4.2 RELATIVE ATOMIC MASS AND ISOTOPIC ABUNDANCE

PRACTICE

(Page 164)

Understanding Concepts

1. Atomic mass, like any other quantity, has to have a reference value with which it can be compared, for accuracy.
2. The atomic mass unit is exactly 1/12 the mass of a single atom of carbon-12. The unit symbol is u.
3. Hydrogen, oxygen, and carbon atoms have been used as reference elements for atomic mass.
4. $1.92 \times 12 \text{ u} = 23.0 \text{ u}$ is the relative atomic mass of sodium.

Making Connections

5. A communication system must be convenient, simple, and practical. To be international it must also be accepted universally. The SI and IUPAC systems are both designed around these criteria.

PRACTICE

(Page 166)

Understanding Concepts

6. (a) Average atomic mass is the average value of the mass of atoms in a sample of a naturally occurring element.
   (b) Isotopes of an element are atoms with the same number of protons, but different numbers of neutrons, and so different masses.
   (c) Isotopic abundance refers to the proportion of atoms of an element that are specific isotopes, usually given as a percentage.
7. The isotope C-12 refers to atoms with 6 protons and 6 neutrons.
8. The atomic mass of carbon is not exactly 12 u because a small percentage of carbon atoms are C-13 atoms, which increase the average value of the mass.
9. Since atoms exist as indivisible objects for chemistry purposes, we avoid talking about fractions of atoms to avoid confusion.
10. Assume 10 000 K atoms, for convenience
    93.10% or 9310 atoms are K-39
    6.90% or 690 atoms are K-41

$$m_{tot} = (9310 \times 39 \text{ u}) + (690 \times 41 \text{ u})$$
$$m_{tot} = 391\ 380 \text{ u}$$
$$m_{av} = \frac{391\ 380 \text{ u}}{10\ 000}$$
$$m_{av} = 39.14 \text{ u}$$

    The actual average atomic mass value for potassium is 39.10 u, which is very close to the value calculated by this method.
11. Assume 10 000 Ar atoms, for convenience
    99.60% or 9960 atoms are Ar-40
    0.34% or 34 atoms are Ar-36
    0.06% or 6 atoms are Ar-38

$$m_{tot} = (9960 \times 40 \text{ u}) + (34 \times 36 \text{ u}) + (6 \times 38 \text{ u})$$
$$m_{tot} = 399\ 852 \text{ u}$$
$$m_{av} = \frac{399\ 852 \text{ u}}{10\ 000}$$
$$m_{av} = 39.99 \text{ u}$$

    The actual average atomic mass value for argon is 39.95 u, which is very close to the value calculated by this method.

SECTION 4.2 QUESTIONS

(Page 167)

Understanding Concepts

1. 9 $\times$ 12 u = 108 u (assume *both* numbers are exact), which is very close to the average value for silver, Ag, which is actually 107.87 u.
2. The atomic mass unit is defined as 1/12 the mass of a C-12 atom. Atomic mass is the actual average mass of the atoms of a given element.
3. Because the elements are compared to each other based on the way they combine when they react, the reaction proportions must be known.
4. Chlorine atoms have an average atomic mass of 35.45 u, because chlorine is made up of about 75% Cl-35 atoms, and about 25% Cl-37 atoms.
5. Assume 1000 B atoms, for convenience
   19.8% or 198 atoms are B-10
   80.2% or 802 atoms are B-11

$$m_{tot} = (198 \times 10\ \text{u}) + (802 \times 11\ \text{u})$$

$$m_{tot} = 10\ 802\ \text{u}$$

$$m_{av} = \frac{10\ 802\ \text{u}}{1000}$$

$$m_{av} = 10.8\ \text{u}$$

The average atomic mass for boron is 10.8 u, calculated by this method.

4.3 THE MOLE AND MOLAR MASS

PRACTICE

(Page 168)

Understanding Concepts

1. A mole of anything is the same number of things as the number of C atoms there would be in exactly 12 g of the isotope C-12.
2. Avogadro's constant is 6.02×10^{23} (rounded to three digits ...).
   Note: Since the concepts of "pure" C-12 and "exactly" 12 g are imaginary, there is no pretense in the scientific community that we will ever know the "exact" value for Avogadro's constant. The mole is a purely theoretical definition. As technology improves, we are, of course, able to determine the value to greater precision. Rounded to six digits, the precision routinely stated in postsecondary level work, the currently accepted value is $6.022\ 14 \times 10^{23}$. The Canadian Metric Practice Guide lists 8 digits — $6.022\ 136\ 7 \times 10^{23}$. The most precise recent reported value, obtained from ion X-ray diffraction evidence, is $6.022\ 141\ 99 \times 10^{23}$. This constant, like many others that are frequently used, is usually rounded to three digits for high-school calculations.
3. 602 000 000 000 000 000 000 000 (only the first 3 digits are significant)
   Note: It is useful for students to extend this number to see how large it is, being mindful that all those trailing zeros represent numbers they don't know. It is also thought-provoking for students to consider that when written in scientific notation to the usual high-school text precision, the error of the number is 2×10^{20}, meaning we blithely ignore some two hundred millions of millions of millions, as being too small to make a noticeable difference.
4. $$N_{CO_2} = 3.00\ \cancel{\text{mol}} \times \frac{6.02 \times 10^{23}\ \text{molecules}}{1\ \cancel{\text{mol}}}$$

   $$N_{CO_2} = 1.81 \times 10^{24}\ \text{molecules}$$

   There are 1.81×10^{24} molecules of carbon dioxide in the sample.

