Ch. 7 TRENDS Page 1

7.51 The first ionization energy and electron affinity of Ar are both positive values. (a) What is the significance of the positive value in each case? (b) What are the units of electron affinity?

7.51 *Analyze/Plan.* Consider the definitions of ionization energy, electron affinity and the electron configuration of Ar. *Solve.*

(a) Argon is a noble gas, with a very stable core electron configuration. This causes the element to resist chemical change. Positive, endothermic, values for ionization energy and electron affinity mean that energy is required to either remove or add electrons. Valence electrons in Ar experience the largest Z_{eff} of any element in the third row, because the nuclear buildup is not accompanied by an increase in screening. This results in a large, positive ionization energy. When an electron is added to Ar, the n = 3 electrons become core electrons which screen the extra electrons so effectively that Ar^- has a higher energy than an Ar atom and a free electron. This results in a large positive electron affinity.

(b) The units of electron affinity are kJ/mol.

7.53 Although the electron affinity of bromine is a negative quantity, it is positive for Kr. Use the electron configurations of the two elements to explain the difference.

7.53 *Analyze/Plan.* Consider the definitions of ionization energy and electron affinity, along with pertinent electron configurations. *Solve.*

Electron affinity: $Br(g)$ $+ 1e^-$ $\rightarrow$ $Br^-(g)$

$[Ar]4s^2 3d^{10} 4p^5$ $\qquad$ $[Ar]4s^2 3d^{10} 4p^6$

When a Br atom gains an electron, the Br^- ion adopts the stable electron configuration of Kr. Since the electron is added to the same 4p subshell as other outer electrons, it experiences essentially the same attraction for the nucleus. Thus, the energy of the Br^- ion is lower than the total energy of a Br atom and an isolated electron, and electron affinity is negative.

Electron affinity: $Kr(g)$ $+ 1e^-$ $\rightarrow$ $Kr^-(g)$

$[Ar]4s^2 3d^{10} 4p^6$ $\qquad$ $[Ar]4s^2 3d^{10} 4p^6 5s^1$

Energy is required to add an electron to a Kr atom; Kr^- has a higher energy than the isolated Kr atom and free electron. In Kr^- the added electron would have to occupy the higher energy 5s orbital; a 5s electron is farther from the nucleus and effectively shielded by the spherical Kr core and is not stabilized by the nucleus.

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7.67 Write balanced equations for the following reactions: (a) barium oxide with water, (b) iron(II) oxide with perchloric acid, (c) sulfur trioxide with water, (d) carbon dioxide with aqueous sodium hydroxide.

7.67

(a) $BaO(s) + H_2O(l) \rightarrow Ba(OH)_2(aq)$

(b) $FeO(s) + 2HClO_4(aq) \rightarrow Fe(ClO_4)_2(aq) + H_2O(l)$

(c) $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

(d) $CO_2(g) + 2NaOH(aq) \rightarrow Na_2CO_3(aq) + H_2O(l)$

7.77 Compare the elements bromine and chlorine with respect to the following properties: (a) electron configuration, (b) most common ionic charge, (c) first ionization energy, (d) reactivity toward water, (e) electron affinity, (f) atomic radius. Account for the differences between the two elements.

7.77

	Br	**Cl**
(a)	$[Ar]4s^24p^5$	$[Ne]3s^23p^5$
(b)	-1	-1
(c)	1140 kJ/mol	1251 kJ/mol
(d)	reacts slowly to form HBr+HOBr	reacts slowly to form HCl+HOCl
(e)	-325 kJ/mol	-349 kJ/mol
(f)	1.14 Å	0.99 Å

The $n = 4$ valence electrons in Br are farther from the nucleus and less tightly held than the $n = 3$ valence electrons in Cl. Therefore, the ionization energy of Cl is greater, the electron affinity is more negative and the atomic radius is smaller.

7.81 Write a balanced equation for the reaction that occurs in each of the following cases: (a) Ozone decomposes to dioxygen. (b) Xenon reacts with fluorine. (Write three different equations.) (c) Sulfur reacts with hydrogen gas. (d) Fluorine reacts with water.

7.81

(a) $2O_3(g) \rightarrow 3O_2(g)$

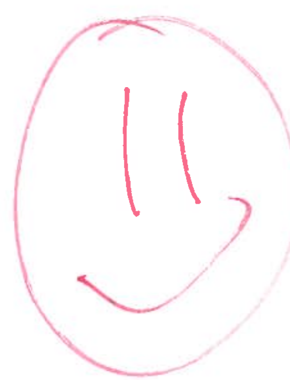
(b) $Xe(g) + F_2(g) \rightarrow XeF_2(g)$

$Xe(g) + 2F_2(g) \rightarrow XeF_4(s)$

$Xe(g) + 3F_2(g) \rightarrow XeF_6(s)$

(c) $S(s) + H_2(g) \rightarrow H_2S(g)$

(d) $2F_2(g) + 2H_2O(l) \rightarrow 4HF(aq) + O_2(g)$



[7.110] When magnesium metal is burned in air (Figure 3.6), two products are produced. One is magnesium oxide, MgO. The other is the product of the reaction of Mg with molecular nitrogen,

smallest bonding atomic radius of any element that forms chemical compounds." If not, correct it. If it is, explain in terms of electron configurations. (c) Explain why the ionization energy of hydrogen is closer to the values for the halogens than for the alkali metals. (d) The hydride ion is H^-. Write out the process corresponding to the first ionization energy of hydride. (e) How does the process you wrote in part (d) compare to the process for the electron affinity of elemental hydrogen?

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7.110 (a) Mg_3N_2

(b) $Mg_3N_2(s) + 3H_2O(l) \rightarrow 3MgO(s) + 2NH_3(g)$

The driving force is the production of $NH_3(g)$.

(c) After the second heating, all the Mg is converted to MgO.

Calculate the initial mass Mg.

$$0.486 \text{ g MgO} \times \frac{24.305 \text{ g Mg}}{40.305 \text{ g MgO}} = 0.293 \text{ g Mg}$$

x = g Mg converted to MgO; y = g Mg converted to Mg_3N_2; x = 0.293 − y

$$\text{g MgO} = x\left(\frac{40.305 \text{ g MgO}}{24.305 \text{ g Mg}}\right); \text{g } Mg_3N_2 = y\left(\frac{100.929 \text{ g } Mg_3N_2}{72.915 \text{ g Mg}}\right)$$

$$\text{g MgO} + \text{g } Mg_3N_2 = 0.470$$

$$(0.293 - y)\left(\frac{40.305}{24.305}\right) + y\left(\frac{100.929}{72.915}\right) = 0.470$$

$$(0.293 - y)(1.6583) + y(1.3842) = 0.470$$

$$-1.6583\,y + 1.3842\,y = 0.470 - 0.48588$$

$$-0.2741\,y = -0.01588 = -0.016$$

$$y = 0.05794 = 0.058 \text{ g Mg in } Mg_3N_2$$

$$\text{g } Mg_3N_2 = 0.05794 \text{ g Mg} \times \frac{100.929 \text{ g } Mg_3N_2}{72.915 \text{ g Mg}} = 0.0802 = 0.080 \text{ g } Mg_3N_2$$

$$\text{mass \% } Mg_3N_2 = \frac{0.0802 \text{ g } Mg_3N_2}{0.470 \text{ g } (MgO + Mg_3N_2)} \times 100 = 17\%$$

(The final mass % has two sig figs because the mass of Mg obtained from solving simultaneous equations has two sig figs.)

(d) $3Mg(s) + 2NH_3(g) \rightarrow Mg_3N_2(s) + 3H_2(g)$

$$6.3 \text{ g Mg} \times \frac{1 \text{ mol Mg}}{24.305 \text{ g Mg}} = 0.2592 = 0.26 \text{ mol Mg}$$

$$2.57 \text{ g } NH_3 \times \frac{1 \text{ mol } NH_3}{17.031 \text{ g } NH_3} = 0.1509 = 0.15 \text{ mol } NH_3$$

$$0.2592 \text{ mol Mg} \times \frac{2 \text{ mol } NH_3}{3 \text{ mol Mg}} = 0.1728 = 0.17 \text{ mol } NH_3$$

0.26 mol Mg requires more than the available NH_3 so NH_3 is the limiting reactant.

$$0.1509 \text{ mol } NH_3 \times \frac{3 \text{ mol } H_2}{2 \text{ mol } NH_3} \times \frac{2.016 \text{ g } H_2}{\text{mol } H_2} = 0.4563 = 0.46 \text{ g } H_2$$

(e) $\Delta H^\circ_{rxn} = \Delta H^\circ_f\, Mg_3N_2(s) + 3\Delta H^\circ_f\, H_2(g) - 3\Delta H^\circ_f\, Mg(s) - 2\Delta H^\circ_f\, NH_3(g)$

$= -461.08 \text{ kJ} + 3(0) - 3(0) - 2(-46.19) = -368.70 \text{ kJ}$