Definitions

Law of Conservation of Mass; Law of Definite Proportion; Law of Multiple Proportions

Questions

1. Who was the first person to propose that matter was composed of atoms?

2. For the following two compounds between nitrogen and hydrogen:

<table>
<thead>
<tr>
<th></th>
<th>Mass of N</th>
<th>Mass of H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound A</td>
<td>14 grams</td>
<td>3 grams</td>
</tr>
<tr>
<td>Compound B</td>
<td>14 grams</td>
<td>2 grams</td>
</tr>
</tbody>
</table>

(a) Propose formulas for the two compounds assuming that each nitrogen atom weighs the same as each hydrogen atom

(b) Propose formulas for the two compounds assuming that each nitrogen atom weighs 7 times more than each hydrogen atom

(c) Propose formulas for the two compounds assuming that each nitrogen atom weighs 14 times more than each hydrogen atom

3. Give the experimental evidence that supported each of the following:

   (a) cathode rays are composed of particles

   (b) cathode rays are negatively charged

   (c) the atom has a small, dense, positive core

4. If you wanted to make an accurate scale model of the hydrogen atom, and decided that the nucleus would have a diameter of 1 mm, what would be the diameter of the entire model?

5. Have access to Handout 1 from the Class Web Site.
HOMEWORK 1B

Definitions

Electromagnetic Radiation; Wavelength; Frequency; Quantized; Photon; Diffraction

Questions

1. One of the primary visible emissions from mercury occurs at 404.7 nm. For this given wavelength of light, calculate:
   (a) the wavelength in meters.
   (b) the frequency.
   (c) the energy of a single photon in joules.
   (d) the energy of 1 mole of photons in kilojoules.

2. The energy of electromagnetic radiation needed to remove electrons from the surface of gold atoms is 492 kJ/mol. Calculate:
   (a) the energy of a single photon of this electromagnetic radiation in joules.
   (b) the frequency of this electromagnetic radiation.
   (c) the wavelength of this electromagnetic radiation in meters.
   (d) the wavelength of this electromagnetic radiation in nanometers.

3. Have access to Handout 2 from the Class Web Site.

HOMEWORK 1C

Definitions

Continuous Spectrum; Line Spectrum; Ground State; Wave Function; Orbital; Probability Distribution; Radial Probability Distribution

Questions

1. In the Bohr model of the hydrogen atom:
   (a) what is quantized?
   (b) what is the evidence that supports this?

2. Draw an electronic energy diagram for a hydrogen atom, and using vertical lines show the following 3 transitions:
   (a) \( n = 3 \rightarrow n = 2 \)  (b) \( n = 4 \rightarrow n = 2 \)  (c) \( n = 4 \rightarrow n = 3 \)

3. Calculate the de Broglie wavelength of a baseball (mass = 0.145 kg) moving at the speed of 26.8 m/s. \( \lambda = \frac{h}{mv} \), Planck’s constant, \( h \), is 6.626 x 10^{-34} Js, which is also 6.626 x 10^{34} kgm^2/s

4. What is the experimental evidence that matter actually has wave properties?
Definitions

Nodal Surfaces; Aufbau Principle; Hund’s Rule; Valence Electrons; Core Electrons; Degenerate

Questions

1. Tell whether each of the following orbital designations are allowed or forbidden based upon the Schrödinger Equation.
   (a) 1s    (b) 2d    (c) 6g    (d) 9p

2. Draw a picture of each of the following orbitals.
   (a) 3s    (b) 3p_x    (c) 4p_x    (d) 4p_y
   (e) 5d_{xy}    (f) 5d_{sz}    (g) 5d_{x^2-y^2}

3. For the picture of an atomic orbital below to the left, assume that each dot represents a probable location for an electron in that orbital. Graph the radial probability distribution on the axis below to the right.

4. Tell what each of the following designations mean.
   (a) \( n = 2 \)    (b) \( n = 6 \)    (c) 4p    (d) 3d
   (e) 2p_z    (f) 5d_{xz}

5. Give the maximum number of electrons in an atom that can have the following designations.
   (a) \( n = 3 \)    (b) \( n = 7 \)    (c) 2p    (d) 5f
   (e) 4p_x    (f) 3d_{xy}

6. Give the orbital notation for the following atoms:
   (a) N    (b) Al    (c) S
**HOMEWORK 1E**

*Definitions*

Atomic Number; Mass Number; Isotopes

*Questions*

1. Give the electron configuration notations and the electron dot notations for the following atoms:
   (a) P          (b) Ru          (c) Ba          (d) Am

2. For the phosphorus atom from question 1, name and draw pictures of its occupied valence atomic orbitals.

3. Using radial probability distribution graphs, explain why the 3s sublevel fills before the 3p sublevel in the phosphorus atom.

4. For the following electron configuration notations of boron, identify each as a ground state electron configuration, an excited state electron configuration, or an impossible electron configuration:
   (a) 1s$^2$2s$^2$2p$^1$          (b) 1s$^2$2s$^2$3p$^1$          (c) 1s$^2$2s$^2$2d$^1$

5. Using the periodic table, give the number of protons, neutrons and electrons in each of the following atoms:
   (a) $^{15}$N          (b) $^{207}$Pb$^{2+}$          (c) $^{107}$Ag          (d) $^{109}$Ag

6. What pair of atoms in question 3 are isotopes?

**HOMEWORK 1F**

*Definitions*

Stable Isotope; Radioisotope; Half-Life; Fission; Fusion

*Questions*

1. Indicate the isotope in each pair that is most likely to be radioactive.
   (a) $^5$Li or $^6$Li          (b) $^{20}$Ne or $^{23}$Ne          (c) $^{156}$Pt or $^{196}$Pt

2. Radioactive $^{24}$Na with a half-life of 14.8 hours is injected into an animal in a tracer experiment. How many hours will it take for the radioactivity to fall to 12.5% of its original intensity?

3. The age of a bone was to be determined by $^{14}$C dating. $^{14}$C has a half-life of 5,730 years, and a Geiger counter shows that the $^{14}$C in living tissue gives 15.2 cpm g$^{-1}$ of carbon. If the same Geiger counter shows that the $^{14}$C in a sample of the bone gives 3.8 cpm g$^{-1}$ of carbon, how old is the bone?

4. The most abundant elements found in the solid Earth are iron, oxygen, silicon, and magnesium.
   (a) Where did the atoms of these elements come from?
   (b) Why are the abundances in the solid Earth of elements such as fluorine and gold so low?
Definitions

Element’s Atomic Mass; Mole

Questions

1. Assume that the element Uus is synthesized and that it has the following stable isotopes:

\[
\begin{array}{ccc}
\text{Isotope} & \text{Mass} & \text{Percentage} \\
^{284}\text{Uus} & 283.4 \text{ u} & 34.60\% \\
^{285}\text{Uus} & 284.7 \text{ u} & 21.20\% \\
^{288}\text{Uus} & 287.8 \text{ u} & 44.20\% \\
\end{array}
\]

What is the value of the average atomic mass for Uus that would be listed on the periodic table?

2. The element lithium exists in nature as two isotopes:

\[
\begin{array}{ccc}
\text{Isotope} & \text{Mass} \\
^6\text{Li} & 6.015 \text{ u} \\
^7\text{Li} & 7.016 \text{ u} \\
\end{array}
\]

Calculate the natural percentages of the two lithium isotopes.

3. Identify each of the following:
   (a) the mass of iron that would contain \(6.022 \times 10^{23}\) atoms.
   (b) the mass of carbon that would also contain \(6.022 \times 10^{23}\) atoms.

4. A sample of iron has a mass of 500.0 g. Calculate:
   (a) the number of moles of iron atoms.
   (b) the number of atoms of iron.

5. A diamond contains \(5.0 \times 10^{21}\) carbon atoms. Calculate:
   (a) the number of moles of carbon atoms.
   (b) the number of grams of carbon.
Definitions

Atomic Radii

Questions

1. The present form of the periodic table was originally developed independently by the Russian chemist Dmitri Mendeleev, and what other scientist?

2. Why do elements in the same group on the periodic table have similar properties?

3. For element 117, Tennessine:
   (a) predict its expected electron configuration notation
   (b) predict what other element it will most likely resemble chemically

4. Identify the atom with the largest atomic radius, and explain why:
   (a) Mn, Fe  (b) Si, Cl

5. Identify the atom in each pair with the largest atomic radius:
   (a) Ti, Zr  (b) Ca, Ba
HOMEWORK II

Definitions

Ionization Energy; Electron Affinity

Questions

1. Write the equations for the first, second and third ionizations of a magnesium atom.

2. Identify the atom with the greatest (most endothermic) first ionization energy, and explain why:
   (a) K, Ca
   (b) Si, Cl

3. Identify the atom with the greatest (most endothermic) first ionization energy, and explain why:
   (a) Sr, Ba
   (b) P, Sb

4. Explain the ionization energies of each:
   (a) Al has a lower ionization energy (less endothermic) than Mg
   (b) S has a lower ionization energy (less endothermic) than P

5. Elements X and Y are known to be third or fourth period elements on the periodic table. The first four ionization energies for elements X and Y are shown below. The units are not kJ/mol.

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>170</td>
<td>200</td>
</tr>
<tr>
<td>Second</td>
<td>1450</td>
<td>1700</td>
</tr>
<tr>
<td>Third</td>
<td>1900</td>
<td>2400</td>
</tr>
<tr>
<td>Fourth</td>
<td>2500</td>
<td>3300</td>
</tr>
</tbody>
</table>

   Identify elements X and Y.

6. Write the equations for the first, second, and third electron affinities of an sulfur atom.

7. Identify the atom with the greatest (most exothermic) first electron affinity, and explain why:
   (a) B, C
   (b) Fe, Ni

8. Identify the atom with the greatest (most exothermic) first electron affinity, and explain why:
   (a) K, Rb
   (b) S, Te

9. Explain the electron affinities of each:
   (a) Mg has a lower electron affinity (less exothermic) than Na
   (b) P has a lower electron affinity (less exothermic) than Si
Definitions

Metal; Nonmetal; Group; Family; Period; Series; Representative Elements; Metalloid

Questions

1. How do metals and nonmetals differ in their physical properties?

2. How do metals and nonmetals differ in their chemical properties?

3. Identify the trend in metallic character of the elements when:
   (a) moving from left to right across the periodic table
   (b) moving from top to bottom down the periodic table

4. Give the charge of the expected ion for each of the following elements:
   (a) Li       (b) Br       (c) Ba       (d) S
   (e) Ga       (f) N        (g) Zn       (h) Ag

5. Give the charges of the two ions expected for each of the following elements:
   (a) Sn       (b) Sb

6. Give the name of the Group 1 elements and describe their physical and chemical properties.

7. Give the name of the Group 2 elements and describe their physical and chemical properties.

8. Give the name associated with the d-sublevel elements and describe their physical and chemical properties.

9. Give the name of the Group 17 elements and describe their physical and chemical properties.

10. Give the name of the Group 18 elements and describe their physical and chemical properties.
HOMEWORK 1R

1. Identify the scientist responsible for each of the following:
   
   (a) first to propose that matter is composed of atoms
   (b) identified matter as being composed of either elements or compounds
   (c) showed that mass is conserved during chemical reactions
   (d) proposed that compounds always contain the same proportion of elements by mass
   (e) showed that matter composed of atoms explained the Law of Definite Proportion
   (f) created a periodic table based on atomic masses, with periods of varying lengths
   (g) proposed that the energy of electromagnetic radiation is quantized
   (h) discovered that atoms contain electrons
   (i) showed that the quantum theory of electromagnetic radiation explained the photoelectric effect
   (j) showed that emitted X-ray frequencies are proportional to an atom’s atomic number
   (k) proposed that electrons orbit the nucleus in specific orbits
   (l) proposed that particles have wave properties
   (m) proposed that a particle’s position and momentum cannot be simultaneously known accurately
   (n) created a wave equation for the electron
   (o) discovered that atoms contain neutrons
   (p) proposed that protons and neutrons are composed of quarks

2. Give the volume reading in each of the following graduated glassware:

(continued on next page)
3. Give the number of significant figures in each of the following measurements:
   (a) 0.0012  (b) 437,000  (c) 900.0  (d) 106
   (e) 0.001060  (f) 1.0012  (g) 2006  (h) 3050

4. Do the following metric conversions:
   (a) 1.25 kilometers to meters  (b) 0.375 grams to kilograms
   (c) 750. milliliters to liters  (d) 0.00025 kilograms to micrograms

5. Using the periodic table, give the number of protons, neutrons and electrons in each of the following:
   (a) $^{32}$P  (b) $^{76}$Se  (c) $^{121}$Sb  (d) $^{195}$Pt$^{4+}$

6. Tell what is the same and what is different for atoms that are isotopes.

7. Indicate the isotope in each pair that is most likely to be radioactive.
   (a) $^9$Be or $^{10}$Be  (b) $^{22}$Mg or $^{24}$Mg  (c) $^{209}$Bi or $^{212}$Bi

8. Radioactive fluorine-18, with a half-life of 110. minutes, is used for imaging in PET scans. How many hours will it take for the radioactivity of the fluorine-18 to fall to 6.25% of its original intensity?

9. A sample of vanadium-42 shows an activity of 100. disintegrations per second. After 7.4 minutes the activity decreases to 25 disintegrations per second. Determine the half-life of vanadium-42.

10. Identify the elements that are produced in stars: He, C, Si, Cl, Fe, Pb

11. The element strontium has the following stable isotopes:

   $^{84}$Sr  83.9134 u  0.56%
   $^{86}$Sr  85.9093 u  9.86%
   $^{87}$Sr  86.9089 u  7.02%
   $^{88}$Sr  87.9056 u  82.56%

   What is the value of the average atomic mass for strontium calculated from these data?

12. Find the natural percentages of the 2 stable isotopes of bromine, $^{79}$Br and $^{81}$Br, if their atomic masses are 78.92 u and 80.92 u, respectively.

13. Calculate the number of atoms in 5.00 grams of platinum.

14. Calculate the mass, in grams, of 2.75 x $10^{22}$ gold atoms.

15. Microwave radiation has a wavelength on the order of 1.0 cm. For this given wavelength, calculate:
   (a) the wavelength in meters  (b) the frequency
   (c) the energy of a single photon in joules  (d) the energy of 1 mole of photons in kilojoules

   (continued on next page)
16. The energy of electromagnetic radiation needed to remove electrons from the surface of lithium atoms is 279.7 kJ/mol. Calculate:
   (a) the energy of a single photon of this electromagnetic radiation in joules.
   (b) the frequency of this electromagnetic radiation.
   (c) the wavelength of this electromagnetic radiation.

17. Describe the meaning of each of the following potential energy values for an electron.
   (a) a positive value
   (b) a negative value
   (c) a value of zero

18. Describe the meaning of each of the following energy changes for an electron.
   (a) a positive value
   (b) a negative value

19. Calculate the energy released and the wavelength of light emitted when each of the following transitions occur in the hydrogen atom:
   (a) \( n = 2 \rightarrow n = 1 \)
   (b) \( n = 4 \rightarrow n = 2 \)

20. Draw an electronic energy diagram for a hydrogen atom, and using vertical lines show the 2 transitions from question 19.

21. Predict the longest and shortest wavelengths of light emitted by electrons in hydrogen atoms that begin in the \( n = 6 \) state and then fall to states with smaller values of \( n \).

22. Determine whether or not a photon with a wavelength of 675 nm will ionize an excited hydrogen atom that has its electron in the \( n = 3 \) energy level.

23. Which of the following orbital designations are not allowed in the hydrogen atom?
   (a) 5d
   (b) 1p
   (c) 3f
   (d) 8j

24. Give the maximum number of orbitals in an atom that can have the following designations:
   (a) 5p
   (b) 4d
   (c) \( n = 3 \)
   (d) \( n = 6 \)

25. Give the maximum number of electrons in an atom that can have the following designations:
   (a) 2p
   (b) 3d
   (c) \( n = 4 \)
   (d) \( n = 5 \)

26. Give the electron configuration notations for the following atoms:
   (a) the lightest halogen atom
   (b) the alkali metal with only 2p and 3p electrons
   (c) the heaviest alkaline earth metal
   (d) the group 13 element in the same period as tin
   (e) the most nonmetallic element in group 14
   (f) the undiscovered noble gas after radon

(continued on next page)
27. Give the electron dot notations for each of the atoms in question 26.

28. Give the electron configuration notations for a chromium atom, then name and draw pictures of its occupied atomic orbitals past those found in argon’s electron configuration.

29. The following sets of atoms are arranged in order of increasing size. Explain the order.
   (a) Be < Mg < Ca
   (b) Xe < I < Te

30. Arrange the following sets of atoms in order of increasing size:
   (a) Ga, Ge, In
   (b) P, S, Cl

31. The following sets of atoms are arranged from least endothermic to most endothermic ionization energies. Explain the order.
   (a) Ca < Mg < Be
   (b) Te < I < Xe

32. Arrange the following sets of atoms in order of increasing ionization energies.
   (a) Ga, Ge, In
   (b) P, S, Cl

33. The first four ionization energies for aluminum are shown below.
   \[
   \begin{align*}
   \text{Al}(g) & \rightarrow \text{Al}^+(g) + e^- \quad I_1 = 580 \text{ kJ/mol} \\
   \text{Al}^+(g) & \rightarrow \text{Al}^{2+}(g) + e^- \quad I_2 = 1,815 \text{ kJ/mol} \\
   \text{Al}^{2+}(g) & \rightarrow \text{Al}^{3+}(g) + e^- \quad I_3 = 2,740 \text{ kJ/mol} \\
   \text{Al}^{3+}(g) & \rightarrow \text{Al}^{4+}(g) + e^- \quad I_4 = 11,600 \text{ kJ/mol}
   \end{align*}
   \]
   (a) Account for the trend in the values of the ionization energies.
   (b) Explain the large increase between \( I_3 \) and \( I_4 \).

34. The following sets of atoms are arranged from least exothermic to most exothermic electron affinities. Explain the order.
   (a) Se, Br (most exothermic)
   (b) As, P (most exothermic)

35. Arrange the following sets of atoms in order of least exothermic to most exothermic electron affinities:
   (a) Te, I, Xe
   (b) Li, Be, B

36. Give the physical and chemical properties of the following elements:
   (a) Am
   (b) F
   (c) Cr
   (d) Rb
   (e) Be
   (f) Xe

37. Tell what is the same and what is different for allotropes.

38. Give the most likely ionic charge for ions of each of the following atoms:
   (a) Cl
   (b) Cs
   (c) Te
   (d) N
   (e) Al
   (f) Mg

39. Give the charges of the two ions expected for each of the following elements:
   (a) Tl
   (b) Ge

(continued on next page)
The table below shows the first three ionization energies for atoms of four elements from the third period of the periodic table. The elements are numbered randomly.

<table>
<thead>
<tr>
<th>Element</th>
<th>First Ionization Energies (kJ/mol)</th>
<th>Second Ionization Energies (kJ/mol)</th>
<th>Third Ionization Energies (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,251</td>
<td>2,300</td>
<td>3,820</td>
</tr>
<tr>
<td>2</td>
<td>496</td>
<td>4,560</td>
<td>6,910</td>
</tr>
<tr>
<td>3</td>
<td>738</td>
<td>1,450</td>
<td>7,730</td>
</tr>
<tr>
<td>4</td>
<td>1,000</td>
<td>2,250</td>
<td>3,360</td>
</tr>
</tbody>
</table>

(a) Which element is the most metallic in character?
(b) Identify element 3.
(c) Write the full electron configuration for an atom of element 3.
(d) What is the expected charge for the most common ion of element 2?
(e) What is the chemical symbol for element 2?
(f) A neutral atom of which of the four elements has the smallest radius?

The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated below:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ne-20</td>
<td>19.99</td>
</tr>
<tr>
<td>Ne-22</td>
<td>21.99</td>
</tr>
</tbody>
</table>

(a) Using the information above, calculate the percent abundance of each isotope
(b) Calculate the number of Ne-22 atoms in a 12.55 gram sample of naturally occurring neon.

**HOMEWORK 1R ANSWERS**

1. (a) Democritus  (b) Boyle  (c) Lavoisier  (d) Proust  
   (e) Dalton  (f) Meendeleev  (g) Planck  (h) Thomson  
   (i) Einstein  (j) Moseley  (k) Bohr  (l) deBroglie  
   (m) Heisenberg  (n) Schrödinger  (o) Chadwick  (p) Gell-Mann
2. 5.70, 14.35, 43.5, 25.80
3. (a) 2  (b) 3  (c) 4  (d) 3  (e) 4  (f) 5  (g) 4  (h) 3
4. (a) 1,250 m  (b) 0.000375 kg  (c) 0.750 L  (d) 250,000 μg
5. (a) 15, 17, 15  (b) 34, 42, 34  (c) 51, 70, 51  (d) 78, 117, 74
6. Isotopes are atoms that have the same number of protons, but different numbers of neutrons.
7. (a) $^{10}$Be  (b) $^{22}$Mg  (c) $^{212}$Bi
8. 7.33 hours

*(continued on next page)*
9. 3.7 minutes
10. He, C, Si, Fe
11. 87.62 u
12. 51.0% $^{79}$Br, 49.0% $^{81}$Br
13. $1.54 \times 10^{22}$ Pt atoms
14. 9.00 g Au

15. (a) 0.010 m  (b) $3.0 \times 10^{10}$ s$^{-1}$  (c) $2.0 \times 10^{-23}$ J  (d) 0.012 kJ/mol
16. (a) $4.645 \times 10^{19}$ J  (b) $7.010 \times 10^{14}$ s$^{-1}$  (c) $4.277 \times 10^{-7}$ m

17. (a) the electron is being attracted to another object or particle
(b) the electron is being repelled by another object or particle
(c) the electron is not being repelled or attracted by another object or particle

18. (a) the electron is absorbing energy during the change
(b) the electron is releasing energy during the change

19. (a) $1.634 \times 10^{18}$ J, $1.216 \times 10^{-7}$ m  (b) $4.084 \times 10^{19}$ J, $4.864 \times 10^{-7}$ m

20.

21. longest wavelength: 6 → 5, shortest wavelength: 6 → 1
22. yes, $2.94 \times 10^{19}$ J $> 2.420 \times 10^{19}$ J

23. (a) allowed  (b) forbidden  (c) forbidden  (d) allowed
24. (a) 3  (b) 5  (c) 9  (d) 36
25. (a) 6  (b) 10  (c) 32  (d) 50

(continued on next page)
26. (a) [He]2s²2p⁵  (b) [Ar]4s¹  (c) [Rn]7s²  
  (d) [Kr]5s²4d¹⁰p¹  (e) [He]2s²2p²  (f) [Rn]7s²5f¹⁴6d¹⁰7p⁶

27. (a) : F :  (b) K :  (c) Ra :  (d) In :  (e) C :  (f) X :

28. [Ar]4s³3d⁵

29. (a) The atomic radii increase because the number of shielding energy levels increase, even though the nuclear charge increases. This means the orbitals of the highest occupied energy level are less attracted to the nucleus, making the atomic radius is greater.

(b) The atomic radii increase because the nuclear charge decreases while the number of shielding energy levels remains the same. This means the orbitals of the highest occupied energy level are less attracted to the nucleus, making the atomic radius is greater.

30. (a) Ge < Ga < In  (b) Cl < S < P

31. (a) The ionization energies increase because the number of shielding energy levels decrease, even though the nuclear charge decreases. This means the electrons in the highest occupied energy level are more attracted to the nucleus, requiring more energy to remove them.

(b) The ionization energies increase because the nuclear charge increases while the number of shielding energy levels remains the same. This means the electrons in the highest occupied energy level are more attracted to the nucleus, requiring more energy to remove them.

32. (a) In < Ga < Ge  (b) S < P < Cl

33. (a) As we remove successive electrons, the electron being removed has fewer shielding electrons left, and is therefore more attracted to the nucleus.

(b) For I₁, I₂ and I₃ we remove electrons from the third energy level, for I₄ we begin removing an electron from the second energy level. Electrons in lower energy levels are less shielded and therefore attracted more to the nucleus.

34. (a) The electron affinities increase (become more exothermic) because the nuclear charge increases while the number of shielding energy levels remains the same. This means a free electron is more attracted to the nucleus, releasing more energy when it is added.

(b) The electron affinities increase (become more exothermic) because the number of shielding energy levels decrease, even though the nuclear charge decreases. This means a free electron is more attracted to the nucleus, releasing more energy when it is added.

35. (a) Xe, Te, I (most exothermic)  (b) Be, Li, B (most exothermic)

(continued on next page)
36. (a) Hard, silvery, solid, radioactive metal. Active, forms positive ions.
    (b) Pale, yellow-green nonmetal gas. Very active, forms 1- ions.
    (c) Hard, silvery, solid metal. Active, forms positive ions.
    (d) Very soft, silvery, solid metal. Extremely active, forms 1+ ions.
    (e) Soft, silvery, solid metal. Very active, forms 2+ ions.
    (f) Colorless gas. Very inactive, forms no ions.

37. Allotropes are substances made up of atoms of the same element, but the atoms are bonded together differently.

38. (a) 1- (b) 1+ (c) 2- (d) 3- (e) 3+ (f) 2+

39. (a) 3+, 1+ (b) 4+, 2+

40. (a) 2 (b) Mg (c) 1s^22s^22p^63s^2 (d) 1+ (e) 1

41. (a) 90.5% Ne-20, 9.5% Ne-22 (b) 2.1 \times 10^{22} \text{ atoms}