nuclides as a whole that is transformed at a constant rate. This is very similar to the way in which life insurance companies calculate that the average lifetime for the population as a whole is 73.6 years. Some people will die in their early youth and others will die at age 80 or 90. However, the average over the population as a whole will be about 73.6 years. In a similar manner, it is the average of the nuclides in our sample that matters, not the decay of the individual atoms. The second point is that different radioactive isotopes decay at different rates. Some take billions of years as in the example of rhenium 187 used to estimate the vast age of the universe. Others such as carbon 14 decay at relatively fast rates. Their lifetime is relatively short and carbon 14 is used to calculate dates up to only about 40,000 years ago.

In understanding how the radioactive clock tells geologic time, the analogy of an hourglass may be useful. (see figure A1.4) The hourglass represents a closed system. That is, the decay rate cannot be altered by physical or chemical reactions. This is generally true of radioactive clocks but sometimes the system will be upset by escape or leaching out of the daughter material or some other source of contamination.

Scientists have been able to calculate specific rates of decay for various radioactive nuclides. The decay rate of a substance is usually stated in terms of its half-life. This is the time it takes for half of the atoms of the parent to decay (become stabilized). After the first half-life, there is one-half of the radioactive element remaining; after the second half-life one quarter is left, and so on. Those most commonly used are listed in Table Al.1. They are often used as checks on one another to calibrate for possible sources of error or contamination.

Given the known rate of decay of a specific isotope, it is possible to estimate geologic age from an uncontaminated sample. This age is figured by finding the ratio between the amount of nuclides that has disintegrated (daughter) and that which has not (parent).

Minerals first crystallize upon cooling from a molten state in a newly formed rock of igneous (volcanic type) origin. At this point they normally contain no atoms of related daughter material, only parent radioactive material. The initial daughter-parent ratio is zero. The indicated age is also zero. As time passes, the daughter to parent ratio gradually increases. By factoring in the known decay rate, the radiometric age expressed in years before the present can be calculated.

Radiocarbon Dating. There is a chronological tool known as radiocarbon or carbon 14 dating used by archeologists to date more recent