Solutions

1. Ashley plot
   - Plot all of the data points
   - Comment on a trend
   - Comment on a relationship between the properties

2. \[
   \begin{align*}
   &0.0584(53.940 \text{ amu}) + (0.02154)(55.935 \text{ amu}) + \\
   &0.02119(56.935 \text{ amu}) + (0.00286)(57.933 \text{ amu}) \\
   &= 55.845 \text{ amu}
   \end{align*}
\]

3. a) \[
   \left( \frac{1 \text{ amu}}{6.022 \times 10^{23}} \right) = \boxed{1.661 \times 10^{-24} \text{ g} / \text{amu}}
\]

   \[b) \left( \frac{6.022 \times 10^{23} \text{ atoms}}{\text{g} \cdot \text{mol}} \right) \left( \frac{453.6 \text{ g}}{\text{pound}} \right) = 2.73 \times 10^{26} \frac{\text{atoms}}{\text{lb} \cdot \text{mol}} \]
4. \( Mn^{2+} = [Ar] \ 3d^5 \ 4s^1 \)
\( Sc^{3+} = [Ar] \)
\( Zn^{2+} = [Ar] \ 3d^{10} \)
\( Sr^{2+} = [Kr] \)
\( Cl^- = [Ar] \)
\( Se^{2-} = [Kr] \)

5. a) \( 1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6 (\text{boxed}) 4s^2 \)
\( \text{Incomplete d orbital so is a transition metal} \)

b) \( 1s^2 \ 2s^2 (\text{boxed}) \)
\( \text{Needs 1 more e\textsuperscript{-} to complete} \)
\( \text{p orbital so is a halogen} \)

c) \( 1s^2 \ 2s^2 \ 2p^6 \ 3s^2 (\text{boxed}) \)
\( \text{Complete p orbital so is an inert gas} \)
6. Li$^+$ has an electron structure identical to Helium because it is missing one electron.

- Cl$^-$ is chlorine with an extra electron, so it has the same electron structure as Argon.

7. Force of attraction between K$^+$ and O$^{2-}$, centers 2.1 nm apart.

\[ F_A = F_{\text{attraction}} \]

we know:

\[ E = \int F \, dr \]

(\text{eq. 2.4 8th ed.})

\[ E_A = -\frac{A}{r} \]

(\text{eq. 2.8 8th ed.})

\[ \begin{align*}
F_A &= \frac{dE_A}{dr} = \frac{d}{dr} \left( -\frac{A}{r} \right) = \frac{A}{r^2} \\
A &= \frac{1}{4\pi\varepsilon_0} (|Z_1|e)(|Z_2|e) \\
\varepsilon_0 &= \text{permittivity of a vacuum} (8.85 \times 10^{-12} \text{ F/m})
\end{align*} \]

\[ \text{eq. 2.10 10th ed.} \]

\[ Z_1 \text{ and } Z_2 \text{ are valences of the ions. } Z \text{ for } K^+ = 1, \ Z \text{ for } O^{2-} = -2. \]

\[ F_A = \frac{1(1)(2)(1.602 \times 10^{-19} \text{ C})^2}{4\pi (8.85 \times 10^{-12} \text{ F/m})(2.1 \times 10^{-9} \text{ m})^2} = 1.05 \times 10^{-10} \text{ N} \]

\[ \text{(or } 1.0 \times 10^{-10} \text{ N with correct sig figs)} \]
\[ E_N = -\frac{A}{r} + \frac{B}{r^n} \]

\[ \frac{dE_N}{dr} = \frac{A}{r^2} - \frac{nB}{r^{n+1}} = 0 \]

\[ \frac{A}{r_o^2} = \frac{nB}{r_o^{n+1}} \]

\[ \frac{A}{nB} = \frac{r_o^2}{r_o^{n+1}} \]

Then take the natural log of both sides and simplify expression with log rules

\[ \ln\left(\frac{A}{nB}\right) = 2\ln r_o - (n+1)\ln r_o \]

\[ \ln\left(\frac{A}{nB}\right) = \ln r_o \cdot \frac{2-n-1}{1-n} \]

\[ \ln r_o = \ln\left(\frac{A}{nB}\right) (1-n)^{-1} \]

This is the equilibrium interatomic spacing, which we can now use to find \( E_0 \)

\[ E_0 = -\frac{A}{r_o} + \frac{B}{r_o^n} \]

\[ E_0 = \frac{A}{\left(\frac{A}{nB}\right)^{\frac{1}{n}(1-n)}} + \frac{B}{\left[\left(\frac{A}{nB}\right)^{\frac{1}{n}(1-n)}\right]^n} \]

\[ E_0 = \frac{A}{\left(\frac{A}{nB}\right)^{\frac{1}{n}}} + \frac{B}{\left(\frac{A}{nB}\right)^{\frac{n}{1-n}}} \]
\[ E_A = \frac{-2.468}{r} \; ; \; E_R = \frac{10.35 \times 10^{-6}}{r^9} \]

\[ E_N = E_A + E_R \]

a. See plot

\[ E_A \to -\infty \text{ as } r \to 0 \]

\[ E_R \text{ and } E_N \to +\infty \text{ as } r \to 0 \]

b. From the plot, \( r_0 = 0.280 \text{nm} \), \( E_0 = -7.836 \text{eV} \) (or close)
\[ \%IC = \{1 - \exp\left[-(0.25)(X_A - X_B)^2\right]\} \times 100 \]

**MgO**

\[ X_{Mg} = 1.3, \ X_O = 3.5 \]
\[ (X_{Mg} - X_O)^2 = 4.8 \]
\[ \{1 - \exp[-(0.25)(4.8)]\} \times 100 = 69.9\% \]

**CaF₂**

\[ X_{Ca} = 1.1, \ X_F = 4.1 \]
\[ (X_{Ca} - X_F)^2 = 9 \]
\[ \{1 - \exp[-(0.25)(9)]\} \times 100 = 89.5\% \]

**SiC**

\[ X_{Si} = 1.8, \ X_C = 2.5 \]
\[ (X_{Si} - X_C)^2 = 0.5 \]
\[ \{1 - \exp[-(0.25)(0.5)]\} \times 100 = 11.8\% \]

**ZrO₂**

\[ X_{Zr} = 1.2, \ X_O = 3.5 \]
\[ (X_{Zr} - X_O)^2 = 5.3 \]
\[ \{1 - \exp[-(0.25)(5.3)]\} \times 100 = 73.4\% \]

**Al₂O₃**

\[ X_{Al} = 1.5, \ X_O = 3.5 \]
\[ (X_{Al} - X_O)^2 = 4 \]
\[ \{1 - \exp[-(0.25)(4)]\} \times 100 = 63.2\% \]
12.

The electrons in the outermost shell are the valence electrons.

We can define valence electrons as follows: The electrons of an atom that are not present in the previous rare gas, ignoring filled d or f subshells.

As, valence e⁻ structure = 4s²4p³
5 valence e⁻; 8 − 5 = 3 covalent bonds/atom

Br, valence e⁻ structure = 4s²4p⁵
7 valence e⁻; 8 − 7 = 1 covalent bonds/atom

Ga, valence e⁻ structure = 4s²4p¹
3 valence e⁻; 8 − 3 = 5 covalent bonds/atom

Si, valence e⁻ structure = 3s²3p²
4 valence e⁻; 8 − 4 = 4 covalent bonds/atom