Chapter 2

AN OVERVIEW OF THE PERIODIC TABLE

Exercises

2.1 (a) Elements scandium, yttrium, and lanthanum through lutetium.
(b) Apparent radius of an atom when it is in non-bonded contact with another atom
(c) Actual nuclear charge experienced by an electron in an atom.

2.3 There was no space for argon because it did not fit into any of the then-known groups (the noble gas group was then unknown). Also, because Mendeleev's table was based on measured atomic mass (atomic number was unknown at the time), argon (39.9) should have been placed between potassium (39.1) and calcium (40.1).

2.5 The long form of the table correctly depicts the order of elements; the disadvantage is that the table becomes very elongated.

2.7 The -*ium* ending is used normally to indicate a metal. The ending -*on* has been used for non-metals. When helium was discovered by spectroscopy to exist in the Sun, it was assumed to be a metal, and hence the wrong suffix was chosen and never subsequently changed.

2.9 With nuclei up to 26 protons, nuclear fusion is an exothermic process and is thus favored. Beyond this point, fusion is endothermic and requires the energy from a supernova explosion to happen.

2.11 (a) Lead (previously bismuth until it was realized that Bi-209 was radioactive with an extremely long half-life); (b) technetium; (c) bromine.

2.13 Sodium, because it has an odd number of protons (according to isotope tables, sodium has one stable isotope, that with 12 neutrons—an even number—while magnesium has three stable isotopes).

2.15 50. The number of neutrons must be greater than the number of protons. Fifty is the next higher "magic number" above 39, the proton number.

2.17 (a) Several nonmetals, such as iodine, and some compounds, such as FeS_2, fool's gold, have metallic lusters.
(b) Diamond, a carbon (nonmetal) allotrope, has the highest thermal conductivity of all substances.
(c) The other common carbon allotrope, graphite, also a nonmetal, is a good electrical conductor in two dimensions.

2.19 Potassium. As the effective atomic charge on the outermost electrons increases across a period, so the covalent radius will decrease, resulting in a smaller radius for calcium.

2.21 With the poorly shielding 3*d* orbitals having been filled corresponding to the added protons, the effective nuclear charge on the outer (4*p*) electrons will be increased; hence the covalent radius will decrease.

2.23 Table of effective nuclear charge for the second period elements using Slater's rules.

Element	**Li**	**Be**	**B**	**C**	**N**	**O**	**F**	**Ne**
Z	3	4	5	6	7	8	9	10
1*s*	2.65	3.65	4.65	5.65	6.65	7.65		
	8.65	9.65						
2*s*	1.30	1.95	2.60	3.25	3.90	4.55		
	5.20	5.85						
2*p*			2.60	3.25	3.90	4.55		
	5.20	5.85						

The differences between the simplistic Slater's rules and the more sophisticated Clementi and Raimondi method are quite small. The disadvantage of the Slater method is that it does not distinguish between *s* and *p* electrons in terms of shielding.

2.25 Effective nuclear charge on 4*s* = 2.95; 3*d* = 5.60.

2.27 Phosphorus. With increasing nuclear charge across the period, the ionization energy will increase.

2.29 Group 2. The size of the ionization energies increases rapidly between the second and third values. Hence the third and subsequent values must correspond to the ionization of inner electrons. Two outer electrons indicate that the element belongs to the alkaline earth metals (Group 2).

2.31 Electron configurations: Na = $1s^22s^22p^63s^1$; Mg = $1s^22s^22p^63s^2$. Because the 2*s* electrons of magnesium experience a higher effective nuclear charge than those of sodium, magnesium will have the higher first ionization energy. For sodium, the second electron to be removed will come from the inner 2*p* orbitals. Hence it will be sodium that has the higher second ionization energy. In both cases, the third electron to be removed will come from the 2*p* orbitals. The 2*p* electrons of magnesium will experience the higher effective nuclear charge. Thus magnesium will have the higher third ionization energy.

2.33 Positive. With an electron configuration of $1s^2$, any gained electron would add to the 2*s* orbital. This would experience stronger repulsions from the inner 1*s* electrons than attraction to the well-shielded nucleus. Hence it would be an endothermic process.

2.35 In each case, the preferred isotope will be that having a full shell of neutrons (126). Hence the answers are (a) 208; (b) 209; (c) 210.

Beyond the Basics

2.37 The average kinetic energy ($= \frac{1}{2}mv^2$) of all gases are the same under identical conditions of temperature. As dihydrogen and helium have such low molecular masses, their average velocities will be much higher. A sufficient number of molecules will have greater energy than the escape velocity for them to escape from the Earth's gravitational field. Over time, the vast majority of these molecules have escaped.

2.39 Element 117—let us call it X—would be a member of the halogens. It should be a solid at room temperature and exist as X_2 molecular units. It should form an anion X^-, but at the same time, X is on the border with metals, so positive oxidation states, particularly +1 and +3, should be quite common.

2.41 Some selected responses:

Boron	role unknown
Fluorine	role unknown
Silicon	essential for growth and skeletal development
Vanadium	deficiencies cause developmental problems
Chromium	involved in glucose metabolism
Manganese	activates numerous enzymes
Cobalt	activates enzymes, is central atom of vitamin B_{12}
Nickel	required for liver function
Selenium	component of some enzymes
Molybdenum	present in some enzymes
Tin	weak evidence of essentiality
Iodine	important in growth regulation

One source of information is E. Frieden, New Perspectives on the Essential Trace Elements, *J. Chem. Educ*. **62** (1985): 917–923. Though Frieden suggests that several other elements are essential, there does not seem to be strong evidence.