Lesson 12: Introduction to SI Units

Lesson Overview

The purpose of this module is to review the relationship between the International System of Units and the customary units for radiological measurement.

Upon completion of this lesson, you will be able to:

- Describe the relationships between the International System of Units (SI Units) and the customary units for radiological measurements.
- Convert from SI to customary units and customary units to SI using a hand calculator.

Remember you can access the glossary in one of two ways throughout this course. You can select the glossary button in the top right hand corner of each main content screen. In addition, on content screens you can select underlined words to access their definitions in the online glossary. Selecting an underlined word will take you directly to its definition in the glossary.

This lesson should take approximately **1 hour** to complete.

Introduction to SI Units

The transition to measurement using the International System of Units, or SI, which stands for Systeme International d'Unites, is required by Presidential Executive Order 12770 and Public Laws 94-168 and 100-418.

To ensure a smooth transition to SI units, international and domestic organizations have begun showing information on packages and shipping documents in both the SI and customary units.

Many sources of information use customary units, such as the Curie, and others use SI units, such as the Becquerel. Going from one measurement to another requires the use of a conversion factor, which you'll learn more about later in this lesson.

Before moving on to measurement conversions, let's review the metric prefixes used to more easily express measured values.

Metric Prefixes

Since very large and very small numbers are used in quantifying radioactive materials, it is necessary to use numerical abbreviations to write the measured values in a practical way. The most common units used in measurements to describe radiation characteristics are:

- kilo (k) = 10 x 103
- milli (m) = 10 x 10-3
- micro (μ) = 10 x 10-6
- nano (n) = 10 x 10-9

- pico (p) = 10 x 10-12

Now that you understand metric prefixes, let's review common units of measure and learn their SI equivalents.

Radiological Units

- **Curie (Ci) -** The curie (Ci) describes the quantity or activity of radioactive materials. It is equal to 37 billion disintegrations per second (dps).

  Its SI equivalent, the becquerel (Bq), is equal to only 1 dps.
  Therefore:
  - 1 Bq = 27 pCi
  - 1 Ci = 37 GBq

- **Rad -** The amount of energy deposited in any material is measured in rads. The rad is the unit of absorbed dose. 1 rad = 100 ergs/gram.
  Its SI equivalent, the gray (Gy), is equal to 1 joule/kilogram.
  Therefore:
  - 1.) Gy = 100 rad

- **Rem -** The rem (roentgen equivalent man) is used to measure the dose equivalent to human tissue.
  Its SI equivalent is the sievert (Sv).
  - 2.) 1 Sv = 100 rem

Other Common Units

Many SI units are used in dose projections and accident assessments. The list below contains those most commonly used in this course.

- **Length -** The meter (m) is the SI unit of length. Common units of measure are equal to the following:
  - 1 inch (in) = 2.540 centimeters (cm)
  - 1 foot (ft) = 12 in = 30.48 cm (or 0.3048 m)
  - 1 yard (yd) = 0.9144 m • 1 mile (mi) = 5280 ft = 1.609 kilometers (km)
  - 1 km = 1000 m = 0.6214 mi

  To quickly convert between miles (mi) and kilometers (km), use the following:
  - ___ mi x 1.61 = ___ km
  - ___ km ÷ 1.61 = ___ mi

- **Velocity** - The SI unit of velocity is meters/second (m/sec). Common units of measure are equal to the following:
  - 1 mile per hour (mph) = 0.4469 m/sec (or 1.467 ft/sec = 1.609 km/h)

- 1 knot (kt) = 1.151 mph
- 1 m/sec = 3.281 ft/sec = 2.237 mph = 3.6 km/h

To quickly convert between miles per hour (mph) and meters/second (m/sec), use the following:

- ___ mph x 0.45 = ___ m/sec
- ___ m/sec ÷ 0.45 = ___ mph

- **Area** - The SI unit of area is the square meter (m2). Common units of measure are equal to the following:
  - 1 in2 = 6.452 cm2
  - 1 ft2 = 144 in2 = 929.0 cm2
  - 1 yd2 = 0.836 m2
  - 1 mi2 = 2.59 km2

  Remember that:
  - 10,000 cm2 = 1 m2
- **Volume** - The SI unit of volume is the cubic meter (m3). Common units of measure are equal to the following:
  - 1 gal = 3.785 liters (l)
  - 1 in3 = 16.387 cm3 (cc)
  - 1 ft3 = 28.32 l

  Remember that:
  - 1,000,000 cm3 = 1 m3
- **Flow rate** – An SI unit of flow rate is liters per minute (lpm). 1 cubic foot per minute (cfm) is equal to 28.32 lpm.

  To quickly convert between cfm and lpm, use the following:
  - ___ cfm x 28.32 = ___ lpm
  - ___ lpm ÷ 28.32 = ___ cfm
- **Weight** - The SI unit of weight is the gram (g). Common units of measure are equal to the following:
  - 1 ounce (oz) = 28.32 grams (g)
  - 1 pound (lb) = 0.4536 kilograms (kg)

  To quickly convert between lbs and kg, use the following:
  - ___ lbs x 0.45 = ___ kg
  - ___ kg ÷ 0.45 = ___ lbs
- **Temperature**- The SI unit of temperature is the Kelvin (K). Common units of measure are equal to the following:
  - 0° Fahrenheit (F) = –17.778° Celsius (C)
  - 1° C = 1.8° F
  - 0° C = 273° Kelvin (K)

To convert Fahrenheit (F) to Kelvin (K), you must first convert Fahrenheit (F) to Celsius (C) as follows:

- °C = (°F – 32) ÷ 1.8
- °F = (1.8 x °C) + 32

Kelvin (K) is calculated with:

- °K = °C + 273

- **Density** - The SI unit of density is the kilogram per cubic meter (kg/m3). Common units of measure are equal to the following:
  - 0.03613 lb/in3 = 1 g/cm3
  - 62.43 lb/ft3 = 1000 kg/m3
- **Pressure -** The SI unit of pressure is the pascal (Pa). Common units of measure are equal to the following:
  - 1 atmosphere (atm) = 14.696 lb/in2 = 101.33 kiloPascals (kPa) = 760 mm mercury (Hg) = 29.92 in. Hg
  - 1 pound per square inch (psi) = 6.8947 kPa

Application

Now that you have learned about several important units of measure, you will learn how to perform unit analysis for simple and complex conversions, and how to calculate activity from detector readings.

Unit Analysis – Simple Conversions

Unit analysis is the process of converting from one unit to another.

For example, one millicurie of Cs-137 equals how many becquerels?

Locate the conversion factor or factors that will allow you to convert to the desired unit. In this example, the necessary conversion factors are 1000 millicuries equals 1 curie, 1 curie equals 3.7 times 10 to the 10th disintegrations per second, and 1 becquerel equals 1 disintegration per second.

The unit analysis can now be completed by substituting in the conversion factors and solving the equation.

1 millicurie is equal to 3.7 times 10 to the 7th becquerels.

Unit Analysis – Complex Conversions

The process of unit analysis using conversion factors is applied to complex conversions as well as simple ones. 8.63 times 10 to the negative 9th sievert per becquerel equals how many millirem per picocurie?

Locate the conversion factor or factors that will allow you to convert to the desired unit. In this example, the necessary conversion factors are as follows: 1 sievert equals 100 rem.

Since 1 rem is equal to 1000 millirem, you can find that 1 sievert is equal to 1 times 10 to the 5th millirem. 1 becquerel is equal to 1 disintegration per second.

1 curie is equal to 3.7 times 10 to the 10th disintegrations per second.

Since 1 curie is equal to 1 times 10 to the 12th picocurires, you can find that 1 times 10 to the 12th picocurires equals 3.7 times 10 to the 10th disintegrations per second.

The unit analysis can now be completed by substituting in the conversion factors and solving the equation.

8.63 times 10 to the negative 9th sievert per becquerel equals 3.19 times 10 to the negative 5th millirem per picocurie.

Detector Readings

This equation is used to calculate the activity from a detector reading.

"A" represents the activity, or decay rate, measured in microcuries. This equation will be used to solve for “A.”

To find the activity, you’ll need values for ‘G,’ ‘B,’ and efficiency.

The detector efficiency will vary based on the kind of the detector and the material being measured.

G represents the gross count, in counts per minute.

B represents the background count, also in counts per minute.

With those three values, the activity can be calculated. For example: given a detector efficiency of 10% for Cesium-137, an average background rate of 216 counts per minute in the absence of the sample, and a count of 25,306 counts per minute for the sample, what is the activity of the sample in microcuries?

All the values need to be substituted in.

Then it can be solved.

The activity sample is 0.11 microcuries.

Lesson Summary

Let's summarize what you have learned in this lesson:

- The transition to measurement using SI is required by Presidential Executive Order and Public Laws.

- Common units of measure have an SI equivalent: The SI equivalent of the Curie (Ci) is the Becquerel (Bq).
- The SI equivalent of the Rad is the Gray (Gy).
- The SI equivalent of the Rem is the Seivert (Sv).

The process of converting from one unit to another is called unit analysis. It is performed with the following steps: On the left side of the equation, place the unit you are converting from.

Locate the conversion factors that will allow you to convert to the desired unit.

Multiply the right side of the equation by the conversion factors.

The next lesson will provide an overview of mathematical equations used throughout the course and how to solve problems using the equations.