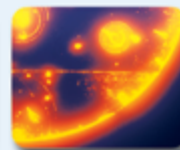
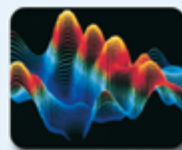


Chemistry in Action



Breaking Up Is Easy To Do

It may seem obvious that chemistry is important in the making of materials, but chemistry is also vital to the study of how materials break. Everyday items have to be made to withstand various types of force and pressure or they cannot be used. For example, scientists and engineers work to ensure that highway bridges do not collapse.

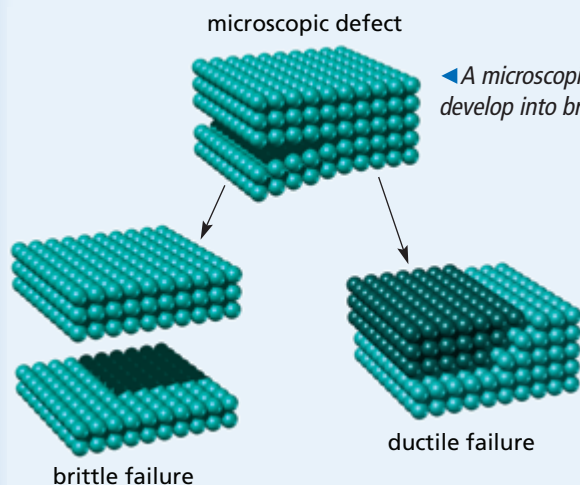
When excessive force is applied to an object, the material that the object is made of will break. The object breaks because the force creates stress on the bonds between the atoms of the material and causes the bonds to break. This creates microscopic cracks in the material. When a material breaks, it is said to have undergone *failure*. Materials typically break in one of two ways: *ductile failure* and *brittle failure*. Both types of failure start with microscopic cracks in the material. However, the way a material eventually breaks depends on how its atoms are organized.

Shattering glass undergoes brittle failure. Glass shatters when the bonds between the two layers of atoms that are along the initial crack break. This breakage causes the layers to pull apart, which separates the material into pieces. This type of failure is common in materials that do not have a very orderly arrangement of atoms.

When a car bumper crumples, ductile failure happens. This type of failure tends to happen in materials such as metals, that have a regular, ordered arrangement of atoms. This arrangement of atoms is known as a *crystal structure*. Ductile failure happens when the bonds in the material break across many layers of atoms that are not in the same plane as the original crack. Rather than splitting apart, the layers slip past each other into new positions. The atoms form new chemical bonds, between them and the material stays in one piece; only the shape has changed.

In addition to the type of material influencing breakage, the quality of the material also influences breakage. All objects contain microscopic defects, such as bubbles in plastic pieces. A material will tend to undergo failure at its defect sites first. Careful fabrication procedures can minimize, but not completely eliminate, defects in materials.

Even though materials are designed to withstand a certain amount of force, the normal wear and tear that materials experience over their lifetimes creates defects in the material. This process is referred to as *fatigue*. If fatigue were to go undetected, the microscopic cracks that form could then undergo brittle or ductile failure. It would be catastrophic if the materials in certain products, such as airplane parts, failed. To avoid such a failure, people monitor materials that are exposed to constant stress for signs of fatigue. The defects in the metal parts of airplanes can be detected with nondestructive techniques, such as electromagnetic analysis.



◀ A microscopic crack in a material can develop into brittle or ductile failure.

Questions

1. Can you name some ways in which metal or plastic parts might obtain defects caused by chemical reactions?
2. Does a ceramic dinner plate undergo brittle or ductile failure when it is dropped and breaks?