General Chemistry I
PLI #12 AK
June 22, 2021

1. **In the ground state of cadmium (Cd):**
    a. **Write the full and noble gas ground state electron configuration:**

Normal: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$
Noble gas: $[Kr]5s^2 4d^{10}$

    b. **How many electrons have l=2 as one of their quantum numbers?**

20 electrons
L= 2 refers to the d orbitals, which for Cd are the 3d and 4d orbitals. These contain 20 total electrons as they are completely filled.

    c. **How many electrons have n=4 as one of their quantum numbers?**

18 electrons
The 4s, 4p, and 4d orbitals are all completely full

    d. **How many electrons have m_l = -1 as one of their quantum numbers?**

10 electrons
This can specify a specific orientation of p and d orbitals. So one orbital in 2p, 3p, 3d, 4p, 4d, which is 5 orbitals total. Each holds 2 electrons, so 10 total electrons.

2. **Write the full and noble gas notation ground state electron configuration for the following elements:**
    a. **Tellurium**

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

    b. **Cesium**

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

    c. **Arsenic**

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

d. **Iridium**

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^7$
$[Xe]6s^2 4f^{14} 5d^7$

e. **Copper**

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

Be careful with copper! It's tricky. Half-filled and fully filled orbitals are generally more stable than partially filled ones.

3. **The successive ionization energies for an unknown element are I1 = 896 kJ/mol; I2 = 1752 kJ/mol; I3 = 14807 kJ/mol; I4 = 17948 kJ/mol. To which group in the periodic table does the unknown element most likely belong?**

Since there is a significant difference between I_2 and I_3, this atom must belong to group 2. This means it is relatively easy to ionize the atom to a +2 charge, but takes significantly more energy to remove another electron.

4. **Two elements, A and B, have the electron configuration shown:**

A - $[Ar]\ 4s^2$ and B - $[Ar]3d^{10}4s^2 4p^5$

a. **Which element is a metal?** A
b. **Which element has the greater ionization energy?** B
c. **Which element has the larger atomic radius?** A
d. **Which element has the greater electron affinity?** B

5. **Write the noble gas electron configuration of mercury:**

$[Xe]6s^2 4f^{14} 5d^{10}$

a. **How many electrons occupy atomic orbitals with n=3?**

18 electrons – 3s, 3p, and 3d subshells have 9 orbitals

b. **How many electrons occupy d atomic orbitals?**

30 electrons – 3d, 4d, and 5d orbitals all filled.

c. How many electrons have the "up" spin (m_s = +1/2)

40 electrons – 80 total, half of which have "up" spin

6. Write a complete set of quantum numbers for each of the electrons in the Cu valance shell:

The electron configuration, as done above, is: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

There is only one valence electron, with the following quantum numbers:

$n=4, l=0, m_l=0, m_s=+1/2$

a. Write the complete electron configuration for the Cu^{2+} ion:

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$

b. If the first and second ionizations of copper are 745.4 kJ/mol and 1957.9 kJ/mol respectively, what are the wavelengths of the photons emitted upon ionization?

$\underline{I_1}$:

$$745.4\frac{kJ}{mol} * \frac{1\ molCu}{6.022 * 10^{23}\ atoms\ Cu} = 1.24 * 10^{-21}\frac{kJ}{atom} = 1.24 * 10^{-18}\frac{J}{atom}$$

$$E = \frac{hc}{\lambda}$$

$$1.24 * 10^{-18} J = \frac{(6.626 * 10^{-34}\ J * s)(3.00 * 10^{8}\frac{m}{s})}{\lambda}$$

$$\lambda = \frac{(6.626 * 10^{-34}\ J * s)(3.00 * 10^{8}\frac{m}{s})}{1.24 * 10^{-18} J} = 1.61 * 10^{-7} m = 161\ nm$$

$\underline{I_2}$:

$$1957.9\frac{kJ}{mol} * \frac{1\ molCu}{6.022 * 10^{23}\ atoms\ Cu} = 3.25 * 10^{-21}\frac{kJ}{atom} = 3.25 * 10^{-18}\frac{J}{atom}$$

$$E = \frac{hc}{\lambda}$$

$$3.25 * 10^{-18} J = \frac{(6.626 * 10^{-34}\, J * s)(3.00 * 10^{8}\, \frac{m}{s})}{\lambda}$$

$$\lambda = \frac{(6.626 * 10^{-34}\, J * s)(3.00 * 10^{8}\, \frac{m}{s})}{3.25 * 10^{-18} J} = 6.12 * 10^{-8} m = 61.2\, nm$$

7. **Within any period, noble gases have the highest ionization energy. Why?**

Noble gases have a complete octet (or duet in the case of He) and thus have stable filled valence shells. Additionally, noble gases have the highest Z_{eff} (the highest net charge experienced by an electron), so the electrons are held tightly to the nucleus. Thus, it is hard to remove the electron, reflected in the relatively higher ionization energy.