“A” students work (without solutions manual)
~10 problems/night.

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Module #13
Solution Properties
Defining types of concentrations
For mixtures

Method for Conversion from Molarity to molality

1. Assume 1 L volume
2. Calculate moles of solute
\[ \text{moles}_{\text{solute}} = \frac{\text{moles}_{\text{solute}}}{L_{\text{solution}}} \times L = \frac{\text{moles}_{\text{solute}}}{L_{\text{solution}}} \times 1L = \text{moles}_{\text{solute}} \]
3. Calculate g of solution from d, V
\[ d_{\text{solution}} \times \left( \frac{10^3 mL}{L} \right) \times (1L_{\text{solution}}) = G_{\text{solution}} \]
4. Calculate g of solute from M
\[ M(1L_{\text{solution}}) \times \frac{G_{\text{solute}}}{\text{mol}_{\text{solute}}} = G_{\text{solute}} \]
5. Subtract to get g of solvent
\[ G_{\text{solution}} - G_{\text{solute}} = G_{\text{solvent}} \]
6. Calculate g solute/g solvent
\[ \text{molality} = m = \frac{\text{moles}_{\text{solute}}}{\text{kg}_{\text{solvent}}} \]

Example Density of an aqueous solution of ammonium sulfate is 1.06g/mL and the molarity is 0.886. What is the molality?
\[ (\text{NH}_4)_2\text{SO}_4 \]

1. Assume 1 L volume
2. Calculate moles of solute
\[ \frac{\text{moles}_{\text{solute}}}{L_{\text{solution}}} \times (1L_{\text{solution}}) = \frac{\text{moles}_{\text{solute}}}{L_{\text{solution}}} \times 1L = 0.886 \text{ moles}_{\text{solute}} \]
3. Calculate g of solution from d, V
\[ 1.06 \left( \frac{g}{mL} \right) \times \left( \frac{1000mL}{L} \right) \times (1L_{\text{solution}}) = 1060g_{\text{solution}} \]
4. Calculate g of solute from M
\[ 0.886 \left( \frac{\text{mol}}{L_{\text{solution}}} \right) \times \left( \frac{133.09g_{\text{solute}}}{\text{mol}_{\text{solute}}} \right) = 117.9248g_{\text{solute}} \]
5. Subtract to get g of solvent
\[ 1060g_{\text{solution}} - 117.9248g_{\text{solute}} = 942.0752g_{\text{solvent}} \]
6. Calculate g solute/g solvent
\[ \text{molality} = m = \frac{\text{moles}_{\text{solute}}}{\text{kg}_{\text{solvent}}} = \frac{0.886\text{moles}_{\text{solute}}}{0.9421\text{kg}_{\text{solvent}}} = 0.941 \]
Method for Conversion from molality to Molarity

1. Assume 1 kg solvent
2. Calculate moles of solute
   \[ \text{moles solute} = \frac{\text{moles solute}}{\text{kg solvent}} \times 1 \text{kg solvent} = \text{moles solute} \]
3. Calculate g of solute from MM
   \[ \text{mass solute} = \frac{\text{moles solute}}{\text{mole prot}} \times \text{prot mass} \]
4. Sum masses to get total mass of solution
   \[ \text{mass solution} = \text{mass solute} + \text{mass solvent} \]
5. Calculate V of solution from density
   \[ \text{V solution} = \frac{\text{mass solution}}{\text{density solution}} \]
6. Calculate moles/V
   \[ M = \frac{\text{moles solute}}{\text{V solution}} \]

Example: Density of an aqueous solution of KOH is 1.43g/mL and the molality is 14.2. What is the molarity?

1. Assume 1 kg solvent
2. Calculate moles of solute
   \[ \left[ \frac{14.2 \text{ moles KOH}}{1 \text{ kg water}} \right] = 14.2 \text{ moles KOH} \]
3. Calculate g of solute from MM
   \[ \left[ \frac{14.2 \text{ moles KOH}}{\text{mole KOH}} \right] \times \left[ \frac{39.10 + 16.00 + 1.08 \text{ g KOH}}{1 \text{ mole KOH}} \right] = 797.756 \text{ g KOH} \]
4. Sum masses to get total mass of solution
   \[ \text{mass solution} = \text{mass KOH} + \text{mass water} = 1000 \text{ g} + 797.756 \text{ g} = 1797.756 \text{ g solution} \]
5. Calculate V of solution from density
   \[ \left[ \frac{1797.756 \text{ g solution}}{1 \text{ mL solution}} \right] \times \left[ \frac{1 \text{ mL solution}}{1438 \text{ g solution}} \right] = 1.257 \text{ mL} \]
6. Calculate moles/V
   \[ M = \frac{\text{moles KOH}}{\text{V solution}} = \frac{14.2 \text{ moles KOH}}{1.257 \text{ mL solution}} = 11.296 \]

Methods of measurement are related but not equivalent

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Module #13
Solution Properties

Water/Salt Solutions 1
SOLUTIONS

Any two components A and B
Mixed in any mole fraction

Solute is usually considered the "dissolved"
Solvent is usually considered the "dissolver"

Solutions Diagrammed as an Example of Hess's Law

MgSO₄ → MgSO₄– + SO₄²⁻
ΔH = -912 kJ/mol

-1376.1 kJ/mole

-1284.9 kJ/mole

A mixture is usually plotted as variation in mole fractions

χₐ + χₜ = nₐ + nₜ
nₐ + nₜ = 1

Solvation Diagrammed as an Example of Hess's Law
MgSO₄ → Mg²⁺ + SO₄²⁻
ΔH = -912 kJ/mol

Separated solids
Separated solute particles
ΔH₂
Silver + solute
Not exothermic process
ΔH₃
Solution

-1376.1 kJ/mole
\[ \text{NH}_4\text{NO}_3(s) \rightarrow \text{NH}_4^+(aq) + \text{NO}_3^-(aq) \quad \Delta H = +28.1 \text{kJ} \]

For most salts, heat will increase solubility.

For most salts, heat will increase solubility.

“\(A\)” students work (without solutions manual)

\(\sim 10\) problems/night.

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Module #13
Solution Properties

Organic/Solute Solutions

\[ \text{MgSO}_4(s) \rightarrow \text{Mg}^{2+}(aq) + \text{SO}_4^{2-}(aq) \quad \Delta H = -91.2 \text{kJ/mol} \]
What trends do you see here?

Like Dissolves Like
similar intermolecular forces between
solute-solute
solvent-solvent
imply solute-solvent interaction will be decent

Solute-Solvent interactions: Vitamin C and Lead

Vitamin C is more soluble in the aqueous Phase of the body (urine) than other Vitamins which are stored in fat.

Vitamin C is water soluble so it is excreted from the body the longest you can last without serious disease without consuming fresh vitamin C is 6 months

Context Slide
Solute-Solvent interactions: Vitamin C and Lead

Context Slide
Sir Franklin
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Module #13
Solution Properties
Gas/Solvent Solutions
Raoult’s Law, Freezing Point, Boiling Pt changes
Osmotic Pressure
**SOLUTIONS**

Consider first case where A is a pure substance

\[ n_A = \chi_A = 1 \]

<table>
<thead>
<tr>
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<th>State of Solvent</th>
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<td>Liquid</td>
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</tr>
<tr>
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<td>Liquid</td>
<td>Salt in water</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
<td>Hydrogen in palladium</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
<td>Mercury in silver</td>
</tr>
<tr>
<td>Liquid</td>
<td>Component A</td>
<td>Component B</td>
</tr>
</tbody>
</table>

**Predict:**
1. T86 more gas vapor
2. T8 less sticking of gases more gas vapor

**Intermolecular forces**

Exponential represents fraction of molecules at temperature T with sufficient energy to break intermolecular forces

\[ P_{\text{pure liquid}} = e^{\frac{-\Delta H_{\text{vaporization}}}{RT}} \]

**From earlier chapter we learned of kinetic energy:**

Maxwell’s Distribution

\[ E_k = \frac{1}{2} m v^2 \]

**Review**

\[ f(x) = e^{-\frac{1}{2} \left( \frac{x-\mu}{\sigma} \right)^2} \]

**Number of escapes will depend on**
1. **Number of molecules with energy>> intermolecular forces**
2. Fraction of molecules with that energy at some the given temperature
3. **The Surface area available for escape**
4. Escapes independent of what gas is doing

**Number of returns will depend on**
1. **Intermolecular forces** in gas phase greater than collisional energy
2. Fraction of molecules at with less energy than intermolecular forces at that temperature
3. Sticking followed by dropping does not depend upon the surface area

**Prediction 1**
1. T8, more escapes, more gas phase A
2. T8, less sticking (fewer returns)
**A. rate escapes** → **A.**

Number of escapes will depend on:
1. Number of molecules with energy $\gg$ intermolecular forces
2. Fraction of molecules with that energy at some the given temperature
3. The Surface area available for escape
4. Escapes independent of what gas is doing

**A. rate sticking** → **A.**

Number of returns will depend on:
1. Intermolecular forces in gas phase greater than collisional energy
2. Fraction of molecules at with less energy than intermolecular forces at that temperature
3. Sticking followed by dropping does not depend upon the surface area

Prediction 2
1. Surface Area 9, less escapes, less gas A
2. Surface Area 9, no impact on rate sticking

A mixture is usually plotted as variation in mole fractions

$$X_A + X_B = \frac{n_A}{n_A + n_B} + \frac{n_B}{n_A + n_B}$$

Within every layer of liquid (10x10) there are 99A and 1B
How has the surface area available for escape changed?

New Surface Area = $X_A$ (Original Surface Area)

How will vapor pressure change?

We just made a prediction!

Predict:
1. 1B 6more gas vapor
2. Surface area 9 6less gas vapor
3. Escapes independent of gas!!

**SOLUTIONS**

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<td>Gas</td>
<td>Hydrogen in palladium</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
<td>Liquid</td>
<td>Mercury in sulfur</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
<td>Solid</td>
<td>Silver in gold</td>
</tr>
</tbody>
</table>

One way to diminish surface area is to add solute to Pure substance A

$$n_A = \chi_A < 1$$

**Pure A**

**Pure B**

**mixture**

**Liquid**

**Gas**

**Solution**

**solute**

**solvent**

**Raoult's Law**
Boiling Point elevation

Freezing Point depression

Constants for water

\[ K_b \text{ molal}_B = \Delta T_{A,bp} \]
\[ K_b = 0.52 \frac{\circ C}{\text{molal}} \]

\[ K_f \text{ molal}_B = \Delta T_{A,mp} \]
\[ K_f = 186 \frac{\circ C}{\text{molal}} \]

Raoult’s Law

Assumes effect of “B” is to simply block the surface
No interaction of “B” (solute) with “A” (solvent)

Boiling Point elevation

Freezing Point depression

SOLUTIONS

Constants for water

\[ K_b \text{ molal}_B = \Delta T_{A,bp} \]
\[ K_b = 0.52 \frac{\circ C}{\text{molal}} \]

\[ K_f \text{ molal}_B = \Delta T_{A,mp} \]
\[ K_f = 186 \frac{\circ C}{\text{molal}} \]
When "A" is completely surrounded by "B"

\[
A_{in \text{ B liquid}} \xrightarrow{\text{rate escapes}} A_g
\]

1. Number of possible A/B collisions (Partial Pressure of A) \(P_A\)
2. Intermolecular forces of A/B in gas phase greater than collisional energy
3. Fraction of molecules with intermolecular energy greater than collisional energy increases as T goes down.
4. No dependence on surface area

\[
\begin{align*}
C_g &= k_H P_A \\
C_k P_{gH} A &= \frac{A/B \text{ intermolecular forces}}{\chi_A} \frac{P_A}{h} \text{ Math (slide after next)}
\end{align*}
\]

Predictions
1. Greater \(P_A\), more collisions with B, greater condensation, greater solution concentration.
2. Greater T less collisions in which intermolecular forces allow sticking, less solution concentration.

Henry’s Law

\[
P_A = \left(\text{break } A-B \text{ energy}\right)_{k_{H, A}}
\]

\[
P_A = k^{\ast\ast} \left(\frac{n_A}{m_B}\right)
\]

Molality when \(m_B\) in kg.

\[
P_A = \frac{k^{\ast\ast} n_A}{n_A + n_B}
\]

\[
\frac{1}{k^{\ast\ast}} P_A = \left(\frac{n_A}{m_B}\right) = k_H P_A
\]

\[
P_A = k \left(\frac{n_A}{n_B}\right)
\]

\[
P_A = k \left(\frac{m_B}{n_B}\right) \left(\frac{n_A}{\left(n_B\right)^2}\right)
\]

\[
k_H = \frac{n_B}{\left(\text{break } A-B \text{ energy}\right)} \text{ molal}_{A}
\]

Prediction 1: As temp goes up, fewer gas phase collisions between A/B allow them to stick, less condensation.

For the math hungry:
Raoult’s Law
Slope is a function of interactions

Raoult’s Law
Partial Pressure = χ₄P₄

Henry’s Law
Slope is a function of interactions

Partial Pressure

Everything in between is hard to predict

Vapor Pressure

Fitch Rule G3: Science is Referential
Imagine: Two volumes of water
1. is "pure"
\[
\frac{n_{\text{electrolyte}}}{n_{\text{water}} + n_{\text{electrolyte}}} = 0 = \chi_1
\]
2. the second has large salt mole fraction
\[
\frac{n_{\text{electrolyte}}}{n_{\text{water}} + n_{\text{electrolyte}}} = 0.2 = \chi_2
\]
3. There is a barrier between them which is impermeable to the electrolytes
4. Surface area for water escape is less in cube 2
5. Escapes 1 > Escapes 2
6. Water moves 1 to 2
7. As water in 2 increases Pressure builds up against membrane

Osmotic pressure (pressure driving water from one compartment to another) is directly related to the concentration of the solute, B.

\[
\pi = \frac{n_BRT}{V} = [B]RT
\]

1. This provides a convenient way to measure molar masses.
2. Has huge physiological implications

Context
When not well regulated the extracellular fluid increases and edema (bursting of cells) results
A Student who did NOT take Gen Chem

Water motion across cell membranes is driven by osmotic pressure related to the salt concentration gradient

<table>
<thead>
<tr>
<th>Ion</th>
<th>Cell (M)</th>
<th>Blood (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K+</td>
<td>0.139</td>
<td>0.004</td>
</tr>
<tr>
<td>Na+</td>
<td>0.012</td>
<td>0.145</td>
</tr>
<tr>
<td>Cl-</td>
<td>0.004</td>
<td>0.116</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>0.012</td>
<td>0.029</td>
</tr>
<tr>
<td>X⁻</td>
<td>0.138</td>
<td>0.009</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.0008</td>
<td>0.0015</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>&lt;0.0000002</td>
<td>0.0018</td>
</tr>
</tbody>
</table>

The equations

Raoult’s Laws

\[
P_A = P_A^0 \kappa_A
\]

\[
\Delta P_A = \chi_B P_A^0
\]

Derived from Raoult’s Law

Colligative Properties

Depend on Solute Conc.

\[K_f \text{molar}_B = \Delta T_{A,mp}^o\]

\[K_b \text{molar}_B = \Delta T_{A,bp}^o\]

\[C_g = kP_A\]

Henry’s Law

Depends primarily on solvent

The equations

\[\pi = \frac{n_B RT}{V} = [B]RT\]
Example 1: A solution contains 102 g of sugar, C₁₂H₂₂O₁₁, in 375 g of water. Calculate the vapor pressure lowering at 25 °C (vapor pressure of pure water = 23.76 mm Hg).

What do we know?
- sugar in water (sugar = solute; water = solvent)

What equations might apply?
- Vapor pressure lowering
  \[ \Delta P_A = \chi B P_A^o \]

What information is irrelevant? (Red herring)
- none.

\[ \chi^2 P_1^o = \Delta P \]

\[ \chi_{solute} = \frac{\text{mole solute}}{\text{mole solvent} + \text{mole solute}} \]

\[ \chi_{sugar} = \frac{102 \text{ g sugar}}{342 \text{ g total}} = 0.298 \text{ mol sugar} \]

\[ \chi_{water} = \frac{375 \text{ g water}}{18.02 \text{ g water}} + \frac{102 \text{ g sugar}}{342 \text{ g sugar}} = 0.602 \text{ mol water} + 0.298 \text{ mol sugar} \]

\[ \chi_{sugar} = \frac{0.298 \text{ mol sugar}}{0.602 \text{ mol water} + 0.298 \text{ mol sugar}} = 0.0141 \]
Example 2 Calculate the concentration of CO₂ in a soft drink that is bottled with a partial pressure of CO₂ of 4.0 atm over the liquid at 25°C. The Henry's law constant for CO₂ in water at this temperature is 3.1x10⁻² mol/L atm.

\[ C_g = kP_g \]

\[ C_g = \left( 3.1 \times 10^{-2} \frac{mol}{L \cdot atm} \right) (4.0 \text{ atm}) = 0.124 \frac{mol}{L} \]


Example 3 The solubility of pure nitrogen in blood at body temperature, 37°C, and one atmosphere nitrogen is 6.2x10⁻⁴ M. If a diver breathes air (χ N₂ = 0.78) at a depth where the total pressure is 2.5 atm, calculate the concentration of nitrogen in his blood.

\[ C_g = kH P_g \]

\[ C_g = \left( 6.2 \times 10^{-4} \frac{M}{\text{atm}} \right) (1.95 \text{ atm}) = 1.209 \times 10^{-3} \text{ M} \]

\[ 6.2 \times 10^{-4} \text{ M} = k (1 \text{ atm}) \]

\[ k = \frac{6.2 \times 10^{-4} \text{ M}}{(1 \text{ atm})} = 6.2 \times 10^{-4} \frac{M}{\text{atm}} \]

\[ C_g = kP_g \]

Unknown, how can we get it?

Dalton’s Partial Pressure Law!

\[ P_{N_2} = X_{N_2} P_{\text{total}} \quad P_{N_2} = (0.78)(2.5 \text{ atm}) = 1.95 \text{ atm} \]

Example 4 You add 1.00 kg of ethylene glycol (C₂H₆O₂) antifreeze to your car radiator, which contains 4450 g of water. What are the boiling and freezing points of the solution? \( K_b \) of water is 0.512 °C/m and \( K_f \) of water is 1.86 °C/m.

\[ \Delta T_b = k_b [\text{molality}] \]

\[ \Delta T_f = k_f [\text{molality}] \]

\[ \Delta T_b = \left( 0.512 \frac{^\circ \text{C}}{\text{molality}} \right) [\text{molality}] \]

\[ \Delta T_f = \left( 1.86 \frac{^\circ \text{C}}{\text{molality}} \right) [\text{molality}] \]

\[ [\text{molality}] = \frac{\text{mol solute}}{\text{kg solvent}} \]

\[ [\text{molality}] = \frac{10^3 \text{ g}}{1 \text{ kg}} \]

\[ [\text{molality}] = \frac{1 \text{ mol C}_2\text{H}_6\text{O}_2}{4450 \text{ g H}_2\text{O}} \]

\[ [\text{molality}] = \frac{16.1 \text{ mol C}_2\text{H}_6\text{O}_2}{4.450 \text{ kg}} \]

\[ [\text{molality}] = 3.62 \text{ molality} \]

\[ \Delta T_b = \left( 0.512 \frac{^\circ \text{C}}{\text{molality}} \right) (3.62 \text{ molality}) = 1.85 ^\circ \text{C} \]

The radiator will freeze at 32-6.73 °C = 25.27 °C

The radiator will boil at 101.85 °C
Osmotic Pressure Example Calculation:
What is the osmotic pressure related to a 0.10 M CaCl₂ solution?

\[
\pi = \frac{n_B RT}{V} = [B]RT
\]

\[
\pi = [B]RT = \left(3 \times 0.10 \text{ mol L}^{-1}\right) \left(0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}\right) \left(298 K\right) = 7.2 \text{ atm}
\]

Where did this come from?

\[\text{CaCl}_2 \rightarrow \text{ Ca}^{2+} + 2 \text{ Cl}^{-}\]

In order to control this pressure the kidney regulates the amount of Ca²⁺, Na⁺ and other ions in the blood.

Lead can cause significant Blood pressure problems by interfering Kidney regulation of ions

Context Slide: Preparation for your papers
Reference Data for Risk Assessment

\[C_G = kP_G\]

\[K_{ow} = \frac{C_G}{P_G}\]

Set a reference state to compare all chemicals
- solubility in water (s)
- solubility between water and octanol (K_{ow})

Why would this be important?
- Your paper
  - find, listing source of data
  - Why would this be important?
  - Hint, think about
  - Vit. C and Vit A

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Module #13
Solution Properties

Solid/solid solutions
As an example of importance Of freezing point depression

SOLUTIONS

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</tr>
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<td>Salt in water</td>
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"A" students work (without solutions manual)
~10 problems/night.
1. Temperature Range of early "campfires"
2. Grind up and mix tin to copper and you can lower the melting point
3. Bonus point: final material harder than copper!!
4. Many early economics of societies collapsed as fuel (forests) ran out
5. England’s interest in controlling Ireland was initially over wood supply

Egyptian Glass how did they do it?
Additives to the quartz (SiO₂) allow the glass to melt (becomes less viscous) at campfire temperatures.

Viscosity = measures flow
Low viscosity = easy flow

Campfire Temps

A Different Kind of Phase Diagram

Bronze phase diagram as Tin is added to Copper

These represent various unit cell structures (face centered cubic, etc.) adopted.
Sugar of Lead = Pb(CH₃COO)₂

\[
Pb^{2+} \quad 2\overset{\ddagger}{\quad} O \quad C \quad C \quad H \quad H
\]

Where does the negative charge reside?
Is this acetate anion q/r large or small?
Is this acetate anion charge dense or not?
Will acetate "hold on" to Pb²⁺ or will water win?

Renal biopsy
26 year old
Ship paint stripper

Failure of kidneys leads to deposition of Excess uric acid to joints = Gout

Immersion of the body Up to head creates a Pressure gradient in the blood volume towards the head; Body compensates with increased urine to lower Blood volume to brain; Increased urination leads to increased loss Of electrolytes (lead)

Initial symptoms are hallucinations creepy bugs, etc.

Tetraethyl lead poisoning is highly acute leading very rapidly to edema
Why and what does this have to do with osmotic pressure?
**Context**

Tetraethyl lead has what kind of structure?

$\text{Pb}(\text{C}_2\text{H}_5)_4$

*Hint: Valence Shell Electron Pair Repulsion (VSEPR) model*

- Valence electrons of atoms: $5(4) = 20$
- Single bonds: $2(4) = 8$
- Remainder to Cs: $12$

VSEPR = $AX_4$ = tetrahedral

Tetrahedral arrangement is important because the lead is **buried** beneath the organic $\text{CH}_3\text{CH}_2$ chains - making it lipid soluble.

Floppy $\text{CH}_3\text{CH}_2$ chain buries Pb

**Context**

Bond strength - is the Pb-C bond as strong as a **true** fully covalent C-C bond?

- Pb-C: $206.7 \text{kJ/mol}$

Carbon gets the electron

$\text{Pb}([\text{CH}_3\text{CH}_2])_4 \to \text{Pb}([\text{CH}_3\text{CH}_2])_3 + \text{CH}_3\text{CH}_2$

Chloride ion gets buried in the carbon chain center, making it lipid soluble

$\text{Pb}([\text{CH}_3\text{CH}_2])_3 + \text{Cl}^- \to \text{Pb}([\text{CH}_3\text{CH}_2])_3\text{Cl}$

**Context**

Triethyllead carries chloride ions across the cell membrane disrupting the energy cycle of the cell and the osmotic pressures - ultimately results in cell death by “popping” **(edema)**

**Context**

<table>
<thead>
<tr>
<th>Ion</th>
<th>Cell (M)</th>
<th>Blood (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{K}^+$</td>
<td>0.139</td>
<td>0.004</td>
</tr>
<tr>
<td>$\text{Na}^+$</td>
<td>0.012</td>
<td>0.145</td>
</tr>
<tr>
<td>$\text{Cl}^-$</td>
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<td>0.116</td>
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<tr>
<td>$\text{HCO}_3^-$</td>
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<tr>
<td>$\text{X}^-$</td>
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<td>0.009</td>
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<tr>
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<tr>
<td>$\text{Ca}^{2+}$</td>
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</tbody>
</table>
“A” students work (without solutions manual) ~10 problems/night.

Alanah Fitch
Flanner Hall 402
508-3119
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Office Hours Th & F 2-3:30 pm

Module #13
Solution Properties
END