CHEM1002 Worksheet 11 – Answers to Critical Thinking Questions

The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

**Model 1: The Unit Cell**

1. Number of atoms = $8 \times \frac{1}{8} = 1$.
2. Number of atoms = $8 \times \frac{1}{8}$ (atoms on corners) + 1 (atom at centre) = 2.
3. Number of atoms = $8 \times \frac{1}{8}$ (atoms on corners) + $6 \times \frac{1}{2}$ (atoms on faces) = 4.

**Model 2: The Unit Cell and Stoichiometry**

1. (a) Number of Cl atoms = $8 \times \frac{1}{8}$ (atoms on corners) + $6 \times \frac{1}{2}$ (atoms on faces) = 4.
   (b) Number of Na atoms = $12 \times \frac{1}{4}$ (atoms on edges) + 1 (atom at centre) = 4.
   (c) Cation : anion = 4 : 4 or 1 : 1. This is consistent with the formula NaCl.
2. (a) Number of Ti atoms = 1 (atom at centre).
   (b) Number of Ca atoms = $8 \times \frac{1}{8}$ (atoms on corners) = 1.
   (c) Number of O atoms = $6 \times \frac{1}{2}$ (atoms on edges) = 3.
   (d) The formula is Ca$_1$Ti$_1$O$_3$ or CaTiO$_3$.

**Model 3: The solubility product**

1. (a) $\text{AgCl(s)} \rightleftharpoons \text{Ag}^+(aq) + \text{Cl}^-(aq)$; $K_{sp} = [\text{Ag}^+(aq)][\text{Cl}^-(aq)]$
   (b) $\text{PbCl}_2(s) \rightleftharpoons \text{Pb}^{2+}(aq) + 2\text{Cl}^-(aq)$; $K_{sp} = [\text{Pb}^{2+}(aq)][\text{Cl}^-(aq)]^2$
2. (a) $[\text{Pb}^{2+}(aq)] = x$ and $[\text{Cl}^-(aq)] = 2x$.
   (b) $K_{sp} = \text{Pb}^{2+}(aq)[\text{Cl}^-]^2 = (x)(2x)^2 = 4x^3$
      If $4x^3 = 1.6 \times 10^{-5}$, then $x = 1.59 \times 10^{-2}$.
      $[\text{Pb}^{2+}(aq)] = x = 1.59 \times 10^{-2} \text{ M}$ and $[\text{Cl}^-(aq)] = 2x = 3.17 \times 10^{-2} \text{ M}$
3. Molar solubility = $(K_{sp} / 27)^{1/4}$

**Model 4: To dissolve or not to dissolve?**

1. (a) $[\text{Mg}^{2+}(aq)] = 0.050 \text{ M}$ and $[\text{OH}^-(aq)] = 0.060 \text{ M}$
   (b) $Q_{sp} = [\text{Mg}^{2+}(aq)][\text{OH}^-(aq)]^2 = (0.050)(0.060)^2 = 1.8 \times 10^{-4}$
   (c) $Q_{sp} > K_{sp}$ so Mg(OH)$_2$ (s) precipitate forms.