151.489 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.18860 \text{ mol L}^{-1} = 0.189 \text{ mol L}^{-1} \end{aligned}$$

C.

$$\begin{aligned} c(\text{OH}^-) &= n(\text{OH}^-) V(\text{solution})^{-1} \\ &= \left\{ n(\text{NaOH})_{\text{initial}} - n(\text{NaOH})_{\text{consumed}} \right\} r(\text{OH}^-, \text{NaOH}) V(\text{solution})^{-1} \\ &= \left\{ \left[c(\text{NaOH}) V(\text{NaOH}) \right] - \left[n(\text{Na}_3\text{PO}_4) r(\text{NaOH}, \text{Na}_3\text{PO}_4) \right] \right\} r(\text{OH}^-, \text{NaOH}) V(\text{solution})^{-1} \\ &= \left\{ \left[\frac{1.00 \text{ mol NaOH}}{\text{L}} \left(\frac{150.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \right] - \left[0.028571 \text{ mol Na}_3\text{PO}_4 \left(\frac{3 \text{ mol NaOH}}{\text{Na}_3\text{PO}_4} \right) \right] \right\} \\ &\quad \left(\frac{\text{mol OH}^-}{\text{mol NaOH}} \right) \left(\frac{1}{151.489 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.42436 \text{ mol L}^{-1} = 0.424 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0025-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction; limiting reactant

26. A stock solution with a total volume of 1000.0 mL contains 37.1 g $\text{Mg}(\text{NO}_3)_2$. If you take a 20.0 mL aliquot and then dilute it with water to a total volume of 500.0 mL, what is the molar concentration (in mol L^{-1}) of Mg^{2+} and NO_3^{2-} in the final solution?

A: 0.0100 M; 0.0200 M

$$\begin{aligned}
 c(\text{Mg}^{2+}) &= n(\text{Mg}^{2+})_{\text{dilute aliquot}} V(\text{dilute aliquot})^{-1} \\
 &= n(\text{Mg}^{2+})_{\text{stock solution}} V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= m(\text{Mg}(\text{NO}_3)_2) M(\text{Mg}(\text{NO}_3)_2)^{-1} r(\text{Mg}^{2+}, \text{Mg}(\text{NO}_3)_2) \\
 &\quad V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= 37.1 \text{ g Mg}(\text{NO}_3)_2 \left(\frac{\text{mol Mg}(\text{NO}_3)_2}{148.33 \text{ g}} \right) \left(\frac{\text{mol Mg}^{2+}}{\text{mol Mg}(\text{NO}_3)_2} \right) \\
 &\quad \left(\frac{1}{1000.0 \text{ mL}} \right) \left(\frac{20.0 \text{ mL}}{\phantom{1000.0 \text{ mL}}} \right) \left(\frac{1}{500.0 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\
 &= 0.010004 \text{ mol L}^{-1} = 0.0100 \text{ mol L}^{-1}
 \end{aligned}$$

$$\begin{aligned}
 c(\text{NO}_3^{2-}) &= n(\text{NO}_3^{2-})_{\text{dilute aliquot}} V(\text{stock solution})^{-1} \\
 &= n(\text{NO}_3^{2-})_{\text{stock solution}} V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= m(\text{Mg}(\text{NO}_3)_2) M(\text{Mg}(\text{NO}_3)_2)^{-1} r(\text{NO}_3^{2-}, \text{Mg}(\text{NO}_3)_2) \\
 &\quad V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= 37.1 \text{ g Mg}(\text{NO}_3)_2 \left(\frac{\text{mol Mg}(\text{NO}_3)_2}{148.33 \text{ g}} \right) \left(\frac{2 \text{ mol NO}_3^{2-}}{\text{mol Mg}(\text{NO}_3)_2} \right) \\
 &\quad \left(\frac{1}{1000.0 \text{ mL}} \right) \left(\frac{20.0 \text{ mL}}{\phantom{1000.0 \text{ mL}}} \right) \left(\frac{1}{500.0 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\
 &= 0.020009 \text{ mol L}^{-1} = 0.0200 \text{ mol L}^{-1}
 \end{aligned}$$

Alternatively,

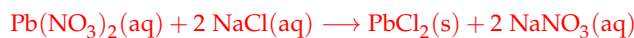
$$\begin{aligned}
 c(\text{NO}_3^{2-}) &= c(\text{Mg}^{2+})_{\text{dilute aliquot}} r(\text{NO}_3^{2-}, \text{Mg}^{2+}) \\
 &= \frac{0.010004 \text{ mol}}{\text{L}} \left(\frac{2 \text{ mol NO}_3^{2-}}{\text{mol Mg}(\text{NO}_3)_2} \right) \\
 &= 0.020008 \text{ mol L}^{-1} = 0.0200 \text{ mol L}^{-1}
 \end{aligned}$$

sec04-q0026-01.tex

Keyword:stoichiometry; molarity; dilution

27. Determine the molar concentrations (in g mol^{-1}) the ions present in a solution created from mixing equal volumes of 1.0 M aqueous lead(II) nitrate and 1.0 M aqueous sodium chloride solutions? Assume that the volumes are precise to one decimal place in normalized scientific notation.

$$\text{A: Pb}^{2+}: 0.25 \text{ M}; \text{NO}_3^{2-}: 1.0 \text{ M}; \text{Na}^+: 0.50 \text{ M}; \text{Cl}^-: 0 \text{ M}$$



This solution considers the mixing of two 1.0×10^0 L solutions to give a 2.0 L final solution. Determine the limiting reactant.

$$\begin{aligned} n(\text{PbCl}_2) &= c(\text{Pb}(\text{NO}_3)_2) V(\text{Pb}(\text{NO}_3)_2)_{\text{initial}} r(\text{PbCl}_2, \text{Pb}(\text{NO}_3)_2) \\ &= \frac{1.0 \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{\text{mol PbCl}_2}{\text{mol Pb}(\text{NO}_3)_2} \right) \\ &= 1.0 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{PbCl}_2) &= c(\text{NaCl}) V(\text{NaCl})_{\text{initial}} r(\text{PbCl}_2, \text{NaCl}) \\ &= \frac{1.0 \text{ mol NaCl}}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{\text{mol PbCl}_2}{2 \text{ mol NaCl}} \right) \\ &= 0.5 \text{ mol} \end{aligned}$$

NaCl is the limiting reactant.

$$\begin{aligned} c(\text{Pb}^{2+}) &= n(\text{Pb}^{2+}) V(\text{solution})^{-1} \\ &= \left\{ n(\text{Pb}^{2+})_{\text{initial}} - n(\text{Pb}^{2+})_{\text{reacted}} \right\} r(\text{Pb}^{2+}, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \left\{ \left[c(\text{Pb}(\text{NO}_3)_2) V(\text{Pb}(\text{NO}_3)_2) \right] - \left[n(\text{PbCl}_2) r(\text{Pb}(\text{NO}_3)_2, \text{PbCl}_2) \right] \right\} r(\text{Pb}^{2+}, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \left\{ \left[\left(\frac{1.0 \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \right) \left(\frac{1.0 \text{ L Pb}(\text{NO}_3)_2}{\text{L}} \right) \right] - \left[0.5 \text{ mol PbCl}_2 \left(\frac{\text{mol Pb}(\text{NO}_3)_2}{\text{mol PbCl}_2} \right) \right] \right\} \left(\frac{\text{mol Pb}^{2+}}{\text{PbCl}_2} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 0.25 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{NO}_3^{2-}) &= n(\text{NO}_3^{2-}) V(\text{solution})^{-1} \\ &= c(\text{Pb}(\text{NO}_3)_2) V(\text{Pb}(\text{NO}_3)_2)_{\text{initial}} r(\text{NO}_3^{2-}, \text{Pb}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \frac{1.0 \text{ mol Pb}(\text{NO}_3)_2}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{2 \text{ mol NO}_3^{2-}}{\text{mol Pb}(\text{NO}_3)_2} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 1.0 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{Na}^+) &= n(\text{Na}^+) V(\text{solution})^{-1} \\ &= c(\text{NaCl}) V(\text{NaCl})_{\text{initial}} r(\text{Na}^+, \text{NaCl}) V(\text{solution})^{-1} \\ &= \frac{1.0 \text{ mol NaCl}}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{\text{mol Na}^+}{\text{mol NaCl}} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 0.5 \text{ mol L}^{-1} \end{aligned}$$

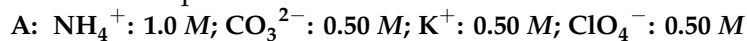
Because NaCl is the limiting reactant, all Cl^- ions are precipitated in PbCl_2 .

$$c(\text{Cl}^-) = 0.0 \text{ mol L}^{-1}$$

sec04-q0027-01.tex

Keyword:stoichiometry; molarity; dilution; limiting reactant

28. Determine the molar concentrations (in g mol^{-1}) the ions present in a solution created from mixing equal volumes of 1.0 M aqueous ammonium carbonate and 1.0 M aqueous potassium perchlorate. Assume that the volumes are precise to one decimal place in normalized scientific notation.



This solution considers the mixing of two 1.0 L solutions to give a 2.0 L final solution.

$$\begin{aligned} c(\text{NH}_4^+) &= n(\text{NH}_4^+) V(\text{solution})^{-1} \\ &= n((\text{NH}_4)_2\text{CO}_3) r(\text{NH}_4^+, (\text{NH}_4)_2\text{CO}_3) V(\text{solution})^{-1} \\ &= c((\text{NH}_4)_2\text{CO}_3) V((\text{NH}_4)_2\text{CO}_3) r(\text{NH}_4^+, (\text{NH}_4)_2\text{CO}_3) V(\text{solution})^{-1} \\ &= \frac{1.0 \text{ mol } (\text{NH}_4)_2\text{CO}_3}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{2 \text{ mol } \text{NH}_4^+}{\text{mol } (\text{NH}_4)_2\text{CO}_3} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 1.0 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{CO}_3^{2-}) &= n(\text{CO}_3^{2-}) V(\text{solution})^{-1} \\ &= n((\text{NH}_4)_2\text{CO}_3) r(\text{CO}_3^{2-}, (\text{NH}_4)_2\text{CO}_3) V(\text{solution})^{-1} \\ &= c((\text{NH}_4)_2\text{CO}_3) V((\text{NH}_4)_2\text{CO}_3) r(\text{CO}_3^{2-}, (\text{NH}_4)_2\text{CO}_3) V(\text{solution})^{-1} \\ &= \frac{1.0 \text{ mol } (\text{NH}_4)_2\text{CO}_3}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{\text{mol } \text{CO}_3^{2-}}{\text{mol } (\text{NH}_4)_2\text{CO}_3} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 0.50 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{K}^+) &= n(\text{K}^+) V(\text{solution})^{-1} \\ &= n(\text{KClO}_4) r(\text{K}^+, \text{KClO}_4) V(\text{solution})^{-1} \\ &= c(\text{KClO}_4) V(\text{KClO}_4) r(\text{K}^+, \text{KClO}_4) V(\text{solution})^{-1} \\ &= \frac{1.0 \text{ mol } \text{KClO}_4}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{\text{mol } \text{K}^+}{\text{mol } \text{KClO}_4} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 0.50 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{ClO}_4^-) &= n(\text{ClO}_4^-) V(\text{solution})^{-1} \\ &= n(\text{KClO}_4) r(\text{ClO}_4^-, \text{KClO}_4) V(\text{solution})^{-1} \\ &= c(\text{KClO}_4) V(\text{KClO}_4) r(\text{ClO}_4^-, \text{KClO}_4) V(\text{solution})^{-1} \\ &= \frac{1.0 \text{ mol } \text{KClO}_4}{\text{L}} \left(\frac{1.0 \text{ L}}{\text{L}} \right) \left(\frac{\text{mol } \text{ClO}_4^-}{\text{mol } \text{KClO}_4} \right) \left(\frac{1}{2.0 \text{ L}} \right) \\ &= 0.50 \text{ mol L}^{-1} \end{aligned}$$

29. Determine the molar concentration (in g mol^{-1}) of the salt produced by a reaction between a 200. mL 0.100 M aqueous HCl solution with a 100. mL 0.50 M aqueous KOH solution.

A: 0.0667 M



Determine the limiting reactant.

$$\begin{aligned} n(\text{KCl}) &= n(\text{HCl}) r(\text{KCl, HCl}) \\ &= c(\text{HCl}) V(\text{initial}) r(\text{KCl, HCl}) \\ &= \frac{0.100 \text{ mol HCl}}{\text{L}} \left(\frac{200. \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol KCl}}{\text{mol HCl}} \right) \\ &= 0.0200 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{KCl}) &= n(\text{KOH}) r(\text{KCl, KOH}) \\ &= c(\text{KOH}) V(\text{initial}) r(\text{KCl, KOH}) \\ &= \frac{0.50 \text{ mol KOH}}{\text{L}} \left(\frac{100. \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol KCl}}{\text{mol KOH}} \right) \\ &= 0.0500 \text{ mol} \end{aligned}$$

KCl is the limiting reactant.

$$\begin{aligned} c(\text{KCl}) &= n(\text{KCl}) V(\text{final})^{-1} \\ &= 0.0200 \text{ mol KCl} \left(\frac{1}{(200. + 100.) \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.0667 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0029-01.tex

Keyword:stoichiometry; molarity; acid-base reaction; limiting reactant

30. What volume (in mL) of a 0.100 M aqueous HNO₃ solution is required to neutralize a 50.0 mL 0.150 M aqueous Ba(OH)₂ solution?

A: 150. mL

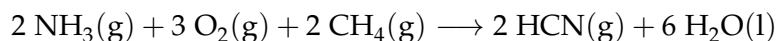


$$\begin{aligned} V(\text{HNO}_3) &= n(\text{HNO}_3) c(\text{HNO}_3)^{-1} \\ &= n(\text{Ba}(\text{OH})_2) r(\text{HNO}_3, \text{Ba}(\text{OH})_2) c(\text{HNO}_3)^{-1} \\ &= V(\text{Ba}(\text{OH})_2) c(\text{Ba}(\text{OH})_2) r(\text{HNO}_3, \text{Ba}(\text{OH})_2) c(\text{HNO}_3)^{-1} \\ &= 50.0 \text{ mL Ba}(\text{OH})_2 \left(\frac{0.150 \text{ mol Ba}(\text{OH})_2}{\text{L}} \right) \left(\frac{2 \text{ mol HNO}_3}{\text{mol Ba}(\text{OH})_2} \right) \left(\frac{\text{L}}{0.100 \text{ mol}} \right) \\ &= 150. \text{ mL} \end{aligned}$$

sec04-q0030-01.tex

Keyword:stoichiometry; molarity; acid-base reaction

31. Hydrogen cyanide is produced industrially from a reaction between gaseous ammonia, oxygen, and methane.



If 5.00×10^3 kg of each reactant react, what mass (in kg) of each product would be produced (assuming a 100 % yield)?

A: HCN: 2.82×10^3 kg; H₂O: 5.63×10^3 kg

Find the limiting reactant.

$$\begin{aligned} n(\text{HCN}) &= n(\text{NH}_3) r(\text{HCN}, \text{NH}_3) \\ &= m(\text{NH}_3) M(\text{NH}_3)^{-1} r(\text{HCN}, \text{NH}_3) \\ &= 5.00 \times 10^3 \text{ kg NH}_3 \left(\frac{10^3 \text{ g}}{\text{kg}} \right) \left(\frac{\text{mol NH}_3}{17.04 \text{ g}} \right) \left(\frac{2 \text{ mol HCN}}{2 \text{ mol NH}_3} \right) \\ &= 2.9342 \times 10^5 \text{ mol} \\ n(\text{HCN}) &= n(\text{O}_2) r(\text{HCN}, \text{O}_2) \\ &= m(\text{O}_2) M(\text{O}_2)^{-1} r(\text{HCN}, \text{O}_2) \\ &= 5.00 \times 10^3 \text{ kg O}_2 \left(\frac{10^3 \text{ g}}{\text{kg}} \right) \left(\frac{\text{mol O}_2}{32.00 \text{ g}} \right) \left(\frac{2 \text{ mol HCN}}{3 \text{ mol O}_2} \right) \\ &= 1.0416 \times 10^5 \text{ mol} \\ n(\text{HCN}) &= n(\text{CH}_4) r(\text{HCN}, \text{CH}_4) \\ &= m(\text{CH}_4) M(\text{CH}_4)^{-1} r(\text{HCN}, \text{CH}_4) \\ &= 5.00 \times 10^3 \text{ kg CH}_4 \left(\frac{10^3 \text{ g}}{\text{kg}} \right) \left(\frac{\text{mol CH}_4}{16.05 \text{ g}} \right) \left(\frac{2 \text{ mol HCN}}{2 \text{ mol CH}_4} \right) \\ &= 3.1152 \times 10^5 \text{ mol} \end{aligned}$$

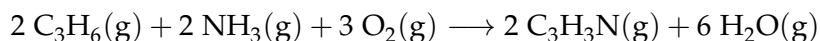
O₂ is limiting.

$$\begin{aligned} m(\text{HCN}) &= n(\text{HCN}) M(\text{HCN}) \\ &= 1.0416 \times 10^5 \text{ mol HCN} \left(\frac{27.03 \text{ g}}{\text{mol}} \right) \left(\frac{\text{kg}}{10^3 \text{ g}} \right) \\ &= 2.8154 \times 10^3 \text{ kg} = 2.82 \times 10^3 \text{ kg} \\ m(\text{H}_2\text{O}) &= n(\text{H}_2\text{O}) M(\text{H}_2\text{O}) \\ &= n(\text{HCN}) r(\text{H}_2\text{O}, \text{HCN}) M(\text{H}_2\text{O}) \\ &= 1.0416 \times 10^5 \text{ mol HCN} \left(\frac{6 \text{ mol H}_2\text{O}}{2 \text{ mol HCN}} \right) \left(\frac{18.02 \text{ g}}{\text{mol}} \right) \left(\frac{\text{kg}}{10^3 \text{ g}} \right) \\ &= 5.6308 \times 10^3 \text{ kg} = 5.63 \times 10^3 \text{ kg} \end{aligned}$$

sec04-q0031-01.tex

Keyword: stoichiometry; limiting reactant

32. Acrylonitrile (C_3H_3N) is the starting material for many synthetic carpets and fabrics and is produced by the following reaction.



If 15.0 g C_3H_6 , 5.00 g NH_3 , and 8.00 g O_2 react, what mass (in g) of acrylonitrile can be produced (assuming a 100 % yield)?

A: 11.1 g

Find the limiting reactant.

$$\begin{aligned} n(C_3H_3N) &= n(C_3H_6) r(C_3H_3N, C_3H_6) \\ &= m(C_3H_6) M(C_3H_6)^{-1} r(C_3H_3N, C_3H_6) \\ &= 15.0 \text{ g } C_3H_6 \left(\frac{\text{mol } C_3H_6}{53.07 \text{ g}} \right) \left(\frac{2 \text{ mol } C_3H_3N}{2 \text{ mol } C_3H_6} \right) \\ &= 0.28264 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(C_3H_3N) &= n(NH_3) r(C_3H_3N, NH_3) \\ &= m(NH_3) M(NH_3)^{-1} r(C_3H_3N, NH_3) \\ &= 5.00 \text{ g } NH_3 \left(\frac{\text{mol } NH_3}{17.04 \text{ g}} \right) \left(\frac{2 \text{ mol } C_3H_3N}{2 \text{ mol } NH_3} \right) \\ &= 0.29342 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(C_3H_3N) &= n(O_2) r(C_3H_3N, O_2) \\ &= m(O_2) M(O_2)^{-1} r(C_3H_3N, O_2) \\ &= 8.00 \text{ g } O_2 \left(\frac{\text{mol } O_2}{32.00 \text{ g}} \right) \left(\frac{2 \text{ mol } C_3H_3N}{3 \text{ mol } O_2} \right) \\ &= 0.16666 \text{ mol} \end{aligned}$$

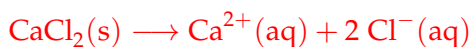
O_2 is limiting.

$$\begin{aligned} m(C_3H_3N) &= n(C_3H_3N) M(C_3H_3N) \\ &= 0.16666 \text{ mol } C_3H_3N \left(\frac{53.07 \text{ g}}{\text{mol}} \right) \\ &= 8.8446 \text{ g} = 8.84 \text{ g} \end{aligned}$$

sec04-q0032-01.tex

Keyword:stoichiometry; limiting reactant

33. Calcium chloride is a strong electrolyte and is used to “salt” streets in the winter to melt ice and snow. Write a net ionic reaction to show how this substance breaks apart when it dissolves in water.



sec04-q0033-01.tex

Keyword:net ionic equation

34. A solution of ethanol in water is prepared by dissolving 75.0 mL of ethanol ($\rho = 0.79 \text{ g cm}^{-3}$) in enough water to make a 250.0 mL solution. What is the molar concentration (in mol L^{-1}) of the ethanol in this solution?

A: 5.14 M

$$\begin{aligned} c(\text{C}_2\text{H}_6\text{O}) &= n(\text{C}_2\text{H}_6\text{O}) V(\text{solution})^{-1} \\ &= m(\text{C}_2\text{H}_6\text{O}) M(\text{C}_2\text{H}_6\text{O})^{-1} V(\text{solution})^{-1} \\ &= V(\text{C}_2\text{H}_6\text{O}) \rho(\text{C}_2\text{H}_6\text{O}) M(\text{C}_2\text{H}_6\text{O})^{-1} V(\text{solution})^{-1} \\ &= 75.0 \text{ mL} \left(\frac{\text{cm}^3}{\text{mL}} \right) \left(\frac{0.79 \text{ g}}{\text{cm}^3} \right) \left(\frac{\text{mol C}_2\text{H}_6\text{O}}{46.08 \text{ g}} \right) \left(\frac{1}{250.0 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 5.1432 \text{ mol L}^{-1} = 5.14 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0034-01.tex

Keyword:stoichiometry; molarity

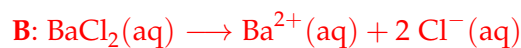
35. Which of the following aqueous solutions contains the largest number of ions?

- A. 100.0 mL of 0.100 M NaOH
- B. 50.0 mL of 0.200 M BaCl₂
- C. 75.0 mL of 0.150 M Na₃PO₄

A: C



$$\begin{aligned} n(\text{ions}) &= n(\text{NaOH}) r(\text{ions, NaOH}) \\ &= c(\text{NaOH}) V(\text{NaOH}) r(\text{ions, NaOH}) \\ &= \frac{0.100 \text{ mol}}{\text{L}} \left(\frac{100.0 \text{ mL}}{1} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{2 \text{ mol ions}}{\text{mol NaOH}} \right) \\ &= 0.0200 \text{ mol} \end{aligned}$$



$$\begin{aligned} n(\text{ions}) &= n(\text{BaCl}_2) r(\text{ions, BaCl}_2) \\ &= c(\text{BaCl}_2) V(\text{BaCl}_2) r(\text{ions, BaCl}_2) \\ &= \frac{0.200 \text{ mol}}{\text{L}} \left(\frac{50.0 \text{ mL}}{1} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{3 \text{ mol ions}}{\text{mol BaCl}_2} \right) \\ &= 0.0300 \text{ mol} \end{aligned}$$



$$\begin{aligned} n(\text{ions}) &= n(\text{Na}_3\text{PO}_4) r(\text{ions, Na}_3\text{PO}_4) \\ &= c(\text{Na}_3\text{PO}_4) V(\text{Na}_3\text{PO}_4) r(\text{ions, Na}_3\text{PO}_4) \\ &= \frac{0.150 \text{ mol}}{\text{L}} \left(\frac{75.0 \text{ mL}}{1} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{4 \text{ mol ions}}{\text{mol Na}_3\text{PO}_4} \right) \\ &= 0.0450 \text{ mol} \end{aligned}$$

C has the largest number of ions.

sec04-q0035-01.tex

Keyword:stoichiometry; molarity; ions

36. If 12.0 g of AgNO_3 is available, what volume (in L) of 0.25 M AgNO_3 can be prepared?

A: 0.28 L

$$\begin{aligned} V(\text{AgNO}_3) &= n(\text{AgNO}_3) c(\text{AgNO}_3)^{-1} \\ &= m(\text{AgNO}_3) M(\text{AgNO}_3)^{-1} c(\text{AgNO}_3)^{-1} \\ &= 12.0 \text{ g AgNO}_3 \left(\frac{\text{mol AgNO}_3}{169.88 \text{ g}} \right) \left(\frac{\text{L}}{0.25 \text{ mol AgNO}_3} \right) \\ &= 0.2825 \text{ L} = 0.28 \text{ L} \end{aligned}$$

sec04-q0036-01.tex

Keyword:stoichiometry; molarity

37. A solution is prepared by dissolving 10.8 g ammonium sulfate in enough water to make 100.0 mL of stock solution. A 10.0 mL aliquot is taken and 50.00 mL of water is added. What is the molar concentration (in mol L⁻¹) of ammonium ions and sulfate ions in the final solution?

A: NH₄⁺: 0.272 M; SO₄²⁻: 0.136 M

$$\begin{aligned}
 c(\text{NH}_4^+) &= n(\text{NH}_4^+)_{\text{dilute aliquot}} V(\text{dilute aliquot})^{-1} \\
 &= n(\text{NH}_4^+)_{\text{stock solution}} V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= m((\text{NH}_4)_2\text{SO}_4) M((\text{NH}_4)_2\text{SO}_4)^{-1} r(\text{NH}_4^+, (\text{NH}_4)_2\text{SO}_4) \\
 &\quad V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= 10.8 \text{ g } (\text{NH}_4)_2\text{SO}_4 \left(\frac{\text{mol } (\text{NH}_4)_2\text{SO}_4}{132.16 \text{ g}} \right) \left(\frac{2 \text{ mol NH}_4^+}{\text{mol } (\text{NH}_4)_2\text{SO}_4} \right) \\
 &\quad \left(\frac{1}{100.0 \text{ mL}} \right) \left(\frac{10.0 \text{ mL}}{\phantom{100.0 \text{ mL}}} \right) \left(\frac{1}{60.0 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\
 &= 0.27\bar{2}39 \text{ mol L}^{-1} = 0.272 \text{ mol L}^{-1}
 \end{aligned}$$

$$\begin{aligned}
 c(\text{SO}_4^{2-}) &= n(\text{SO}_4^{2-})_{\text{dilute aliquot}} V(\text{stock solution})^{-1} \\
 &= n(\text{SO}_4^{2-})_{\text{stock solution}} V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= m((\text{NH}_4)_2\text{SO}_4) M((\text{NH}_4)_2\text{SO}_4)^{-1} r(\text{SO}_4^{2-}, (\text{NH}_4)_2\text{SO}_4) \\
 &\quad V(\text{stock solution})^{-1} V(\text{aliquot}) V(\text{dilute aliquot})^{-1} \\
 &= 10.8 \text{ g } (\text{NH}_4)_2\text{SO}_4 \left(\frac{\text{mol } (\text{NH}_4)_2\text{SO}_4}{132.16 \text{ g}} \right) \left(\frac{\text{mol SO}_4^{2-}}{\text{mol } (\text{NH}_4)_2\text{SO}_4} \right) \\
 &\quad \left(\frac{1}{100.0 \text{ mL}} \right) \left(\frac{10.0 \text{ mL}}{\phantom{100.0 \text{ mL}}} \right) \left(\frac{1}{60.0 \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\
 &= 0.13\bar{6}19 \text{ mol L}^{-1} = 0.136 \text{ mol L}^{-1}
 \end{aligned}$$

Alternatively,

$$\begin{aligned}
 c(\text{SO}_4^{2-}) &= c(\text{NH}_4^+)_{\text{dilute aliquot}} r(\text{SO}_4^{2-}, \text{NH}_4^+) \\
 &= \frac{0.27\bar{2}39 \text{ mol}}{\text{L}} \left(\frac{\text{mol SO}_4^{2-}}{2 \text{ mol NH}_4^+} \right) \\
 &= 0.13\bar{6}19 \text{ mol L}^{-1} = 0.136 \text{ mol L}^{-1}
 \end{aligned}$$

sec04-q0037-01.tex

Keyword:stoichiometry; molarity; dilution

38. What mass (in g) of Na_2CrO_4 is required to precipitate all of the silver ions from a 75.0 mL 0.100 M aqueous solution of AgNO_3 ?

A: 0.607 g



$$\begin{aligned} m(\text{Na}_2\text{CrO}_4) &= n(\text{Na}_2\text{CrO}_4) M(\text{Na}_2\text{CrO}_4) \\ &= n(\text{AgNO}_3) r(\text{Na}_2\text{CrO}_4, \text{AgNO}_3) M(\text{Na}_2\text{CrO}_4) \\ &= c(\text{AgNO}_3) V(\text{AgNO}_3) r(\text{Na}_2\text{CrO}_4, \text{AgNO}_3) M(\text{Na}_2\text{CrO}_4) \\ &= \frac{0.100 \text{ mol AgNO}_3}{\text{L}} \left(\frac{75.0 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{2 \text{ mol AgNO}_3} \right) \left(\frac{161.98 \text{ g Na}_2\text{CrO}_4}{\text{mol}} \right) \\ &= 0.60742 \text{ g} = 0.607 \text{ g} \end{aligned}$$

sec04-q0038-01.tex

Keyword:stoichiometry; molarity; precipitation

39. What mass (in g) of iron(III) hydroxide precipitate can be produced by reacting a 72.0 mL 0.105 M aqueous iron(III) nitrate solution with a 125 mL 0.150 M aqueous sodium hydroxide solution?

A: 0.668 g



Determine the limiting reactant.

$$\begin{aligned}n(\text{Fe}(\text{OH})_3) &= n(\text{Fe}(\text{NO}_3)_3) r(\text{Fe}(\text{OH})_3, \text{Fe}(\text{NO}_3)_3) \\&= c(\text{Fe}(\text{NO}_3)_3) V(\text{initial}) r(\text{Fe}(\text{OH})_3, \text{Fe}(\text{NO}_3)_3) \\&= \frac{0.105 \text{ mol Fe}(\text{NO}_3)_3}{\text{L}} \left(\frac{72.0 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Fe}(\text{OH})_3}{\text{mol Fe}(\text{NO}_3)_3} \right) \\&= 7.5600 \times 10^{-3} \text{ mol}\end{aligned}$$

$$\begin{aligned}n(\text{Fe}(\text{OH})_3) &= n(\text{NaOH}) r(\text{Fe}(\text{OH})_3, \text{NaOH}) \\&= c(\text{NaOH}) V(\text{initial}) r(\text{Fe}(\text{OH})_3, \text{NaOH}) \\&= \frac{0.150 \text{ mol NaOH}}{\text{L}} \left(\frac{125 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Fe}(\text{OH})_3}{3 \text{ mol NaOH}} \right) \\&= 6.2500 \times 10^{-3} \text{ mol}\end{aligned}$$

NaOH is limiting.

$$\begin{aligned}m(\text{Fe}(\text{OH})_3) &= n(\text{Fe}(\text{OH})_3) M(\text{Fe}(\text{OH})_3) \\&= 6.2500 \times 10^{-3} \text{ mol Fe}(\text{OH})_3 \left(\frac{106.88 \text{ g Fe}(\text{OH})_3}{\text{mol}} \right) \\&= 0.66800 \text{ g} = 0.668 \text{ g}\end{aligned}$$

sec04-q0039-01.tex

Keyword:stoichiometry; molarity; precipitation; limiting reactant

40. A 100.0 mL 0.200 M aqueous potassium hydroxide solution is mixed with a 100.0 mL 0.200 M aqueous magnesium nitrate solution.

- Write a balanced chemical equation for the reaction that occurs.
- Determine the precipitate that forms (if any).
- Determine the mass (in g) of precipitate that forms (if any).
- Determine the molar concentration (in g mol⁻¹) of each ion in solution after the reaction goes to 100 % completion. Assume the volume change of the solution is negligible.

A:



B: Mg(OH)₂

C: Determine the limiting reactant.

$$\begin{aligned} n(\text{Mg}(\text{OH})_2) &= c(\text{KOH}) V(\text{initial}) r(\text{Mg}(\text{OH})_2, \text{KOH}) \\ &= \frac{0.200 \text{ mol KOH}}{\text{L}} \left(\frac{100.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Mg}(\text{OH})_2}{2 \text{ mol KOH}} \right) \\ &= 0.0100 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Mg}(\text{OH})_2) &= c(\text{Mg}(\text{NO}_3)_2) V(\text{initial}) r(\text{Mg}(\text{OH})_2, \text{Mg}(\text{NO}_3)_2) \\ &= \frac{0.200 \text{ mol Mg}(\text{NO}_3)_2}{\text{L}} \left(\frac{100.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Mg}(\text{OH})_2}{\text{mol Mg}(\text{NO}_3)_2} \right) \\ &= 0.0200 \text{ mol} \end{aligned}$$

KOH is limiting.

$$\begin{aligned} m(\text{Mg}(\text{OH})_2) &= n(\text{Mg}(\text{OH})_2) M(\text{Mg}(\text{OH})_2) \\ &= 0.0100 \text{ mol Mg}(\text{OH})_2 \left(\frac{58.33 \text{ g Mg}(\text{OH})_2}{\text{mol}} \right) \\ &= 0.58330 \text{ g} = 0.583 \text{ g} \end{aligned}$$

D:

$$\begin{aligned} c(\text{K}^+) &= n(\text{K}^+) V(\text{solution})^{-1} \\ &= n(\text{KOH}) r(\text{K}^+, \text{KOH}) V(\text{solution})^{-1} \\ &= c(\text{KOH}) V(\text{KOH}) r(\text{K}^+, \text{KOH}) V(\text{solution})^{-1} \\ &= \frac{0.200 \text{ mol KOH}}{\text{L}} \left(\frac{100.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol K}^+}{\text{mol KOH}} \right) \left(\frac{1}{(100.0 + 100.0) \text{ mL}} \right) \\ &= 0.100 \text{ mol L}^{-1} \end{aligned}$$

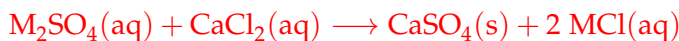
$c(\text{OH}^-) = 0$ since KOH is limiting and all hydroxide precipitates as Mg(OH)₂

$$\begin{aligned} c(\text{Mg}^{2+})_{\text{final}} &= n(\text{Mg}^{2+}) V(\text{solution})^{-1} \\ &= \left\{ n(\text{Mg}(\text{NO}_3)_2)_{\text{initial}} - n(\text{Mg}(\text{NO}_3)_2)_{\text{reacted}} \right\} r(\text{Mg}^{2+}, \text{Mg}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \left\{ \left[c(\text{Mg}(\text{NO}_3)_2) V(\text{Mg}(\text{NO}_3)_2) \right] - \left[n(\text{Mg}(\text{OH})_2)_{\text{formed}} r(\text{Mg}(\text{NO}_3)_2, \text{Mg}(\text{OH})_2) \right] \right\} r(\text{Mg}^{2+}, \text{Mg}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \left\{ \left[\left(\frac{0.200 \text{ mol Mg}(\text{NO}_3)_2}{\text{L}} \right) \left(\frac{100.0 \text{ mL Mg}(\text{NO}_3)_2}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \right] - \left[\left(\frac{0.0100 \text{ mol Mg}(\text{OH})_2}{\text{L}} \right) \left(\frac{\text{mol Mg}(\text{NO}_3)_2}{\text{mol Mg}(\text{OH})_2} \right) \right] \right\} \\ &\quad \left(\frac{\text{mol Mg}^{2+}}{\text{mol Mg}(\text{NO}_3)_2} \right) \left(\frac{1}{(100.0 + 100.0) \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.0500 \text{ mol L}^{-1} \end{aligned}$$

$$\begin{aligned} c(\text{NO}_3^-) &= n(\text{NO}_3^-) V(\text{solution})^{-1} \\ &= n(\text{Mg}(\text{NO}_3)_2) r(\text{NO}_3^-, \text{Mg}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= c(\text{Mg}(\text{NO}_3)_2) V(\text{Mg}(\text{NO}_3)_2) r(\text{NO}_3^-, \text{Mg}(\text{NO}_3)_2) V(\text{solution})^{-1} \\ &= \frac{0.200 \text{ mol Mg}(\text{NO}_3)_2}{\text{L}} \left(\frac{100.0 \text{ mL}}{\text{L}} \right) \left(\frac{2 \text{ mol NO}_3^-}{\text{mol Mg}(\text{NO}_3)_2} \right) \left(\frac{1}{(100.0 + 100.0) \text{ mL}} \right) \\ &= 0.200 \text{ mol L}^{-1} \end{aligned}$$

41. A 1.42 g sample of a pure, metal (M) containing compound (M_2SO_4) was dissolved in water and treated with an excess of aqueous calcium chloride. All the sulfate ions precipitated as calcium sulfate which was collected, dried, and found to be 1.36 g. What is the identity and standard atomic weight of the metal?

A: Na; 23.0



$$\begin{aligned}
 M(M^+) &= m(M^+) n(M^+)^{-1} \\
 &= \left\{ m(M_2SO_4) - m(SO_4^{2-}) \right\} \left\{ n(M_2SO_4) r(M_2SO_4, SO_4^{2-}) r(M^+, M_2SO_4) \right\}^{-1} M_u \\
 &= \left\{ m(M_2SO_4) - m(SO_4^{2-}) \right\} \left\{ n(CaSO_4) r(SO_4^{2-}, CaSO_4) r(M_2SO_4, SO_4^{2-}) r(M^+, M_2SO_4) \right\}^{-1} M_u \\
 &= \left\{ m(M_2SO_4) - \left[m(CaSO_4) M(CaSO_4)^{-1} r(SO_4^{2-}, CaSO_4) \right] \right\} \\
 &\quad \left\{ m(CaSO_4) M(CaSO_4)^{-1} r(M_2SO_4, CaSO_4) r(M_2SO_4, SO_4^{2-}) r(M^+, M_2SO_4) \right\}^{-1} M_u \\
 &= \left\{ 1.42 \text{ g } M_2SO_4 - \left[1.36 \text{ g } CaSO_4 \left(\frac{\text{mol } CaSO_4}{136.14 \text{ g}} \right) \left(\frac{\text{mol } SO_4^{2-}}{\text{mol } CaSO_4} \right) \left(\frac{96.06 \text{ g}}{\text{mol } SO_4^{2-}} \right) \right] \right\} \\
 &\quad \left\{ 1.36 \text{ g } CaSO_4 \left(\frac{\text{mol } CaSO_4}{136.14 \text{ g}} \right) \left(\frac{\text{mol } SO_4^{2-}}{\text{mol } CaSO_4} \right) \left(\frac{\text{mol } M_2SO_4}{\text{mol } SO_4^{2-}} \right) \left(\frac{2 \text{ mol } M^+}{\text{mol } M_2SO_4} \right) \right\}^{-1} \left(\frac{\text{mol}}{\text{g}} \right) \\
 &= \frac{0.46038 \text{ g}}{0.019979 \text{ mol}} \left(\frac{\text{mol}}{\text{g}} \right) \\
 &= 23.043 = 23.0
 \end{aligned}$$

The metal is sodium (Na).

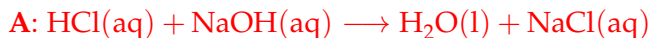
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Keyword: stoichiometry; molarity; precipitation; molar mass

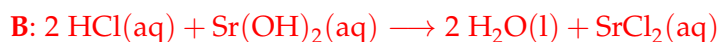
42. What volume (in mL) of each of the following bases will completely react with 25.0 mL of 0.200 M HCl?

- A. 0.100 M NaOH
- B. 0.0500 M Sr(OH)₂
- C. 0.250 M KOH

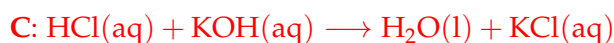
A: 50.0 mL; 50.0 mL; 20.0 mL



$$\begin{aligned} V(\text{NaOH}) &= n(\text{NaOH}) c(\text{NaOH})^{-1} \\ &= n(\text{HCl}) r(\text{NaOH, HCl}) c(\text{NaOH})^{-1} \\ &= c(\text{HCl}) V(\text{HCl}) r(\text{NaOH, HCl}) c(\text{NaOH})^{-1} \\ &= \frac{0.200 \text{ mol NaOH}}{\text{L}} \left(\frac{25.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol NaOH}}{\text{mol HCl}} \right) \left(\frac{\text{L}}{0.100 \text{ mol NaOH}} \right) \\ &= 50.0 \text{ mL} \end{aligned}$$



$$\begin{aligned} V(\text{Sr(OH)}_2) &= n(\text{Sr(OH)}_2) c(\text{Sr(OH)}_2)^{-1} \\ &= n(\text{HCl}) r(\text{Sr(OH)}_2, \text{HCl}) c(\text{Sr(OH)}_2)^{-1} \\ &= c(\text{HCl}) V(\text{HCl}) r(\text{Sr(OH)}_2, \text{HCl}) c(\text{Sr(OH)}_2)^{-1} \\ &= \frac{0.200 \text{ mol NaOH}}{\text{L}} \left(\frac{25.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol Sr(OH)}_2}{2 \text{ mol HCl}} \right) \left(\frac{\text{L}}{0.0500 \text{ mol Sr(OH)}_2} \right) \\ &= 50.0 \text{ mL} \end{aligned}$$



$$\begin{aligned} V(\text{KOH}) &= n(\text{KOH}) c(\text{KOH})^{-1} \\ &= n(\text{HCl}) r(\text{KOH, HCl}) c(\text{KOH})^{-1} \\ &= c(\text{HCl}) V(\text{HCl}) r(\text{KOH, HCl}) c(\text{KOH})^{-1} \\ &= \frac{0.200 \text{ mol NaOH}}{\text{L}} \left(\frac{25.0 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol KOH}}{\text{mol HCl}} \right) \left(\frac{\text{L}}{0.250 \text{ mol KOH}} \right) \\ &= 20.0 \text{ mL} \end{aligned}$$

sec04-q0042-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

43. A 25.0 mL sample of HCl(aq) requires 24.16 mL of 0.106 M NaOH for complete neutralization. What is the molar concentration (in mol L⁻¹) of the original HCl(aq) solution?

A: 0.102 M



$$\begin{aligned}c(\text{HCl}) &= n(\text{HCl}) V(\text{HCl})^{-1} \\&= n(\text{NaOH}) r(\text{HCl, NaOH}) V(\text{HCl})^{-1} \\&= c(\text{NaOH}) V(\text{NaOH}) r(\text{HCl, NaOH}) V(\text{HCl})^{-1} \\&= \frac{0.106 \text{ mol NaOH}}{\text{L}} \left(\frac{24.16 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol HCl}}{\text{mol NaOH}} \right) \left(\frac{1}{25.0 \text{ mL HCl}} \right) \\&= 0.102 \text{ mol L}^{-1}\end{aligned}$$

sec04-q0043-01.tex

Keyword:balancing equations; stoichiometry; molarity; acid-base reaction

44. 5.00 g of barium chloride was added to 225 mL of a 1.40 M solution of sodium sulfide.
- Write the balanced molecular equation and include phase labels.
 - Write the full ionic equation and include phase labels.
 - Write the net ionic equation and include phase labels. If there is no net ionic equation, write "no net ionic equation."
 - Indicate the precipitate (if any).
 - Determine the limiting reactant.

A: Molecular equation:



B: Complete ionic equation:



C: Net ionic equation:

no net ionic equation

D: There is no precipitate.

E:

$$\begin{aligned} n(\text{BaS}) &= n(\text{BaCl}_2) r(\text{BaS}, \text{BaCl}_2) \\ &= m(\text{BaCl}_2) M(\text{BaCl}_2) r(\text{BaS}, \text{BaCl}_2) \\ &= 5.00 \text{ g BaCl}_2 \left(\frac{\text{mol BaCl}_2}{208.23 \text{ g}} \right) \left(\frac{\text{mol BaS}}{\text{mol BaCl}_2} \right) \\ &= 0.024011 \text{ mol} \\ n(\text{BaS}) &= n(\text{Na}_2\text{S}) r(\text{BaS}, \text{Na}_2\text{S}) \\ &= c(\text{Na}_2\text{S}) V(\text{initial}) r(\text{BaS}, \text{Na}_2\text{S}) \\ &= \frac{1.40 \text{ mol Na}_2\text{S}}{\text{L}} \left(\frac{225 \text{ mL}}{\text{L}} \right) \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol BaS}}{\text{mol Na}_2\text{S}} \right) \\ &= 0.31500 \text{ mol} \end{aligned}$$

BaCl₂ is limiting.

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Keyword:balancing equations; stoichiometry; molarity; limiting reactant;
double-displacement reaction

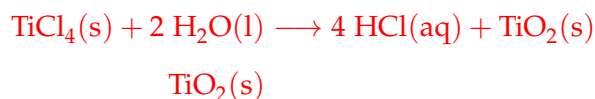
45. A precipitate forms when titanium(IV) chloride is added to water. Two water molecules react and form four HCl molecules. What is the identity of the precipitate?

A. What is the identity of the precipitate?

B. What is the molar concentration (in mol L⁻¹) of H⁺ ions if 2.00 g of TiCl₄ was added to enough water to give a 100.0 mL solution?

A: TiCl₄; 0.422 M

A:



B:

$$\begin{aligned} c(\text{H}^+) &= n(\text{H}^+) V(\text{solution})^{-1} \\ &= n(\text{HCl}) r(\text{H}^+, \text{HCl}) V(\text{solution})^{-1} \\ &= n(\text{TiCl}_4) r(\text{HCl}, \text{TiCl}_4) r(\text{H}^+, \text{HCl}) V(\text{solution})^{-1} \\ &= m(\text{TiCl}_4) M(\text{TiCl}_4)^{-1} r(\text{HCl}, \text{TiCl}_4) r(\text{H}^+, \text{HCl}) V(\text{solution})^{-1} \\ &= 2.00 \text{ g TiCl}_4 \left(\frac{\text{mol TiCl}_4}{189.67 \text{ g}} \right) \left(\frac{4 \text{ mol HCl}}{\text{mol TiCl}_4} \right) \left(\frac{\text{mol H}^+}{\text{mol HCl}} \right) \left[100.0 \text{ mL} \left(\frac{\text{L}}{10^3 \text{ mL}} \right) \right]^{-1} \\ &= 0.42178 \text{ mol L}^{-1} = 0.422 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0045-01.tex

Keyword:balancing equations; stoichiometry; molarity

46. A 123 mL sample of 0.210 M aqueous magnesium chloride forms a precipitate when mixed with 324 mL 0.120 M aqueous sodium hydroxide.

- A. How much (in g) precipitate is formed?
 B. What is the molar concentration (in mol L⁻¹) of the magnesium(2+) ion?
 C. What is the molar concentration (in mol L⁻¹) of the sodium(1+) ion?

A: 1.13 g; 0.0286 M; 0.0870 M



A: Find the limiting reactant

$$\begin{aligned} n(\text{Mg}(\text{OH})_2) &= n(\text{MgCl}_2) r(\text{Mg}(\text{OH})_2, \text{MgCl}_2) \\ &= c(\text{MgCl}_2) V(\text{MgCl}_2) r(\text{Mg}(\text{OH})_2, \text{MgCl}_2) \\ &= \frac{0.210 \text{ mol MgCl}_2}{\text{L}} \left(\frac{123 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Mg}(\text{OH})_2}{\text{mol MgCl}_2} \right) \\ &= 0.02583 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Mg}(\text{OH})_2) &= n(\text{NaOH}) r(\text{Mg}(\text{OH})_2, \text{NaOH}) \\ &= c(\text{NaOH}) V(\text{NaOH}) r(\text{Mg}(\text{OH})_2, \text{NaOH}) \\ &= \frac{0.120 \text{ mol NaOH}}{\text{L}} \left(\frac{324 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Mg}(\text{OH})_2}{2 \text{ mol NaOH}} \right) \\ &= 0.019440 \text{ mol} \end{aligned}$$

NaOH is limiting.

$$\begin{aligned} m(\text{Mg}(\text{OH})_2) &= n(\text{Mg}(\text{OH})_2) M(\text{Mg}(\text{OH})_2)^{-1} \\ &= 0.019440 \text{ mol Mg}(\text{OH})_2 \left(\frac{58.33 \text{ g Mg}(\text{OH})_2}{\text{mol}} \right) \\ &= 1.1339 \text{ g} = 1.13 \text{ g} \end{aligned}$$

B:

$$\begin{aligned} c(\text{Mg}^{2+}) &= n(\text{Mg}^{2+}) V(\text{solution})^{-1} \\ &= \left\{ n(\text{Mg}^{2+})_{\text{initial}} - n(\text{Mg}^{2+})_{\text{reacted}} \right\} V(\text{solution})^{-1} \\ &= \left\{ \left[n(\text{MgCl}_2)_{\text{initial}} r(\text{Mg}^{2+}, \text{MgCl}_2) \right] - \left[n(\text{MgCl}_2)_{\text{final}} r(\text{Mg}^{2+}, \text{MgCl}_2) \right] \right\} V(\text{solution})^{-1} \\ &= \left\{ \left[n(\text{Mg}^{2+})_{\text{initial}} r(\text{Cl}^-, \text{MgCl}_2) \right] - \left[n(\text{Mg}(\text{OH})_2) r(\text{MgCl}_2, \text{Mg}(\text{OH})_2) r(\text{Mg}^{2+}, \text{MgCl}_2) \right] \right\} V(\text{solution})^{-1} \\ &= \left\{ \left[c(\text{MgCl}_2)_{\text{initial}} V(\text{MgCl}_2) r(\text{Mg}^{2+}, \text{MgCl}_2) \right] - \left[n(\text{Mg}(\text{OH})_2) r(\text{MgCl}_2, \text{Mg}(\text{OH})_2) r(\text{Mg}^{2+}, \text{MgCl}_2) \right] \right\} \\ &\quad V(\text{solution})^{-1} \\ &= \left\{ \left[\frac{0.210 \text{ mol MgCl}_2}{\text{L}} \left(\frac{123 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Mg}^{2+}}{\text{mol MgCl}_2} \right) \right] - \right. \\ &\quad \left. \left[0.019440 \text{ mol Mg}(\text{OH})_2 \left(\frac{\text{mol MgCl}_2}{\text{mol Mg}(\text{OH})_2} \right) \left(\frac{\text{mol Mg}^{2+}}{\text{mol MgCl}_2} \right) \right] \right\} \left(\frac{1}{(123 + 324) \text{ mL}} \right) \left(\frac{10^3 \text{ mL}}{\text{L}} \right) \\ &= 0.014295 \text{ mol L}^{-1} = 0.0143 \text{ mol L}^{-1} \end{aligned}$$

C:

$$\begin{aligned} c(\text{Na}^+) &= n(\text{Na}^+) V(\text{solution})^{-1} \\ &= n(\text{NaOH})_{\text{initial}} r(\text{Na}^+, \text{NaOH}) V(\text{solution})^{-1} \\ &= c(\text{NaOH})_{\text{initial}} V(\text{NaOH})_{\text{initial}} r(\text{Na}^+, \text{NaOH}) V(\text{solution})^{-1} \\ &= \frac{0.120 \text{ mol NaOH}}{\text{L}} \left(\frac{324 \text{ mL}}{10^3 \text{ mL}} \right) \left(\frac{\text{mol Na}^+}{\text{mol NaOH}} \right) \left(\frac{1}{(123 + 324) \text{ mL}} \right) \\ &= 0.086979 \text{ mol L}^{-1} = 0.0870 \text{ mol L}^{-1} \end{aligned}$$

47. If 275 mL of a 0.125 M aqueous NaCl solution and 375 mL of a 0.575 M aqueous Na₂SO₄ solution are mixed, determine the molar concentrations (in mol L⁻¹) of the following:

- A. chloride ions
- B. sulfate ions
- C. sodium ions

A: 0.0481 M; 0.332 M; 0.712 M



All compounds are soluble and there is no net ionic equation. Can determine ion molar concentrations without determining the limiting reactant.

A

$$\begin{aligned} c(\text{Cl}^-) &= n(\text{Cl}^-) V(\text{solution})^{-1} \\ &= c(\text{NaCl}) V(\text{NaCl}) r(\text{Cl}^-, \text{NaCl}) V(\text{solution})^{-1} \\ &= \frac{0.125 \text{ mol NaCl}}{\text{L}} \left(\frac{275 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol Cl}^-}{\text{mol NaCl}} \right) \left(\frac{1}{(275 + 375) \text{ mL}} \right) \\ &= 0.048076 \text{ mol L}^{-1} = 0.0481 \text{ mol L}^{-1} \end{aligned}$$

B

$$\begin{aligned} c(\text{SO}_4^{2-}) &= n(\text{SO}_4^{2-}) V(\text{solution})^{-1} \\ &= c(\text{Na}_2\text{SO}_4) V(\text{Na}_2\text{SO}_4) r(\text{SO}_4^{2-}, \text{Na}_2\text{SO}_4) V(\text{solution})^{-1} \\ &= \frac{0.575 \text{ mol Na}_2\text{SO}_4}{\text{L}} \left(\frac{375 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol SO}_4^{2-}}{\text{mol Na}_2\text{SO}_4} \right) \left(\frac{1}{(275 + 375) \text{ mL}} \right) \\ &= 0.33173 \text{ mol L}^{-1} = 0.332 \text{ mol L}^{-1} \end{aligned}$$

C

$$\begin{aligned} c(\text{Na}^+) &= n(\text{Na}^+) V(\text{solution})^{-1} \\ &= \left\{ n(\text{NaCl}) + n(\text{Na}_2\text{SO}_4) \right\} V(\text{solution})^{-1} \\ &= \left\{ \left[c(\text{NaCl}) V(\text{NaCl}) r(\text{Na}^+, \text{NaCl}) \right] + \left[c(\text{Na}_2\text{SO}_4) V(\text{Na}_2\text{SO}_4) r(\text{Na}^+, \text{Na}_2\text{SO}_4) \right] \right\} V(\text{solution})^{-1} \\ &= \left\{ \left[\frac{0.125 \text{ mol NaCl}}{\text{L}} \left(\frac{275 \text{ mL}}{\text{L}} \right) \left(\frac{\text{mol Na}^+}{\text{mol NaCl}} \right) \right] + \left[\frac{0.575 \text{ mol Na}_2\text{SO}_4}{\text{L}} \left(\frac{375 \text{ mL}}{\text{L}} \right) \left(\frac{2 \text{ mol Na}^+}{\text{mol Na}_2\text{SO}_4} \right) \right] \right\} \\ &\quad \left(\frac{1}{(275 + 375) \text{ mL}} \right) \\ &= 0.71153 \text{ mol L}^{-1} = 0.712 \text{ mol L}^{-1} \end{aligned}$$

sec04-q0047-01.tex

Keyword:balancing equations; stoichiometry; molarity

Exam 2 Review: Thermochemistry Basics

1. Sugar is melted in a pot and its temperature is measured as it heats. In this scenario, what is the system?
- A. the pot and sugar
 - B. the stove
 - C. the entire kitchen
 - D. the rest of the universe

A

sec05-q0001-01.tex

Keyword:thermochemistry basics

2. Which of the following is not a type of potential energy (select all that apply)?
- A. Energy held in chemical bonds
 - B. Energy resulting from intramolecular attractions
 - C. Energy from the random motion of molecules
 - D. Energy of a ball dropping from a height

C, D

sec05-q0002-01.tex

Keyword:thermochemistry basics

3. Which of the following is true of heat (select all that apply)?
- A. Heat is a form of thermal energy.
 - B. Heat is the transfer of thermal energy.
 - C. Heat is the action of forces through a distance.
 - D. A negative heat in the system means the surroundings loses energy.
 - E. A negative heat in the system means the system loses energy.

B, E

sec05-q0003-01.tex

Keyword:thermochemistry basics

4. Which of the following are false (select all that apply)?
- A. Energy can be converted from one type to another.
 - B. Energy is the capacity to do work.
 - C. Kinetic energy is energy resulting from condition, position, or composition.
 - D. Potential energy is energy transferred between a system and its surroundings as a result of a temperature difference.

C, D

sec05-q0004-01.tex

Keyword:thermochemistry basics

5. A block of ice absorbs heat and melts. The value q for the system is:

- A. Positive
- B. Negative
- C. Zero
- D. There is not enough information to determine.

A

sec05-q0005-01.tex

Keyword: thermochemistry basics

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