CHAPTER 1 REVIEW

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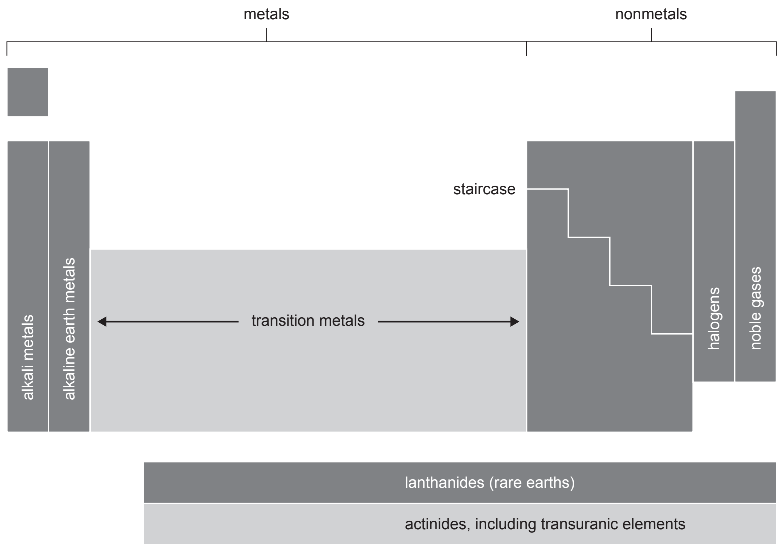
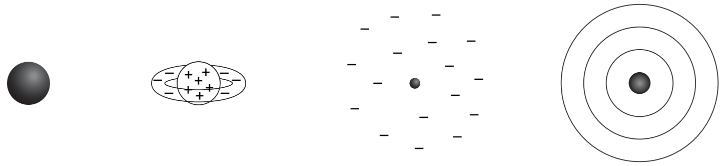
Understanding Concepts

1. Metals are malleable, ductile, and conductors of electricity. They are also described as lustrous, or shiny. Nonmetals are generally nonconductors of electricity in their solid form; at SATP the nonmetals are mostly gases or solids. Solid nonmetals are brittle and lack the lustre of metals.
2. The symbol CA is not an acceptable international symbol for calcium. The International Union of Pure and Applied Chemistry (IUPAC) specifies rules for chemical names and symbols — for elements, the first letter (only) of the symbol is to be an uppercase letter. The acceptable international symbol for calcium is Ca.
3. The periodic law came to be accepted because of Mendeleev's detailed predictions of the properties of undiscovered elements, using his knowledge of periodic trends.
4. (a) liquids at SATP: bromine, mercury; gases at SATP: hydrogen, helium, nitrogen, oxygen, fluorine, neon, chlorine, argon, krypton, xenon, radon
   (b) The "staircase line" is a zigzag line that separates metals (to the left) from nonmetals (to the right).
   (c) The noble gases remained undiscovered until the late 1800s because they are so stable and unreactive and their boiling points are so low. It is difficult to detect such an element — they would not form compounds under conditions of a typical early lab.
   (d) The atomic number of hydrogen is 1, of oxygen is 8, of aluminum is 13, of silicon is 14, of chlorine is 17, and of copper is 29.
   (e) Oxygen has 6 electrons in its outer energy level.
   (f) Carbon has 4 of its 8 electrons in its second energy level.
   (g) Beryllium would tend to lose 2 electrons.
   (h) Fluorine would tend to gain 1 electron.
5. The order of the elements did change, but only slightly. Cobalt and nickel would exchange places, as would tellurium and iodine. Scientists also added the newly discovered group, the "noble gases."
6. (a)



   (b) The number of valence electrons for alkali metals is 1, for alkaline earth metals is 2, and for halogens is 7. From his study of the periodic table, Bohr concluded that the maximum number of electrons that can populate a given shell can be calculated from the equation $2n^2$ (where n is the principal quantum number). The electrons in the highest occupied shell are called the valence electrons. According to Bohr's theory, there is a pattern linking electron arrangements to the periodic table for the representative elements.
7. (a) The most reactive metal is francium (accept cesium). The most reactive nonmetal is fluorine.
   (b) With the alkali metals, reactivity increases moving down the group, due to increasing atomic radii and decreasing first ionization energies. With the halogens, reactivity increases moving up the group, due to decreasing atomic radii and increasing electron affinity.
   (c) The Bohr model

8. Hydrogen has only one electron in the first energy level. All other elements have two electrons in the first energy level.
9. (a) Dalton (b) Nagaoka (c) Rutherford (d) Bohr



(a) indivisible atoms
(b) a positive core (nucleus) surrounded by a ring of electrons
(c) a small positive core (nucleus) surrounded by a much larger cloud of electrons
(d) a nucleus containing protons and neutrons surrounded by electrons in shells

10. While each atomic theory made significant contributions to the current understanding of atomic structure, each had shortcomings and limitations. These shortcomings resulted in ongoing intense investigation that led to the development of the succeeding theory.
11.

Subatomic particle	Relative mass	Charge	Location
Electron	1	1-	space surrounding the atom
Proton	1836.12	1+	nucleus of the atom
Neutron	1838.65	0	nucleus of the atom

12. Bohr suggested that the properties of the elements could be explained by the arrangement of electrons in orbits around the nucleus. From his study of the periodic table, Bohr concluded that there was a restriction on the number of electrons that can populate a given shell, with the valence electrons occupying the highest energy level. According to Bohr, elements in the same chemical group shared not only properties but also the number of valence electrons — a powerful indicator of the relationship between electron arrangement and periodic trends.
13. Use the representative element chlorine as an example:
   (a) The atomic number of chlorine is 17. Therefore, there are 17 protons.
   (b) The number of protons equals the number of electrons. Therefore, chlorine has 17 electrons.
   (c) In Groups 13–18 the number of valence electrons corresponds to the second digit of the group number; as chlorine is in Group 17, the number of valence electrons is 7.
   (d) Chlorine is in Period 3, so it has three occupied energy levels.
14. (a) magnesium: 12 protons, 12 electrons, 2 valence electrons
   (b) aluminum: 13 protons, 13 electrons, 3 valence electrons
   (c) iodine: 53 protons, 53 electrons, 7 valence electrons
15. (a) 11 protons and 10 electrons: sodium ion, Na^+
   (b) 18 electrons and a net charge of 3- phosphorus ion, P^{3-}
   (c) 16 protons and 18 electrons: sulfur ion, S^{2-}
16. No. Both alpha and beta decay alter the number of protons in the nucleus.
17. (a) calcium-42: 20 protons, 20 electrons, 22 neutrons
   (b) strontium-90: 38 protons, 38 electrons, 52 neutrons
   (c) cesium-137: 55 protons, 55 electrons, 82 neutrons
   (d) iron-59: 26 protons, 26 electrons, 33 neutrons
   (e) sodium-24: 11 protons, 11 electrons, 13 neutrons
18. (a) The mass number for iodine in the periodic table is 126.90. Iodine-123 has an atomic mass of 3.90 u less than the average iodine atom. The atomic mass of iodine given in the table is a weighted average of the atomic masses of each of the isotopes of the element that are normally present in any sample of the element.
   (b) As the atomic mass of 126.90 is not very close to 123, this would indicate that iodine-123 is not in great abundance in a typical sample of iodine atoms.
19. (a) Within Group 1 and 2 elements, reactivity increases moving down the group.
   (b) Within Group 16 and 17 elements, reactivity decreases moving down the group.
   (c) Within a period, reactivity tends to be high in Group 1 metals, lower in elements toward the middle of the table, and increase to a maximum in Group 17 nonmetals.
   (d) Within Group 18, the elements are stable and extremely unreactive. However, reactivity does increase from the top to the bottom of the group.
20. (a) Atomic radii decrease as you move from left to right across each period. From left to right across a period, the nuclear charge increases while the shielding effect provided by the non-valence electrons remains the same. As a

result, of the increasing nuclear charge, the electrons are more strongly attracted to the nucleus, pulling them closer to the nucleus and decreasing the size of the atom.

The atomic radii increase as you move down a given group. As you move down a group, there is an increasing number of energy levels that are filled with electrons. This has the effect of increasing the shielding effect, decreasing nuclear attraction, and increasing the size of the atom.

(b) First ionization energies generally increase as you move from left to right across a period. From left to right across a period, the nuclear charge increases while the shielding effect provided by the non-valence electrons remains the same. As a result the valence electrons are more strongly attracted to the nucleus, and more energy is required to remove an electron from the atom.

First ionization energies generally decrease as you move down a group. As you move down a group, there is an increase in the size of the atoms. As the atomic radius increases, the distance between the valence electrons and the nucleus also increases. The non-valence electrons between the nucleus and the valence electrons produce a shielding effect. As a result, the attraction between the valence electrons and the nucleus becomes weaker, so less energy is required to remove an electron from the atom.

(c) Electronegativity generally increases as you move from left to right across a period, as the attraction of the nucleus for any new electrons increases.

Electronegativity decreases as you move down a group, as new electrons are shielded from the nucleus by increasing numbers of shells of electrons.

(d) Electron affinity increases as you move from left to right across a period. Smaller atoms with larger nuclei have a stronger attraction to new electrons.

Electron affinity decreases as you move down a group. Larger atoms with more distant and more shielded nuclei have a smaller attraction for new electrons.

21. When chlorine gains an electron to form a negative ion, the repulsion forces among the electrons increase while nuclear charge remains the same. The result is an enlarged electron cloud and a greater ionic radius. When sodium loses an electron to form a positive ion, the repulsion forces among the electrons decrease while the nuclear charge remains the same. The result is a reduced electron cloud and a smaller ionic radius.

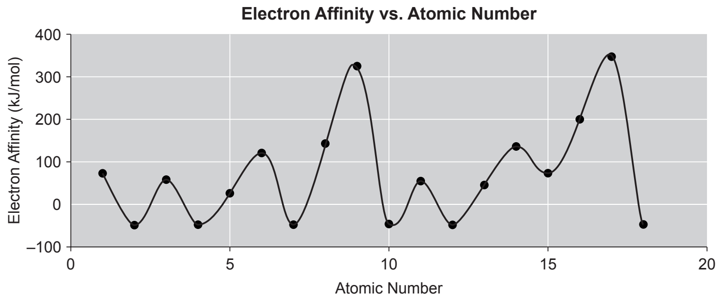
22. (a) Group 17 nonmetals from most reactive to the least reactive: fluorine, chlorine, bromine, iodine, astatine.

(b) During chemical reactions, the nonmetals of Group 17 have a tendency to gain an electron. However, electron affinity declines as you move down Group 17.

23. The noble gas group is especially interesting to chemists because elements in this group are so stable and unreactive. Bohr suggested that the properties of the elements could be explained by the arrangement of electrons around the nucleus. Bohr hypothesized that these elements have filled outermost energy levels.

Applying Inquiry Skills

24. (a)



Note: Where the electron affinity value was given as less than zero, an arbitrary -50 kJ/mol has been assigned. This has been done so that the graph will show a connected line through all points, and to show that the values fluctuate above and below zero as we move through these 18 elements.

(b) Similarities: Both graphs show a general increase in energy as you move left to right across a period. With respect to electron affinity, we know that the atomic radii tend to decrease across a period, so the attractive force between the nucleus of the atom and the new electron is stronger. And with respect to first ionization energy, it is again the decreasing atomic radii across a period and the increasing nuclear attraction that makes it harder to remove an electron.

Differences: The electron affinity graph fluctuates dramatically up and down as you move left to right across a period and shows some negative values. The negative values occur when the electron repulsive force is greater than the nuclear attractive force, and energy must be injected, instead of energy being released, in ion formation.

Unlike the graph for first ionization energy, the graph of electron affinity for these 18 elements does not show a consistent decrease in energy as you move down the groups.

(c) If the trend shown on the graph continues, the electron affinity value for rubidium would be approximately 45 kJ/mol.

25. (a) The unknown substance is a radioisotope undergoing radioactive decay.

(b) The half-life of the radioisotope is one hour — the time taken for half of the original number of radioactive atoms to decay.

26. (a) With the alkaline earth metals, reactivity increases moving down the group, due to increasing atomic radii and decreasing first ionization energies. Barium has a greater reactivity than magnesium because it has a larger atomic radius and a lower first ionization energy.

(b) The product of the reaction should be hydrogen gas. Hydrogen gas is indicated if a flaming splint at the mouth of a collecting test tube causes a "pop" or small explosion in the gas.

Making Connections

27. It would not be appropriate to store the radioisotope in a cardboard box. Due to the high speed (speed of light) and penetration characteristics of gamma rays, an effective barrier would be 1 m of lead or concrete.

28. (a) Calcium and strontium are both alkaline earth metals, with similar chemical properties. It would not be unreasonable to predict that the human body would treat strontium ions much as it does calcium ions — and so they would be incorporated into bone tissue. (This does, in fact, happen.) The effect of an unusually high concentration of strontium in the diet is greatest among those who are building bone the most rapidly — infants and children in growth spurts. If the strontium is radioactive, it will irradiate neighbouring tissue. Leukemia is often the result.

(b) The student is to use the Internet to research and report on how radioactive strontium-90 is produced and the effect it has when ingested.

(c) The student is to use the information gathered from the Internet research on strontium-90 to prepare a brief cost/benefit analysis of the testing of nuclear warheads.

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29. The student is to use the Internet to investigate Group 1 element bottle labels, MSDS information, and other sources to create a leaflet advising high-school laboratory technicians on safe ways to handle and store each of these elements.

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Exploring

30. The student is to use the Internet to research and report on the CANDU nuclear power process. The report is to include a simple diagram of a CANDU reactor and a description of the function of each part.

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