(b) Decomposition
$2AlF_3 \rightarrow 2Al + 3F_2$
(c) Single replacement
$3CuSO_4 + 2Al \rightarrow Al_2(SO_4)_3 + 3Cu$
(d) Combustion
$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$
(e) Combustion
$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$
(f) Double replacement
$AgNO_3 + NaBr \rightarrow NaNO_3 + AgBr$
(g) Single replacement
$2CsI + Cl_2 \rightarrow 2CsCl + I_2$
(h) Neutralization
$HCl + NaOH \rightarrow NaCl + H_2O$
(i) Double replacement
$K_2Cr_2O_7 + 2AgNO_3 \rightarrow Ag_2Cr_2O_7 + 2KNO_3$
(j) Combustion
$C_5H_{10}O_5 + 5O_2 \rightarrow 5CO_2 + 5H_2O$

6. $2\ Fe + 3Cl_2 \rightarrow 2FeCl_3$

Pause and Reflect Answer

It is not useful to look for the presence of water in the products to help classify the reaction as water can be formed in synthesis, neutralization, and combustion reactions.

Other Assessment Opportunities

- Assessment Checklist 1, Making Observations and Inferences
- Assessment Checklist 4, Laboratory Report
- Assessment Checklist 25, Safety Checklist
- Process Skills Rubric 7, Predicting
- Process Skills Rubric 8, Interpreting Data
- Assessment Rubric 5, Conduct an Investigation Rubric
- Assessment Rubric 11, Communication Rubric
- Assessment Rubric 12, Using Tools, Equipment, and Materials Rubric

6.2 FACTORS AFFECTING THE RATE OF CHEMICAL REACTIONS

BACKGROUND INFORMATION

This section is different from the other chemistry topics studied in this course because, unlike chemical equations, which focus on the reactants and then on the products (before and after the reaction), a study of rates focusses on what is going on during the reaction. In a sense, the part of a chemical equation that has to do with rates is the arrow in the middle. Although the rate of any reaction depends on the particular nature of the reactants, there are certain aspects that are predictable regardless of their identity. For example, increasing temperature always speeds up reaction rates. This is because an increase in temperature at the atomic level corresponds to particles moving faster, on average. This results in more collisions between particles occurring at a higher energy than before heating. Increasing the concentration of a gas or an aqueous substance increases the number of collisions as well, so increasing concentration always increases the rate of a reaction as well. Similarly, for those reactions that take place at a surface, such as when a piece of solid zinc sits in a solution of hydrochloric acid, the greater the surface contact, the greater the chance of collisions between reactant particles, so increasing surface area always increases rate. Not all systems have a surface. For example, methane and oxygen gases mix so that surface area is not an issue in this case.

Lastly, catalysts always help to speed up a reaction. They do not create more collisions, but they make the collisions that do happen produce product more frequently than in the absence of a catalyst. They do this by improving the geometry of the collisions. For example, in the case of an enzyme, or biological catalyst, the enzyme often literally attaches to both reactants and then changes its own shape to cause the reactant molecules to approach each other perfectly lined up. Better geometry means the energy barrier to the reaction is lower than it otherwise would be, so more collisions have sufficient energy to produce products than without the catalyst. After the reaction, an enzyme simply releases the product and then is free to do the same thing with more reactants. In this way, the catalyst is not used up by the reaction. There are other ways in which catalysts work, but they all speed up reactions by providing a way to lower the energy barrier. At the end of the reaction, catalysts are present unchanged from their initial state.

COMMON MISCONCEPTIONS

- Students sometimes fail to make the connection that a high reaction rate is connected to a short reaction time and, conversely, a low reaction rate means a long reaction time. Avoid mixing terms, such as “a fast time” or a “long rate.”
- It is not possible to increase the concentration of a solid in any practical sense. This is because solids do not compress or expand significantly.