CHAPTER 0

THE MOLE

0.1 Calculate the number of molecules in: (a) 8 moles of CO (b) 10 moles of CO_2

0.2 Calculate the number of molecules in: (a) 4 moles of NH_3 (b) 50 moles of H_2SO_4

0.3 Calculate the number of moles in: (a) 6×10^{23} molecules of NO (b) 5×10^{15} molecules of NaCl(c) 3×10^{27} molecules of MgO

0.4 Calculate the number of moles in: (a) 3.2×10^{21} molecules of H_2O (b) 2×10^{23} molecules of CO_2

0.5 Fill the conversion factor that calculates the final property:

$$10^{24}\ \cancel{\text{molecules of } NO_2} \times \frac{\square\ \text{moles of } NO_2}{\square\ \cancel{\text{molecules of } NO_2}} = \square\ \text{moles of } NO_2.$$

0.6 Fill the conversion factor that calculates the final property:

$$3\ \cancel{\text{moles of NO}} \times \frac{\square\ \text{molecules of NO}}{\square\ \cancel{\text{moles of NO}}} = \square\ \text{molecules of NO}.$$

0.7 Fill the conversion factor that calculates the final property:

$$6\ \cancel{\text{moles of } C_6H_{12}O_6} \times \frac{\square}{\square} = \square\ \text{molecules of } C_6H_{12}O_6.$$

0.8 Fill the conversion factor that calculates the final property:

$$10^{25}\ \cancel{\text{molecules of } CH_4N_2O} \times \frac{\square}{\square} = \square\ \text{moles of } CH_4N_2O.$$

CONVERTING MOLES INTO GRAMS AND INTO ATOMS

0.9 Calculate the molar weight of the following molecules: (a) NH_3 (b) O_2 (c) CO (d) H_2 (e) $Fe_2(CO_3)_3$

0.10 Fill the conversion factor that calculates the final property:

$$4\ \cancel{\text{moles of } CO_2} \times \frac{\square\ \text{g of } CO_2}{\square\ \cancel{\text{moles of } CO_2}} = \square\ \text{g of } CO_2.$$

0.11 Fill the conversion factor that calculates the final property:

$$10\ \cancel{\text{g of NO}} \times \frac{\square\ \text{moles of NO}}{\square\ \cancel{\text{g of NO}}} = \square\ \text{moles of NO}.$$

0.12 Fill the conversion factor that calculates the final property:

$$5\ \cancel{\text{moles of } C_6H_{12}O_6} \times \frac{\square}{\square} = \square\ \text{g of } C_6H_{12}O_6.$$

0.13 Fill the conversion factor that calculates the final property:

$$7\ \cancel{\text{g of } CH_4N_2O} \times \frac{\square}{\square} = \square\ \text{moles of } CH_4N_2O.$$

0.14 Fill the conversion factor that calculates the final property:

$$10^{26}\ \cancel{\text{molecules of } NO_2} \times \frac{\square\ \text{atoms of O}}{\square\ \cancel{\text{molecules of } NO_2}} = \square\ \text{atoms of O}.$$

0.15 Fill the conversion factor that calculates the final property:

$$10^{22}\ \cancel{\text{atoms of O}} \times \frac{\square\ \text{molecules of } H_2O}{\square\ \cancel{\text{atoms of O}}} = \square\ \text{molecules of } H_2O$$

0.16 Fill the conversion factor that calculates the final property:

$$6 \text{ molecules of } \cancel{C_6H_{12}O_6} \times \frac{\qquad}{\qquad}$$
$$= \qquad \text{atoms of C.}$$

0.17 Fill the conversion factor that calculates the final property:

$$10^{21} \cancel{\text{ atoms of N}} \times \frac{\qquad}{\qquad}$$
$$= \qquad \text{molecules of } CH_4N_2O.$$

0.18 Answer the following questions: (a) Calculate the number of C atoms in 3 moles of $C_{10}H_{14}N_2$? (b) Calculate the number of H atoms in 3 moles of $C_{10}H_{14}N_2$? (c) Calculate the number of N atoms in 3 moles of $C_{10}H_{14}N_2$

0.19 Answer the following questions: (a) How many grams are there in 4 moles of $C_6H_{12}O_6$? (b) How many C atoms are there in 3 moles of $C_6H_{12}O_6$?(c) How many O atoms are there in 3 moles of $C_6H_{12}O_6$?

0.20 Calculate the molar weight of the following molecules: (a) benzene, C_6H_6 (b) Carbon disulfide, CS_2 (c) Nitrogen tetroxide, N_2O_4

0.21 Calculate the molar weight of the following molecules: (a) Sulfur dioxide, SO_2 (b) Unsymmetrical dimethyl hydrazine, $(CH_3)_2NNH_2$ (c) Dimethyl sulfide, $(CH_3)_2S$

0.22 Fill the conversion factor that calculates the final property, given that the molar mass of C_2H_6 is 30g/mol:

$$7 \times 10^{21} \text{ atoms of C} \times \frac{\qquad}{\qquad} \times \frac{\qquad}{\qquad}$$
$$= \qquad \text{moles of } C_2H_6$$

0.23 Fill the conversion factor that calculates the final property, given that the molar mass of C_2H_6 is 30g/mol:

$$5 \times 10^{25} \text{ atoms of H} \times \frac{\qquad}{\qquad} \times \frac{\qquad}{\qquad}$$
$$\times \frac{\qquad}{\qquad} = \qquad \text{g of } C_2H_6$$

Chemical Reactions

0.24 Balance the following reactions:

(a) $P_4(s) + O_2(g) \longrightarrow P_4O_{10}(s)$

(b) $Al(s) + O_2(g) \longrightarrow Al_2O_3(s)$

0.25 Balance the following reactions:

(a) $FeS(s) + O_2(g) \longrightarrow Fe_2O_3(s) + SO_2(g)$

(b) $NH_3(g) + O_2(g) \longrightarrow NO(g) + H_2O(g)$

0.26 Classify next reaction as combination, decomposition, single replacement, double replacement, or combustion:

(a) $Pb_{(s)} + FeSO_{4(s)} \longrightarrow PbSO_{4(s)} + Fe_{(s)}$

(b) $C_6H_{12(g)} + 9\,O_{2(g)} \longrightarrow 6\,CO_{2(g)} + 6\,H_2O_{(g)}$

(c) $2\,RbNO_{3(aq)} + BeF_{2(aq)} \longrightarrow Be(NO_3)_{2(aq)} + 2\,RbF_{(aq)}$

0.27 Balance the following reactions:

(a) $H_{2(g)} + Br_{2(g)} \longrightarrow HBr_{(g)}$

(b) $C_{(g)} + O_{2(g)} \longrightarrow CO_{(g)}$

(c) $O_{3(g)} \longrightarrow O_{2(g)}$

(d) $NH_4NO_{2(aq)} \longrightarrow N_{2(g)} + H_2O_{(l)}$

(e) $Na_3PO_{4(aq)} + MgCl_{2(aq)} \longrightarrow Mg_3(PO_4)_{2(aq)} + NaCl_{(aq)}$

Stoichiometry and Mass Calculations

0.28 Fill the mole ratio for the following reaction:

$$C_6H_{12}O_6(s) + 6\,O_2(g) \longrightarrow 6\,CO_2(g) + 6\,H_2O(g)$$
$$\frac{\qquad \text{moles of } C_6H_{12}O_6}{\qquad \text{moles of } O_2}$$

0.29 Fill the mole ratio for the following reaction:

$$C_6H_{12}O_6(s) + 6\,O_2(g) \longrightarrow 6\,CO_2(g) + 6\,H_2O(g)$$
$$\frac{\qquad \text{moles of } O_2}{\qquad \text{moles of } CO_2}$$

0.30 Fill the conversion factor that calculates the moles of oxygen needed to react with 2 moles of Silver producing AgO:

$$2\,Ag(s) + O_2(g) \longrightarrow 2\,AgO(s)$$
$$2 \cancel{\text{ moles of Ag}} \times \frac{\qquad \text{moles of } O_2}{\qquad \cancel{\text{moles of Ag}}}$$
$$= 1 \text{ moles of } O_2.$$

0.31 Fill the conversion factor that calculates the moles of AgO produced from 2 moles of Silver:

$$2\,\mathrm{Ag(s)} + \mathrm{O_2(g)} \longrightarrow 2\,\mathrm{AgO(s)}$$

$$2\ \cancel{\text{moles of Ag}} \times \frac{\qquad\ \text{moles of AgO}}{\qquad\ \cancel{\text{moles of Ag}}} = 2 \text{ moles of AgO}.$$

0.32 Fill the conversion factor that calculates the moles of AgO produced from 10 moles of oxygen:

$$2\,\mathrm{Ag(s)} + \mathrm{O_2(g)} \longrightarrow 2\,\mathrm{AgO(s)}$$

$$10\ \cancel{\text{moles of } O_2} \times \frac{\qquad\ \text{moles of AgO}}{\qquad\ \cancel{\text{moles of } O_2}} = 20 \text{ moles of AgO}.$$

0.33 Calculate how many moles of nitrogen are needed to react with 5 moles of hydrogen, to produce ammonia:

$$\underset{5\text{ moles}}{3\,\mathrm{H_2(g)}} + \underset{\qquad\text{moles}}{\mathrm{N_2(g)}} \longrightarrow 2\,\mathrm{NH_3(g)}$$

0.34 Calculate the number of grams of nitrogen needed to react with 4 moles of hydrogen, to produce ammonia:

$$\underset{4\text{ moles}}{3\,\mathrm{H_2(g)}} + \underset{\qquad\text{grams}}{\mathrm{N_2(g)}} \longrightarrow 2\,\mathrm{NH_3(g)}$$

0.35 Calculate the number of grams of hydrogen needed to react with 0.3 moles of nitrogen, to produce ammonia:

$$\underset{\qquad\text{grams}}{3\,\mathrm{H_2(g)}} + \underset{0.3\text{ moles}}{\mathrm{N_2(g)}} \longrightarrow 2\,\mathrm{NH_3(g)}$$

PERCENT YIELD AND LIMITING REAGENT

0.36 Six moles of nitrogen gas react to produce three moles of ammonia according to the following reaction:

$$\underset{6\text{ moles}}{3\,\mathrm{H_2(g)}} + \mathrm{N_2(g)} \longrightarrow \underset{3\text{ moles}}{2\,\mathrm{NH_3(g)}}$$

0.37 Six moles of nitrogen gas react to produce two moles of ammonia according to the following reaction:

$$\underset{6\text{ moles}}{3\,\mathrm{H_2(g)}} + \mathrm{N_2(g)} \longrightarrow \underset{2\text{ moles}}{2\,\mathrm{NH_3(g)}}$$

0.38 We mix three moles of hydrogen gas with three moles of nitrogen gas.

$$\underset{3\text{ moles}}{3\,\mathrm{H_2(g)}} + \underset{3\text{ moles}}{\mathrm{N_2(g)}} \longrightarrow 2\,\mathrm{NH_3(g)}$$

Calculate the limiting reagent.

0.39 We mix three moles of hydrogen gas with half a mole of nitrogen gas.

$$\underset{3\text{ moles}}{3\,\mathrm{H_2(g)}} + \underset{0.5\text{ moles}}{\mathrm{N_2(g)}} \longrightarrow 2\,\mathrm{NH_3(g)}$$

Calculate the limiting reagent.

0.40 We mix two moles of hydrogen gas with five moles of nitrogen gas.

$$\underset{2\text{ moles}}{3\,\mathrm{H_2(g)}} + \underset{5\text{ moles}}{\mathrm{N_2(g)}} \longrightarrow 2\,\mathrm{NH_3(g)}$$

Calculate the limiting reagent.

0.41 Liquid mercury reacts with gas chlorine to produce mercury(II) choride, a white solid:

$$\mathrm{Hg(l)} + \mathrm{Cl_2(g)} \longrightarrow \mathrm{HgCl_2(s)}$$

In an experiment, 5-mL of mercury (AW=200.59g/mol) with density 5g/mL, reactants with 4-g of chlorine to produce 6g of $HgCl_2$. What is the percent yield of the reaction.

0.42 Mercury(II) halides can be converted into mercury (I) halides by combination with metallic mercury. Mercury(I) halides are known as mercurous halides. When chlorine is the halide, the resulting mercury salt is known as calomel:

$$\mathrm{HgCl_2(s)} + \mathrm{Hg(l)} \longrightarrow \mathrm{Hg_2Cl_2(s)}$$

When 2 grams of mercury(II) chloride reacts to produce 2 grams of calomel, calculate the percent yield of the reaction.

0.43 The Wurtz reaction results from the reaction of bromomethane (CH_3Br) with sodium to produce ethylene (C_2H_6)

$$2\,\mathrm{CH_3Br_{(g)}} + 2\,\mathrm{Na_{(s)}} \longrightarrow \mathrm{C_2H_{6(g)}} + 2\,\mathrm{NaBr_{(s)}}$$

How many grams of sodium are need to produce 3g of ethylene given that the yield of the reaction is 30%.

0.44 Nitriles with stannous chloride ($SnCl_2$) in the presence of hydrochloric acid produce an imine.

$$\underset{nitrile}{CH_3CN(aq)} + SnCl_{2(aq)} + HCl_{(aq)} \longrightarrow \underset{imine}{CH_3CHNH(aq)}$$

How many moles of imine (MW=43g/mol) are produced if we react 3g of nitrile (MW=41g/mol), with 2g of stannous chloride (MW=188g/mol) and 1g of hydrochloric acid (MW=36g/mol).

Answers **0.1** (a) 4.8×10^{24} (b) 6.0×10^{24} **0.2** (a) 2.4×10^{24} (b) 3×10^{25} **0.3** (a) 0.99 moles of NO (b) 8.3×10^{-9}moles of NaCl (c) 4983.39 moles of MgO **0.4** (a) 5.3×10^{-3} moles of H_2O (b) 0.33 moles of CO_2 **0.5** 10^{24} $\cancel{\text{molecules of } NO_2} \times \frac{1 \text{ moles of } NO_2}{6.02 \times 10^{23} \cancel{\text{ molecules of } NO_2}} = 1.66$ moles of NO_2. **0.6** $3 \cancel{\text{ moles of NO}} \times \frac{6.02 \times 10^{23} \text{ molecules of NO}}{1 \cancel{\text{ moles of NO}}} = 1.8 \times 10^{24}$ molecules of NO. **0.7** $6 \cancel{\text{ moles of } C_6H_{12}O_6} \times \frac{6.02 \times 10^{23} \text{ molecules of } C_6H_{12}O_6}{1 \cancel{\text{ moles of } C_6H_{12}O_6}} = 3.6 \times 10^{24}$ molecules of $C_6H_{12}O_6$. **0.8** 10^{25} $\cancel{\text{molecules of } CH_4N_2O} \times \frac{1 molof CH_4N_2O}{6.02 \times 10^{23} \cancel{\text{ molecules of } CH_4N_2O}} = 16.6$ moles of CH_4N_2O. **0.9** (a) 17 $g \cdot mol^{-1}$ (b) 32 $g \cdot mol^{-1}$ (c) 28 $g \cdot mol^{-1}$ (d) 2 $g \cdot mol^{-1}$ (e) 218 $g \cdot mol^{-1}$ **0.10** $4 \cancel{\text{ moles of } CO_2} \times \frac{44 \text{ g of } CO_2}{1 \cancel{\text{ moles of } CO_2}} =$ 176 g of CO_2. **0.11** $10 \cancel{\text{ g of NO}} \times \frac{1 \text{ moles of NO}}{30 \cancel{\text{ g of NO}}} = 0.33$ moles of NO. **0.12** $5 \cancel{\text{ moles of } C_6H_{12}O_6} \times \frac{180 \text{ g of } C_6H_{12}O_6}{1 \cancel{\text{ moles of } C_6H_{12}O_6}} = 900$ g of $C_6H_{12}O_6$. **0.13** $7 \cancel{\text{ g of } CH_4N_2O} \times \frac{1\text{mol of } CH_4N_2O}{60 \cancel{\text{ g of } CH_4N_2O}} = 0.12$ moles of CH_4N_2O. **0.14** 10^{26} $\cancel{\text{molecules of } NO_2} \times \frac{2 \text{ atoms of O}}{1 \cancel{\text{ molecules of } NO_2}} = 2 \times 10^{26}$ atoms of O. **0.15** $10^{22} \cancel{\text{ atoms of O}} \times \frac{1 \text{ molecules of } H_2O}{2 \cancel{\text{ atoms of O}}} = 5 \times 10^{21}$ molecules of H_2O **0.16** $6 \cancel{\text{ molecules of } C_6H_{12}O_6} \times \frac{6 \text{ atoms of C}}{1 \cancel{\text{ molecule of } C_6H_{12}O_6}} =$ 36 atoms of C **0.17** $10^{21} \cancel{\text{ atoms of N}} \times \frac{1 \text{ molecules of } CH_4N_2O}{1 \cancel{\text{ atoms of N}}} = 10^{21}$ molecules of CH_4N_2O **0.18** (a) 1.8×10^{25} atoms (b) 2.5×10^{-25} atoms (c) 3.6×10^{-24} atoms **0.19** (a) 720.64 grams (b) 2×10^{27} atoms (c) 3.9×10^{27} atoms **0.20** (a) 78.114 g/mole (b) 76.143 g/mole (c) 92.011 g/mole **0.21** (a) 64.065 g/mole (b) 60.0984g/mole (c) 62.136 **0.22** 7×10^{21} atoms of C $\times \frac{1 \text{ molecule of } C_2H_6}{2 \text{ atoms of C}} \times \frac{1 \text{ mole of } C_2H_6}{6.02 \times 10^{23} \text{ molecule of } C_2H_6} = 5.8 \times 10^{-3}$ moles of C_2H_6 **0.23** 5×10^{25} atoms of H $\times \frac{1 \text{ molecule of } C_2H_6}{6 \text{ atoms of H}} \times \frac{1 \text{ mole of } C_2H_6}{6.02 \times 10^{23} \text{ molecule of } C_2H_6} \times \frac{30 \text{ g of } C_2H_6}{1 \text{ mole of } C_2H_6} =$ 415 g of C_2H_6 **0.24** (a) $P_4(s) + 5\,O_2(g) \longrightarrow P_4O_{10}(s)$ (b) $4\,Al(s) + 3\,O_2(g) \longrightarrow 2\,Al_2O_3(s)$ **0.25** (a) $4\,FeS(s) + 7\,O_2(g) \longrightarrow 2\,Fe_2O_3(s) + 4\,SO_2(g)$ (b) $4\,NH_3(g) + 5\,O_2(g) \longrightarrow 4\,NO(g) + 6\,H_2O(g)$ **0.26** (a) single replacement (b) combustion (c) double replacement **0.27** not provided **0.28** 1/6 **0.29** 6/6 **0.30** 1/2 **0.31** 2/2 **0.32** 20 **0.33** 3.3 moles **0.34** 37.3 g **0.35** 1.8 g **0.36** 25% **0.37** 16.6% **0.38** H_2 **0.39** N_2 **0.40** H_2 **0.41** 88% **0.42** 47% **0.43** 15.55g **0.44** 0.45g