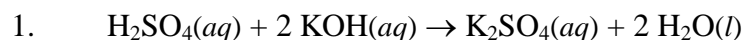


Chapter 14

Answers to Questions



Strategy

Vol/conc $\text{H}_2\text{SO}_4 \rightarrow$ mol H_2SO_4

Mol $\text{H}_2\text{SO}_4 \rightarrow$ mol KOH

Mol/vol KOH \rightarrow conc KOH

Relationship

$n = c \times V$

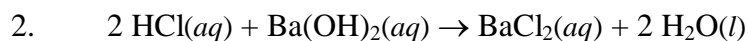
1 mol $\text{H}_2\text{SO}_4 \equiv 2$ mol KOH

$c = n/V$

$$\text{Mol H}_2\text{SO}_4 = 0.2000 \text{ mol} \cdot \text{L}^{-1} \times 1.473 \times 10^{-2} \text{ L} = 2.946 \times 10^{-3} \text{ mol H}_2\text{SO}_4$$

$$\text{Mol KOH} = 2.946 \times 10^{-3} \text{ mol H}_2\text{SO}_4 \times \left(\frac{2 \text{ mol KOH}}{1 \text{ mol H}_2\text{SO}_4} \right) = 5.892 \times 10^{-3} \text{ mol KOH}$$

$$\text{Concentration KOH} = \frac{5.892 \times 10^{-3} \text{ mol}}{2.500 \times 10^{-2} \text{ L}} = 0.2357 \text{ mol} \cdot \text{L}^{-1}$$



Strategy

Vol/conc $\text{Ba}(\text{OH})_2 \rightarrow$ mol $\text{Ba}(\text{OH})_2$

Mol $\text{Ba}(\text{OH})_2 \rightarrow$ mol HCl

Mol/vol HCl \rightarrow conc HCl

Relationship

$n = c \times V$

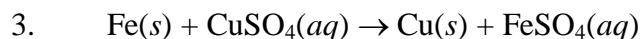
1 mol $\text{Ba}(\text{OH})_2 \equiv 2$ mol HCl

$c = n/V$

$$\text{Mol Ba}(\text{OH})_2 = 0.1000 \text{ mol} \cdot \text{L}^{-1} \times 2.500 \times 10^{-2} \text{ L} = 2.500 \times 10^{-3} \text{ mol Ba}(\text{OH})_2$$

$$\text{Mol HCl} = 2.500 \times 10^{-3} \text{ mol Ba}(\text{OH})_2 \times \left(\frac{2 \text{ mol HCl}}{1 \text{ mol Ba}(\text{OH})_2} \right) = 5.000 \times 10^{-3} \text{ mol HCl}$$

$$\text{Concentration HCl} = \frac{5.000 \times 10^{-3} \text{ mol}}{3.216 \times 10^{-2} \text{ L}} = 0.1555 \text{ mol} \cdot \text{L}^{-1}$$



(a)

Strategy

Mass Fe \rightarrow mol Fe

Mol Fe \rightarrow mol CuSO₄

Mol/conc CuSO₄ \rightarrow vol CuSO₄

Relationship

1 mol Fe \equiv 55.8 g

1 mol Fe \equiv 1 mol CuSO₄

V = n/c

$$\text{Mol Fe} = 0.279 \text{ g Fe} \times \left(\frac{1 \text{ mol}}{55.8 \text{ g}} \right) = 5.00 \times 10^{-3} \text{ mol Fe}$$

$$\text{Mol CuSO}_4 = 5.00 \times 10^{-3} \text{ mol Fe} \times \left(\frac{1 \text{ mol CuSO}_4}{1 \text{ mol Fe}} \right) = 5.00 \times 10^{-3} \text{ mol CuSO}_4$$

$$\text{Volume CuSO}_4 = \frac{5.00 \times 10^{-3} \text{ mol}}{0.200 \text{ mol} \cdot \text{L}^{-1}} = 2.50 \times 10^{-2} \text{ L} = 25.0 \text{ mL}$$

(b)

Strategy

Mol Fe \rightarrow mol Cu

Mol Cu \rightarrow mass Cu

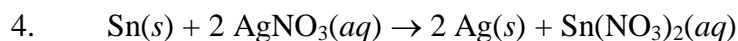
Relationship

1 mol Fe \equiv 1 mol Cu

1 mol Cu \equiv 63.5 g

$$\text{Mol Cu} = 5.00 \times 10^{-3} \text{ mol Fe} \times \left(\frac{1 \text{ mol Cu}}{1 \text{ mol Fe}} \right) = 5.00 \times 10^{-3} \text{ mol Cu}$$

$$\text{Mass Cu} = 5.00 \times 10^{-3} \text{ mol Cu} \times \left(\frac{63.5 \text{ g}}{1 \text{ mol}} \right) = 0.318 \text{ g Cu}$$



(a)

Strategy

Mass Sn \rightarrow mol Sn

Mol Sn \rightarrow mol AgNO₃

Mol/conc AgNO₃ \rightarrow vol AgNO₃

Relationship

1 mol Sn \equiv 118.7 g

1 mol Sn \equiv 2 mol AgNO₃

V = n/c

$$\text{Mol Sn} = 0.7845 \text{ g Sn} \times \left(\frac{1 \text{ mol}}{118.7 \text{ g}} \right) = 6.609 \times 10^{-3} \text{ mol Sn}$$

$$\text{Mol AgNO}_3 = 6.609 \times 10^{-3} \text{ mol Sn} \times \left(\frac{2 \text{ mol AgNO}_3}{1 \text{ mol Sn}} \right) = 1.322 \times 10^{-2} \text{ mol AgNO}_3$$

$$\text{Volume AgNO}_3 = \frac{1.322 \times 10^{-2} \text{ mol}}{0.1250 \text{ mol} \cdot \text{L}^{-1}} = 0.1057 \text{ L} = 105.7 \text{ mL}$$

(b)

Strategy

Mol Sn \rightarrow mol Ag

Mol Ag \rightarrow mass Ag

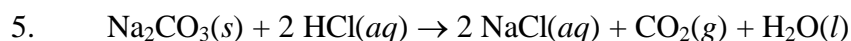
Relationship

1 mol Fe \equiv 2 mol Ag

1 mol Ag \equiv 107.9 g

$$\text{Mol Sn} = 6.609 \times 10^{-3} \text{ mol Ag} \times \left(\frac{2 \text{ mol Ag}}{1 \text{ mol Sn}} \right) = 1.322 \times 10^{-2} \text{ mol Ag}$$

$$\text{Mass Ag} = 1.322 \times 10^{-2} \text{ mol Ag} \times \left(\frac{107.9 \text{ g}}{1 \text{ mol}} \right) = 1.426 \text{ g Ag}$$



(a)

Strategy

Mass $\text{Na}_2\text{CO}_3 \rightarrow$ mol Na_2CO_3

Mol $\text{Na}_2\text{CO}_3 \rightarrow$ mol HCl

Mol/conc $\text{AgNO}_3 \rightarrow$ vol AgNO_3

Relationship

1 mol $\text{Na}_2\text{CO}_3 \equiv$ 106.0 g

1 mol $\text{Na}_2\text{CO}_3 \equiv$ 2 mol HCl

$V = n/c$

$$\text{Mol Na}_2\text{CO}_3 = 5.83 \text{ g Na}_2\text{CO}_3 \times \left(\frac{1 \text{ mol}}{106.0 \text{ g}} \right) = 5.50 \times 10^{-2} \text{ mol Na}_2\text{CO}_3$$

$$\text{Mol HCl} = 5.50 \times 10^{-2} \text{ mol Na}_2\text{CO}_3 \times \left(\frac{2 \text{ mol HCl}}{1 \text{ mol Na}_2\text{CO}_3} \right) = 0.110 \text{ mol HCl}$$

$$\text{Volume HCl} = \frac{0.110 \text{ mol}}{0.200 \text{ mol} \cdot \text{L}^{-1}} = 0.550 \text{ L or } 550 \text{ mL}$$

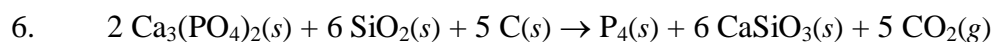
(b)

StrategyMol Na₂CO₃ → mol CO₂Mol/press/temp CO₂ → vol CO₂Relationship1 mol Na₂CO₃ ≡ 1 mol CO₂

V = nRT/P

$$\text{Mol CO}_2 = 5.50 \times 10^{-2} \text{ mol Na}_2\text{CO}_3 \times \left(\frac{1 \text{ mol CO}_2}{1 \text{ mol Na}_2\text{CO}_3} \right) = 5.50 \times 10^{-2} \text{ mol CO}_2$$

$$V = \frac{nRT}{P} = \frac{(5.50 \times 10^{-2} \text{ mol})(8.31 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1})(292 \text{ K})}{(98.7 \text{ kPa})} = 1.35 \text{ L}$$



(a)

StrategyMass P₄ → mol P₄Mol P₄ → mol Ca₃(PO₄)₂Mol Ca₃(PO₄)₂ → mass Ca₃(PO₄)₂Relationship1 mol P₄ ≡ 124.0 g1 mol P₄ ≡ 2 mol Ca₃(PO₄)₂1 mol Ca₃(PO₄)₂ ≡ 310.3 g

$$\text{Mol P}_4 = 1.00 \times 10^3 \text{ g P}_4 \times \left(\frac{1 \text{ mol}}{124.0 \text{ g}} \right) = 8.06 \text{ mol P}_4$$

$$\text{Mol Ca}_3(\text{PO}_4)_2 = 8.06 \text{ mol P}_4 \times \left(\frac{2 \text{ mol Ca}_3(\text{PO}_4)_2}{1 \text{ mol P}_4} \right) = 16.1 \text{ mol Ca}_3(\text{PO}_4)_2$$

$$\begin{aligned} \text{Mass Ca}_3(\text{PO}_4)_2 &= 16.1 \text{ mol Ca}_3(\text{PO}_4)_2 \times \left(\frac{310.3 \text{ g}}{1 \text{ mol}} \right) \\ &= 5.00 \times 10^3 \text{ g Ca}_3(\text{PO}_4)_2 = 5.00 \text{ kg Ca}_3(\text{PO}_4)_2 \end{aligned}$$

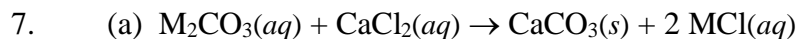
(b)

StrategyMol P₄ → mol CO₂Mol/press/temp CO₂ → vol CO₂Relationship1 mol P₄ ≡ 5 mol CO₂

V = nRT/P

$$\text{Mol CO}_2 = 8.06 \text{ mol P}_4 \times \left(\frac{5 \text{ mol CO}_2}{1 \text{ mol P}_4} \right) = 40.3 \text{ mol CO}_2$$

$$V = \frac{nRT}{P} = \frac{(40.3 \text{ mol})(8.31 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1})(673 \text{ K})}{(104.2 \text{ kPa})} = 2.16 \times 10^3 \text{ L}$$



(b)

Strategy

Mass $\text{CaCO}_3 \rightarrow \text{mol CaCO}_3$

Mol $\text{CaCO}_3 \rightarrow \text{mol M}_2\text{CO}_3$

Mol, mass $\text{M}_2\text{CO}_3 \rightarrow \text{molar mass M}_2\text{CO}_3$

Relationship

1 mol $\text{CaCO}_3 \equiv 100.1 \text{ g}$

1 mol $\text{CaCO}_3 \equiv 1 \text{ mol M}_2\text{CO}_3$

m.m. = m/n

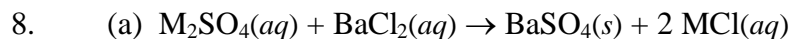
$$\text{Mol CaCO}_3 = 0.1001 \text{ g CaCO}_3 \times \left(\frac{1 \text{ mol}}{100.1 \text{ g}} \right) = 1.000 \times 10^{-3} \text{ mol CaCO}_3$$

$$\begin{aligned} \text{Mol M}_2\text{CO}_3 &= 1.000 \times 10^{-3} \text{ mol CaCO}_3 \times \left(\frac{1 \text{ mol M}_2\text{CO}_3}{1 \text{ mol CaCO}_3} \right) \\ &= 1.000 \times 10^{-3} \text{ mol M}_2\text{CO}_3 \end{aligned}$$

$$\text{Molar mass M}_2\text{CO}_3 = \left(\frac{0.1382 \text{ g}}{1.000 \times 10^{-3} \text{ mol}} \right) = 138.2 \text{ g} \cdot \text{mol}^{-1} \text{ M}_2\text{CO}_3$$

(c) Molar mass, $2 \text{ M} = (138.2 - 60.0) \text{ g} \cdot \text{mol}^{-1} = 78.2 \text{ g} \cdot \text{mol}^{-1}$
 $\text{M} = 39.1 \text{ g} \cdot \text{mol}^{-1}$

(d) As M has to be a metal which forms an ion with a +1 charge, it is potassium



(b)

Strategy

Mass $\text{BaSO}_4 \rightarrow \text{mol BaSO}_4$

Mol $\text{BaSO}_4 \rightarrow \text{mol M}_2\text{SO}_4$

Mol, mass $\text{M}_2\text{SO}_4 \rightarrow \text{molar mass M}_2\text{SO}_4$

Relationship

1 mol $\text{BaSO}_4 \equiv 233.40 \text{ g}$

1 mol $\text{BaSO}_4 \equiv 1 \text{ mol M}_2\text{SO}_4$

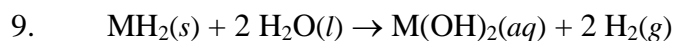
m.m. = m/n

$$\text{Mol BaSO}_4 = 1.1670 \text{ g BaSO}_4 \times \left(\frac{1 \text{ mol}}{233.40 \text{ g}} \right) = 5.0000 \times 10^{-3} \text{ mol BaSO}_4$$

$$\begin{aligned} \text{Mol M}_2\text{SO}_4 &= 5.0000 \times 10^{-3} \text{ mol BaSO}_4 \times \left(\frac{1 \text{ mol M}_2\text{SO}_4}{1 \text{ mol BaSO}_4} \right) \\ &= 5.0000 \times 10^{-3} \text{ mol M}_2\text{SO}_4 \end{aligned}$$

$$\text{Molar mass M}_2\text{SO}_4 = \left(\frac{0.8715 \text{ g}}{5.0000 \times 10^{-3} \text{ mol}} \right) = 174.3 \text{ g} \cdot \text{mol}^{-1} \text{ M}_2\text{SO}_4$$

- (c) Molar mass, $2M = (174.3 - 96.1) \text{ g} \cdot \text{mol}^{-1} = 78.2 \text{ g} \cdot \text{mol}^{-1}$
 $M = 39.1 \text{ g} \cdot \text{mol}^{-1}$
- (d) As M has to be a metal which forms an ion with a +1 charge, it is potassium



(a)

Strategy

Press/vol/temp \rightarrow mol H_2

Mol $\text{H}_2 \rightarrow$ mol MH_2

Mol, mass $\text{MH}_2 \rightarrow$ molar mass MH_2

Relationship

$n = PV/RT$

$2 \text{ mol H}_2 \equiv 1 \text{ mol MH}_2$

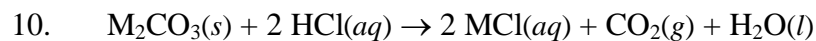
m.m. = m/n

$$n_{\text{H}_2} = \frac{PV}{RT} = \frac{(98.7 \text{ kPa})(0.125 \text{ L})}{(8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1})(298 \text{ K})} = 4.98 \times 10^{-3} \text{ mol H}_2$$

$$\text{Mol MH}_2 = 4.98 \times 10^{-3} \text{ mol H}_2 \times \left(\frac{1 \text{ mol MH}_2}{2 \text{ mol H}_2} \right) = 2.49 \times 10^{-3} \text{ mol MH}_2$$

$$\text{molar mass MH}_2 = \left(\frac{0.347 \text{ g}}{2.49 \times 10^{-3} \text{ mol}} \right) = 139 \text{ g} \cdot \text{mol}^{-1}$$

- (b) Molar mass, $M = (139 - 2.02) \text{ g} \cdot \text{mol}^{-1} = 137 \text{ g} \cdot \text{mol}^{-1}$
- (c) M has to be barium (barium has about the same molar mass as M and it forms a +2 ion).



(a)

Strategy

Press/vol/temp \rightarrow mol CO_2

Mol $CO_2 \rightarrow$ mol M_2CO_3

Mol, mass $M_2CO_3 \rightarrow$ molar mass M_2CO_3

Relationship

$n = PV/RT$

1 mol $CO_2 \equiv$ 1 mol M_2CO_3

m.m. = m/n

$$n_{CO_2} = \frac{PV}{RT} = \frac{(94.4 \text{ kPa})(0.225 \text{ L})}{(8.314 \text{ kPa} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1})(298 \text{ K})} = 8.58 \times 10^{-3} \text{ mol } CO_2$$

$$\begin{aligned} \text{Mol } M_2CO_3 &= 8.58 \times 10^{-3} \text{ mol } CO_2 \times \left(\frac{1 \text{ mol } M_2CO_3}{1 \text{ mol } CO_2} \right) \\ &= 8.58 \times 10^{-3} \text{ mol } M_2CO_3 \end{aligned}$$

$$\text{molar mass } M_2CO_3 = \left(\frac{1.185 \text{ g}}{8.58 \times 10^{-3} \text{ mol}} \right) = 138 \text{ g} \cdot \text{mol}^{-1}$$

(b) Molar mass, $2 M = (138 - 60.0) \text{ g} \cdot \text{mol}^{-1} = 78 \text{ g} \cdot \text{mol}^{-1}$

$M = 39 \text{ g} \cdot \text{mol}^{-1}$

(c) As M has to be a metal which forms an ion with a +1 charge, it is potassium.