(f) Mass measurements are in general more accurate than volume measurements for solids. The volume depends on the size of the particles and how tightly the solid is packed into a measuring spoon or cup. However, for small quantities it is much easier, faster, and requires less expensive equipment to measure volumes than masses. (People who bake use specific techniques and spoons to minimize the problem of varying density of solids.)

5.1 QUANTITATIVE ANALYSIS

PRACTICE

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Understanding Concepts

1. In a quantitative (complete) reaction of two reactants, both cannot be in excess. If both are present in stoichiometric ratio quantity, neither would, strictly speaking, be the limiting reagent (or both would ...).
2. A would have to be limiting. B would have to be reacted in excess, to ensure that all of A reacts — so that subsequent calculations would correctly indicate how much A was originally present.

PRACTICE

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Making Connections

3. A typical report might deal with the recently developed highly complex blood/urine analysis for recombinant human erythropoietin. EPO is a substance that can be used (illegally) by athletes to artificially increase production of red blood cells, which improves the oxygen-carrying capacity of the blood, and thus improves performance in endurance sports. The correlated career would be that of a sports-related laboratory analyst, or of a research scientist (in one example an Australian, Canadian, Chinese, and Norwegian team, working for Bayer corporation at a research centre in New York state).
4. A typical career might be that of a process and quality control analyst for any chemical industry. Such a career usually requires certification from a postsecondary technical institution.


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PRACTICE

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Applying Inquiry Skills

5. A standard curve is a graph of the relationship between quantities of any two substances involved in a quantitative stoichiometric chemical reaction. Such a curve is used to quickly predict the quantity of one of the substances when the quantity of the other is known.
6. (a) Successive 10-mL samples (aliquots) of sodium sulfide solution should be added to the lead(II) nitrate solution, allowing the precipitate to settle each time, until addition of the next aliquot causes no reaction. The total volume of sodium sulfide solution used is then in excess.
   (b) The mass of lead(II) nitrate should be the dependent variable (y-axis) and the mass of lead(II) sulfide should be the independent variable (x-axis).

Making Connections

7. The postal data could be used to make a bar graph but not a standard curve, because the postal service charges the same cost for a range of masses.

SECTION 5.1 QUESTIONS

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Understanding Concepts

1. (a) B is the limiting reagent.

   (b) $1\ A + 1\ B \rightarrow 2\ C$

   $2.1\ mol \quad n$

   $$n_C = 2.1\ \cancel{mol\ B} \times \frac{2\ mol\ C}{1\ \cancel{mol\ B}}$$

   $$n_C = 4.2\ mol$$

   The amount of C formed will be 4.2 mol.

2. $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$

   $32\ g \quad m$

   $16.05\ g/mol \quad 32.00\ g/mol$

   $$n_{CH_4} = 32\ \cancel{g} \times \frac{1\ mol}{16.05\ \cancel{g}}$$

   $$n_{CH_4} = 2.0\ mol$$

   $$n_{O_2} = 2.0\ mol \times \frac{2}{1} \qquad \text{(mole ratio } O_2 : CH_4 \text{ is } 2 : 1)$$

   $$n_{O_2} = 4.0\ mol$$

   $$m_{O_2} = 4.0\ \cancel{mol} \times \frac{32.00\ g}{1\ \cancel{mol}}$$

   $$m_{O_2} = 1.3 \times 10^2\ g = 0.13\ kg$$

   or

   $$m_{O_2} = 32\ \cancel{g\ CH_4} \times \frac{1\ \cancel{mol\ CH_4}}{16.05\ \cancel{g\ CH_4}} \times \frac{2\ \cancel{mol\ O_2}}{1\ \cancel{mol\ CH_4}} \times \frac{32.00\ g\ O_2}{1\ \cancel{mol\ O_2}}$$

   $$m_{O_2} = 1.3 \times 10^2\ g = 0.13\ kg$$

   The minimium mass of oxygen required for complete combustion would be 0.13 kg. A 10% excess would be $0.13\ kg \times 110\% = 0.14\ kg$.

3. A standard curve is a graph of the relationship between quantities of any two substances involved in a quantitative stoichiometric chemical reaction. If the curve is plotted empirically, from repeated mass measurements, the reaction equation becomes irrelevant.

Applying Inquiry Skills

4. The limiting reagent must be measured accurately, because the predictive calculation is made from this value.
5. Successive samples (aliquots) of excess reagent solution should be added to the limiting reagent solution, allowing the precipitate to settle each time, until addition of the next aliquot causes no reaction. The total volume of excess reagent solution used is then empirically in excess.
6. Several reactions must be done with samples of aluminum of varying masses, and excess copper(II) sulfate solution each time. From the measured mass of copper produced each time, an average copper/aluminum mass ratio can be calculated, and used to draw a standard "curve" for this reaction.

Making Connections

7. Almost all everyday and workplace situations that involve a quantity ratio are now performed by calculators, rather than by use of tables or graphs. Everyday examples include cooking quantities and automobile mileage; while work examples might be quantities used in photofinishing, or mixing herbicide solutions on a farm, or a whole host of other examples.