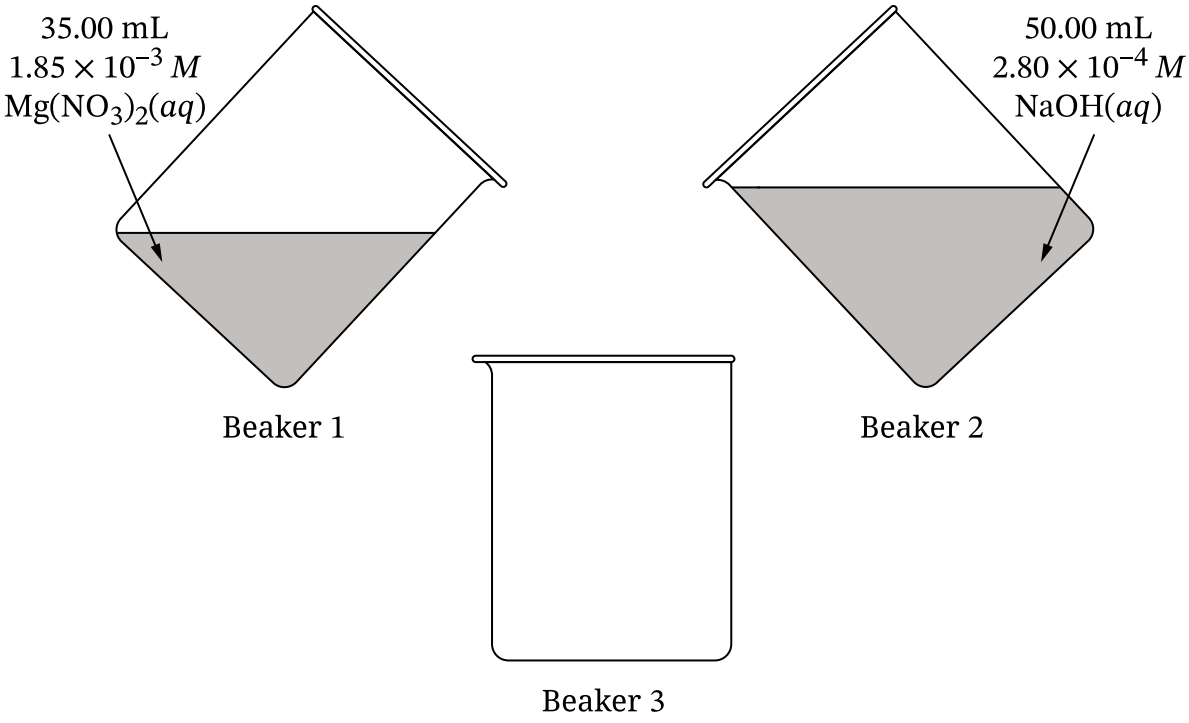
D. A student combines 35.00 mL of $1.85\times10^{-3}\ M\ \mathrm{Mg(NO_3)_2}(aq)$ with 50.00 mL of $2.80\times10^{-4}\ M\ \mathrm{NaOH}(aq)$, as shown in the diagram. Calculate $\left[\mathrm{Mg^{2+}}\right]$ after the two solutions are combined but before any reaction takes place. (Assume that volumes are additive.)



E. The dissolution of magnesium hydroxide is represented by the following equation.

$$\mathrm{Mg(OH)_2}(s) \rightleftarrows \mathrm{Mg^{2+}}(aq) + 2\ \mathrm{OH^-}(aq) \quad K_{sp} = 5.61\times10^{-12}$$

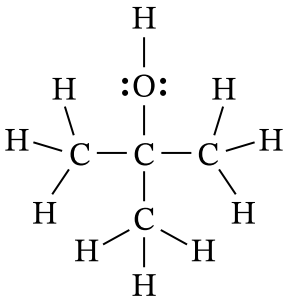
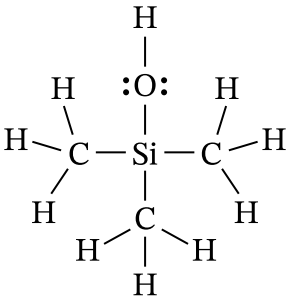
i. Write the expression for the solubility product constant, K_{sp}.

ii. After the two solutions are combined in beaker 3 as described in part D, but before any reaction takes place, $\left[\mathrm{OH^-}\right] = 1.65\times10^{-4}\ M$. Using your answer to part D, calculate the value of the reaction quotient, Q.

iii. Using the reaction quotient, Q, predict whether a precipitate should form as the mixture in beaker 3 approaches equilibrium. Justify your answer.

F. In a separate experiment, the student adds $\mathrm{HNO_3}(aq)$ to decrease the pH of a saturated solution containing undissolved $\mathrm{Mg(OH)_2}(s)$. Does the amount of undissolved $\mathrm{Mg(OH)_2}(s)$ increase, decrease, or remain the same as the $\mathrm{HNO_3}(aq)$ is added? Justify your answer.

5. Complete Lewis diagrams and some physical properties for compounds X and Y are given.

Compound	X	Y
Lewis diagram		
Molar mass	74.1 g/mol	90.2 g/mol
Boiling point	82°C	98°C

A. Based on VSEPR theory, predict the geometry around the Si atom in compound Y.

B. A student claims that compound Y has a higher boiling point than that of compound X because compound Y has stronger London dispersion forces. Do you agree or disagree? Justify your answer.

C. An equimolar mixture of the two compounds is heated. When the mixture reaches 82°C, which compound will have the higher vapor pressure? Justify your answer.

D. The mixture is heated to 198°C in a sealed, rigid 12.5 L container, at which point both substances are gases and the total pressure in the container is 2.30 atm. Calculate the number of moles of gas particles in the container.

Question 5: Short Answer — 4 points

A — **Point 01**

For the correct answer:

Tetrahedral

B — **Point 02**

For the correct answer and a valid justification:

Agree. Compound Y *has a larger, more polarizable electron cloud because the* Si *atom has more occupied electron shells than the* C *atom, giving compound* Y *stronger London dispersion forces and a higher boiling point than compound* X.

C — **Point 03**

For the correct answer and a valid justification.

Examples of acceptable responses may include the following:

- *Compound* X. *Compound* X *has weaker intermolecular forces than compound* Y, *so molecules of* X *are more likely to be in the gas phase at* 82°C *and would therefore have a higher vapor pressure.*
- *Compound* X. *At* 82°C, *compound* X *has reached its boiling point, but compound* Y *has not. Therefore, the proportion of* X *molecules in the vapor phase would be much greater than that of compound* Y, *giving compound* X *the higher vapor pressure.*

D — **Point 04**

For the correct calculated value:

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(2.30\text{ atm})(12.5\text{ L})}{(0.08206\frac{\text{L}\cdot\text{atm}}{\text{K}\cdot\text{mol}})(471\text{K})} = 0.744\text{ mol}$$