of moving in definite, fixed orbits around the nucleus as suggested in the Bohr model, the wave-mechanical model portrays electrons with distinct amounts of energy moving in areas called orbitals. An **orbital** is described as a region in which an electron of a particular amount of energy is most likely to be located. Models of orbitals are shown in Figure 1-3.

Thus, the modern model of the atom is not the invention of a single scientist, but rather one that has evolved over a long period of time. Figure 1-4 summarizes some of the atomic models involved in the evolution of the current atomic model.

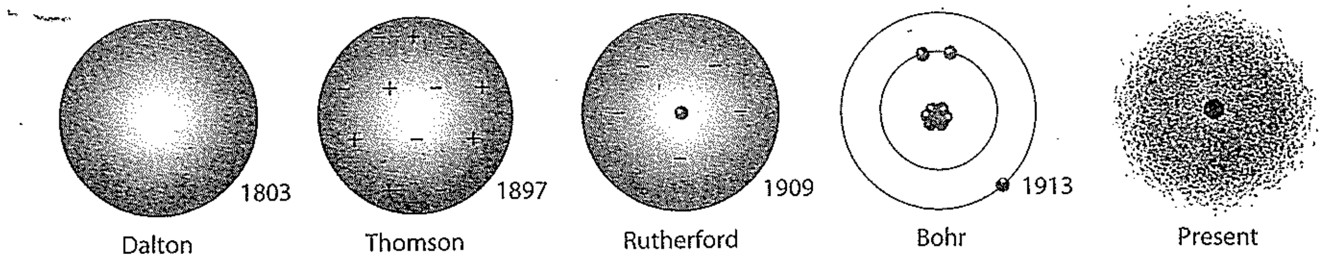

Figure 1-4. Changing views of atomic structure over time: The representations show the cannonball, plum pudding, nuclear, planetary, and wave-mechanical atomic models.

Review Questions

1. The concept that matter is composed of tiny, discrete particles is generally attributed to the
   (1) Greeks
   (2) Romans
   (3) English
   (4) Germans

2. The first subatomic particle discovered was the
   (1) proton
   (2) neutron
   (3) electron
   (4) photon

3. According to the law of the conservation of mass, if the products of a reaction have a mass of 64.0 g, then the total mass of the reactants
   (1) must be less than 64.0 g
   (2) must be equal to 64.0 g
   (3) must be more than 64.0 g
   (4) is not related to the mass of the products

4. The gold-foil experiment led scientists to conclude that an atom's
   (1) positive charge is evenly distributed throughout its volume
   (2) negative charge is mainly concentrated in its nucleus
   (3) mass is evenly distributed throughout its volume
   (4) volume is mainly unoccupied

5. The model of the atom that pictured the atom with electrons stuck randomly throughout the mass of the atom was called the
   (1) cannonball model
   (2) plum pudding model
   (3) planetary model
   (4) wave-mechanical model

6. After bombarding a gold foil sheet with alpha particles, scientists concluded that atoms mainly consist of
   (1) electrons
   (2) empty space
   (3) protons
   (4) neutrons

7. Experimental evidence indicates that the nucleus of an atom
   (1) contains most of the mass of the atom
   (2) contains a small percentage of the mass of the atom
   (3) has no charge
   (4) has a negative charge

. Dalton's atomic theory states that

(1) all atoms of an element are positively charged
(2) different elements can have the same mass
(3) atoms of a given element must be identical
(4) all the atoms in a compound are identical

. Modern theory pictures an electron as

(1) a particle only
(2) a wave only
(3) both a particle and a wave
(4) neither a particle nor a wave

10. What are the major differences between the plum pudding and planetary models of the atom?

11. Why did Rutherford conclude that the atom was mostly empty space?

12. What is a major difference between the Rutherford and the wave-mechanical models of the atom?

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igging Deeper

e concept of protons, ctrons, and neutrons as idamental particles can used to explain most of chemical behavior of atom. However, recent earch has shown that tons and neutrons are mselves made of smaller rticles called quarks. Each ark has a fractional arge of either $\frac{2}{3}+$ or $\frac{1}{3}-$. h proton and neutron is nposed of three quarks. cause it has a total 1+ arge, a proton must be nposed of two quarks each th a charge of $\frac{2}{3}+$ and one ark with a charge of $\frac{1}{3}-$. ieutron has no charge, so nust be composed of one ark with a charge of $\frac{2}{3}+$ d two quarks each with a arge of $\frac{1}{3}-$.

Subatomic Particles

You have seen that all atoms are composed of a small, dense, positively charged nucleus surrounded by a large space occupied by electrons. The nucleus contains two types of particles—protons with a positive charge, and neutrons with no charge.

Protons have a mass of only 1.67×10^{-24} g. Because the mass of a proton is so small, it is more convenient to use a different scale whose units are called **atomic mass units** to represent its mass. A proton is assigned 1.0 atomic mass unit (amu). A neutron has approximately the same mass as a proton.

Each atom of a specific element must contain the same number of protons as every other atom of that element. The number of protons in the nucleus of an atom is the **atomic number** of that element. For example, chlorine has an atomic number of 17. Each chlorine atom contains 17 protons in its nucleus.

Electrons occupy the space of an atom outside the nucleus and have a charge equal to, but opposite of, a proton. Electrons are much less massive than either the proton or neutron, having a mass of only 1/1836 amu. Table 1-1 summarizes information about each of the particles that make up an atom.

It has been mentioned that the mass of an atom is extremely small. The atomic mass scale replaces grams as the unit used to describe the masses of atoms. The nucleus of a carbon atom containing 6 protons and 6 neutrons is taken as the standard mass, and the mass of any atom is a ratio between its mass and that of the carbon nucleus. The sum of the numbers of protons and neutrons in the nucleus is called the **mass number** of the nucleus. Thus, a nucleus with 7 protons and 7 neutrons has a mass number of 14. When determining the mass of an atom, the mass of the electrons is so small it is not considered in the calculation.

Table 1-1. Some Subatomic Particles

Particle	Charge	Mass	Location	Symbol
Proton	+1	1 amu	nucleus	^1_1H or p^1_1
Neutron	0	1 amu	nucleus	^1_0n
Electron	−1	1/1836 amu	outside	$^0_{-1}e$