FIRST SCIENCE ANSWERS.

Chapter 1.

Guided Review.

1. Ratio of H-atom radius to proton radius is $5.3 \times 10^{-11}/0.9 \times 10^{-15} = 5.9 \times 10^{4}$.
   
   Radius of golf ball $\times$ ratio is $2.135 \times 10^{-2} \times 5.9 \times 10^{4} = 1.26 \times 10^{3}$ m or 1.26 km or 0.78 miles.

2. (a) The pressure (= weight divided by cross sectional area) is to be the same. The weight of the giant is 1000 times yours, therefore the bone cross section needs to be 1000 times bigger also.
   
   (b) The cross-section is proportional to the square of the radius, so that the radius (and the diameter) would have to be $\sqrt{1000} = 31.6$ times larger.

   c) $f^3$ and $\sqrt{f^3} = f^{3/2}$

3. $E_B/A = 7.5$ MeV, $A = 238$, so that $E_B = 1785$ MeV.

Problems and Reasoning Skill Building.

2. (a) solar system: use diameter of pluto’s orbit, $10^{13}$ m, sun: $10^9$ m, earth: $10^7$ m.
   
   moon: $10^6$ m.

   (b) H-atom $10^1$ eV, deuteron: $10^6$ eV

4. (a) distance to sun: $1.5 \times 10^{11}$, size of person: $2m$, $1.5 \times 10^{11}/2 \sim 10^{11}$ people.
   
   (b) size of person/size of object = $P/O = R_{\text{orbit}}/P$ so that $O = P^2/R_{\text{orbit}} = 4/1.5 \times 10^{11} \sim 2.7 \times 10^{11}$ m
   
   = approximately the size of a hydrogen atom ($r = 5.3 \times 10^{-11}$ m)

5. (a) neutron
   
   (b) electron (also muon)
   
   (c) proton
   
   (d) electron
   
   (e) neutrino

6. (a) gravitational, (b) electric, (c) nuclear, (d) electric, (e) electric

8. The nuclear and electric forces are in competition. The nucleus is held together by the nuclear force, and tends to be disrupted by the electric force. The disruptive electric force between the protons is a long-range force and affects more of the nuclei than the nuclear force, which is effective only between neighboring nucleons.

10. $^3\text{He}$: 2p, 1n; $^3\text{H}$: 1p, 2n. A proton would have to change to a neutron.


13. (a) $2.24 \times 10^6 / 13.6 = 1.6 \times 10^5$
(b) The nucleus is held together by the much stronger nuclear force. Nuclei are more stable by a factor of more than $10^5$.

15. All 100 protons will experience the additional electric repulsion. Only the ~ 6-8 nucleons surrounding the added proton will experience the added nuclear attraction. As the nucleus gets larger, the electric repulsion will increase faster than the nuclear attraction. At a certain size the nucleus will cease to be stable.

Multiple choice questions.

1. (c)
2. (b)

Synthesis problems and projects

1. The sun dominates, its radius is about $7 \times 10^8$ m. Pluto’s orbit has a mean radius of $6 \times 10^{12}$ m. The ratio is $8.6 \times 10^3$. The ratio of the volumes is the cube of this number, or $6.5 \times 10^{11}$.

2. Radius of proton: $0.9 \times 10^{-15}$ m, radius of H-atom: $5.3 \times 10^{-11}$ m. The ratio is $6 \times 10^4$. The ratio of the volumes is the cube of this number, or about $2 \times 10^{14}$. To a first approximation the ratio is not far different in other atoms, and therefore roughly also in the apple.

3. Mendeleev observed a recurring periodicity in the properties of elements if he ordered them according to their atomic weight.

4. Argon has the greater atomic weight and mass, but potassium has the higher atomic number. Mendeleev used atomic weight, but the modern table of elements is ordered by atomic number. This is the quantity, the number of protons in the nucleus, that determines the atomic structure. Similarly, iodine has the greater atomic number, but tellurium has the higher atomic weight.

6. The order of elements, according to Mendeleev, was determined by their atomic weight, not as we now see, by their atomic number. As a result some elements were not in the right order, notably argon and potassium, and tellurium and iodine.

Many elements, and even groups of elements, are missing: the rare gases, He, Ne, etc., most of the rare earths.
9. Mass and weight are proportional to \( f^3 \). The energy expenditure is proportional to \( f^2 \). It is therefore proportional to \( (f^3)^{2/3} \) or to \( M^{2/3} \). In contrast, the empirical Kleiber’s law says that the energy expenditure is proportional to \( M^{3/4} \).