3.2 Introducing the Mole — The Central Unit of Chemistry

Warm Up, p. 115

1. the number of slurps per gulp
2. $15 \text{ gulps} \times \frac{4 \text{ slurps}}{1 \text{ gulp}} = 60 \text{ slurps}$
3. $20 \text{ slurps} \times \frac{1 \text{ gulp}}{5 \text{ slurps}} = 4 \text{ gulps}$

Quick Check, p. 116

1. a. For example: They both represent a number.
   b. For example: A dozen is known to be 12 of anything whereas we don't know exactly how many things are in a mole.
2. 35.5 g
3. 32.1 g

Practice Problems — Converting Moles to Number of Items, p. 117

1. $3.5 \text{ mol } Cr^{3+} \times \frac{6.02 \times 10^{23} \text{ ions } Cr^{3+}}{1 \text{ mol } Cr^{3+}} = 2.1 \times 10^{24} \text{ ions } Cr^{3+}$

2. $30.0 \text{ mol } H_2O \times \frac{6.02 \times 10^{23} \text{ molecules } H_2O}{1 \text{ mol } H_2O} = 1.81 \times 10^{25} \text{ molecules } H_2O$

3. $0.023 \text{ mol Na} \times \frac{6.02 \times 10^{23} \text{ atoms Na}}{1 \text{ mol Na}} = 1.4 \times 10^{22} \text{ atoms Na}$

Practice Problems — Converting Number of Items to Moles, p. 118

1. $1.81 \times 10^{22} \text{ atoms Ar} \times \frac{1 \text{ mol Ar}}{6.02 \times 10^{23} \text{ atoms Ar}} = 0.0301 \text{ mol Ar}$

2. $2.25 \times 10^{24} \text{ molecules } CO_2 \times \frac{1 \text{ mol } CO_2}{6.02 \times 10^{23} \text{ molecules } CO_2} = 3.74 \text{ mol } CO_2$

3. $9.27 \times 10^{22} \text{ formula units NaCl} \times \frac{1 \text{ mol NaCl}}{6.02 \times 10^{23} \text{ formula units NaCl}} = 0.154 \text{ mol NaCl}$

Practice Problems — Determining a Compound's Formula Mass and/or Molar Mass, p. 119

1. NO_2 1(14.0 u) + 2(16.0 u) = 46.0 u
2. $Na_2Cr_2O_7$ 2(23.0 g) + 2(52.0 g) + 7(16.0 g) = 262.0 g or 262.0 g/mol
3. Fe_2S_3 2(55.8 g) + 3(32.1 g) = 207.9 g or 207.9 g/mol

Practice Problems — Converting Moles to Mass, p. 120

1. $2.65 \text{ mol NaCl} \times \frac{58.5 \text{ g NaCl}}{1 \text{ mol NaCl}} = 155 \text{ g NaCl}$

2. $0.87 \text{ mol } NH_3 \times \frac{17.0 \text{ g } NH_3}{1 \text{ mol } NH_3} = 15 \text{ g } NH_3$

3. $2.0 \times 10^{12} \text{ mol } H_2SO_4 \times \frac{98.1 \text{ g } H_2SO_4}{1 \text{ mol } H_2SO_4} \times \frac{1 \text{ kg } H_2SO_4}{1000 \text{ g } H_2SO_4} \times \frac{1 \text{ tonne } H_2SO_4}{1000 \text{ g } H_2SO_4}$
   $= 2.0 \times 10^{8} \text{ tonnes } H_2SO_4$

Practice Problems — Converting Mass to Moles, p. 120

1. $62.2 \text{ g Au} \times \frac{1 \text{ mol Au}}{197.0 \text{ g Au}} = 0.316 \text{ mol Au}$

2. $3.88 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.0 \text{ g } CO_2} = 0.0882 \text{ mol } CO_2$

3. $500.0 \text{ mg } (NH_4)_2CO_3 \times \frac{1 \text{ g } (NH_4)_2CO_3}{1000 \text{ mg } (NH_4)_2CO_3} = 0.5000 \text{ g } (NH_4)_2CO_3$

   $0.5000 \text{ g } (NH_4)_2CO_3 \times \frac{1 \text{ mol } (NH_4)_2CO_3}{96.0 \text{ g } (NH_4)_2CO_3} = 0.00521 \text{ mol } (NH_4)_2CO_3$

3.2 Activity: A Mole of Pennies, p. 121

1. For example: 8.6×10^{17} km
2. For example: 1.5×10^{21} kg

3.2 Review Questions, p. 122

1. a. A quantity equal to the number of atoms in the atomic mass of any element expressed in grams
   b. $6.02214179 \times 10^{23}$
   c. Avogadro's number

2. a. 12.0 g
   b. 36.0 g
   c. 64.2 g

3. a. 55.8 g
   b. molar mass

4. a. 44.0 u
   b. 74.1 u
   c. 154.0 g

5. $3.2 \text{ mol C} \times \frac{6.02 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}} = 1.9 \times 10^{24} \text{ atoms C}$

6. $0.0085 \text{ moles } C_2H_6 \times \frac{6.02 \times 10^{23} \text{ molecules } C_2H_6}{1 \text{ mol } C_2H_6} = 5.1 \times 10^{21} \text{ molecules } C_2H_6$

7. $1.4 \times 10^{18} \text{ atoms Ag} \times \frac{1 \text{ mol Ag}}{6.02 \times 10^{23} \text{ atoms Ag}} = 2.3 \times 10^{-6} \text{ mol Ag}$

8. $2.99 \text{ g Na} \times \frac{1 \text{ mol Na}}{23.0 \text{ g Na}} = 0.130 \text{ mol Na}$

9. $5.2 \text{ mol F} \times \frac{19.0 \text{ g F}}{1 \text{ mol F}} = 99 \text{ g F}$

10. $2.0 \text{ g Li} \times \frac{1 \text{ mol Li}}{6.9 \text{ g Li}} = 0.316 \text{ mol Li}$

11. $0.32 \text{ mol } NaNO_2 \times \frac{69.0 \text{ g } NaNO_2}{1 \text{ mol } NaNO_2} = 22 \text{ g } NaNO_2$

12. $0.058 \text{ g } C_8H_{10}N_4O_2 \times \frac{1 \text{ mol } C_8H_{10}N_4O_2}{194.0 \text{ g } C_8H_{10}N_4O_2} = 3.0 \times 10^{-4} \text{ mol } C_8H_{10}N_4O_2$

13. $0.725 \text{ mol } CO_2 \times \frac{6.02 \times 10^{23} \text{ molecules } CO_2}{1 \text{ mol } CO_2} = 4.36 \times 10^{23} \text{ molecules } CO_2$

14. $1.70 \times 10^{9} \text{ molecules Pher} \times \frac{1 \text{ mol Pher}}{6.02 \times 10^{23} \text{ molecules Pher}} = 2.82 \times 10^{-15} \text{ mol Pher}$

15. $1300 \text{ g Ti} \times \frac{1 \text{ mol Ti}}{47.9 \text{ g Ti}} = 27 \text{ mol Ti}$

16. $1.75 \text{ mol } CuSO_4, 5H_2O \times \frac{249.6 \text{ g } CuSO_4, 5H_2O}{1 \text{ mol } CuSO_4, 5H_2O} = 437 \text{ g } CuSO_4, 5H_2O$

17. 8.18×10^6 mol $NH_3 \times \frac{17.0\ g\ NH_3}{1\ mol\ NH_3} \times \frac{1\ tonne\ NH_3}{1000\ g\ NH_3} = 1.39 \times 10^5$ tonnes NH_3

18. 2.640×10^3 g $(NH_4)PO_4 \times \frac{1\ mol\ (NH_4)PO_4}{47.9\ g\ (NH_4)PO_4} = 55$ mol $(NH_4)PO_4$

19. 5.925 mol $SnCr_2O_7 \times \frac{334.7\ g\ SnCr_2O_7}{1\ mol\ SnCr_2O_7} = 1983$ g $SnCr_2O_7$

3.3 The Wheel Model of Mole Conversions

Warm Up, p. 124

1. 15 g C
2. 1 mol Zn
3. 34 g CH_4

Practice Problems — Two Step Conversions, p. 126

1. 1×10^{18} molecules $SO_2 \times \frac{1\ mol\ SO_2}{\mathbf{6.02 \times 10^{23}}\ molecules\ SO_2} \times \frac{\mathbf{64.1}\ g\ SO_2}{1\ mol\ SO_2} = \mathbf{1 \times 10^{-4}}$ g SO_2

2. 2.1 g Br $\times \frac{1\ mol\ Br}{79.9\ g\ Br} \times \frac{6.02 \times 10^{23}\ atoms\ Br}{1\ mol\ Br} = 1.6 \times 10^{22}$ atoms Br

3. 1 atom Ag $\times \frac{1\ mol\ Ag}{6.02 \times 10^{23}\ atoms\ Ag} \times \frac{107.9\ g\ Ag}{1\ mol\ Ag} = 1.79 \times 10^{-22}$ g Ag

Practice Problems — One-, Two-, and Three-Step Conversions, p. 128

1. a. $\frac{2\ mol\ O}{1\ mol\ SO_2}$ b. $\frac{1\ mol\ C_2H_4}{4\ mol\ H}$

2. 14 g O $\times \frac{1\ mol\ O}{16.0\ g\ O} \times \frac{1\ mol\ KNO_3}{3\ mol\ O} = 0.29$ mol KNO_3

3. 2.5 g $K_2Cr_2O_7 \times \frac{1\ mol\ K_2Cr_2O_7}{\mathbf{294.2}\ g\ K_2Cr_2O_7} \times \frac{\mathbf{7}\ mol\ O}{1\ mol\ K_2Cr_2O_7} \times \frac{6.02 \times 10^{23}\ atoms\ O}{1\ mol\ O}$

   $= 3.6 \times 10^{22}$ atoms O

4. 1.23×10^{24} f.units $Na_2S \times \frac{1\ mol\ Na_2S}{6.02 \times 10^{23}\ f.units\ Na_2S} \times \frac{2\ mol\ Na^+}{1\ mol\ Na_2S} \times \frac{23.0\ g\ Na^+}{1\ mol\ Na^+}$

   $= 94.0$ g Na^+

3.3 Activity: The Evaporation Rate of Water, p. 129