Salts & Solubility

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YALE UNIVERSITY

CHEMISTRY 161

FALL 2018

www.mioy.org/chem161

What is a salt?

A salt is an ionic compound: metal + nonmetal

Some salts are **soluble** in water (*aqueous*, *aq* = dissolves in water).

Some salts are **insoluble** in water (precipitate, solid, *s*).

MEMORIZE THIS CHART:

You should be able to quickly identify

the ions that comprise a salt!

		Exceptions
SOLUBLE	Group 1 cations	
	NH_4^+	
	NO_3^-	
	CH_3COO^-	
	Cl^-, Br^-, I^-	Ag^+, Hg_2^{2+}, Pb^{2+}, Cu^+
	SO_4^{2-}	Hg_2^{2+}, Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+},
INSOLUBLE	OH^-	Group 1 cations, Ba^{2+}, Ca^{2+}, Sr^{2+}, NH_4^+
	S^{2-}	Group 1 cations, Ba^{2+}, Ca^{2+}, Sr^{2+}, NH_4^+
	CO_3^{2-}, PO_4^{3-}, F^-	Group 1 cations, NH_4^+

Determine if each of the following salts are soluble or insoluble.

1. KNO_3:

2. $PbSO_4$:

3. KOH :

4. $MgSO_4$:

5. $FePO_4$:

6. $Pb(NO_3)_2$:

7. $Pb(SO_4)_2$:

8. $FeCl_2$:

9. ZnS :

10. $Cd(OH)_2$:

11. $MgCO_3$:

12. NH_4Cl :

13. $CaBr_2$:

14. Hg_2I :

15. $CuCH_3COO$:

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Determine if each of the following salts are soluble or insoluble.

1. KNO_3: *soluble*
2. $PbSO_4$: *insoluble*
3. KOH : *soluble*
4. $MgSO_4$: *soluble*
5. $FePO_4$: *insoluble*
6. $Pb(NO_3)_2$: *soluble*
7. $Pb(SO_4)_2$: *soluble*
8. $FeCl_2$: *soluble*
9. ZnS : *insoluble*
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11. $MgCO_3$: *insoluble*
12. NH_4Cl : *soluble*
13. $CaBr_2$: *soluble*
14. Hg_2I : *insoluble*
15. $CuCH_3COO$: *soluble*

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Determine if each of the following salts are soluble or insoluble.

1. Nickel (II) Hydroxide :

2. Sodium Chloride :

3. Barium Nitrate :

4. Ammonium Bromide :

5. Magnesium Hydroxide :

6. Barium Sulfate :

7. Barium Hydroxide :

8. Lanthanum Nitrate :

9. Sodium Acetate :

10. Lead(II) Hydroxide :

11. Lead(IV) Sulfate :

12. Calcium Phosphate :

13. Iron(II) Sulfide :

14. Lithium Fluoride :

15. Aluminum Carbonate :

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Determine if each of the following salts are soluble or insoluble.

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15. Aluminum Carbonate : *insoluble*

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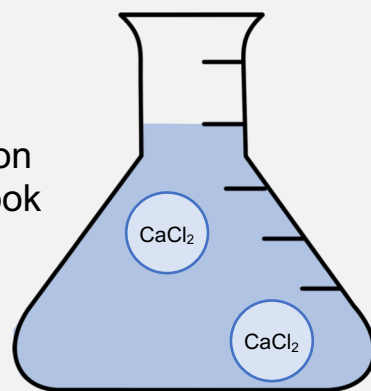We can use the expression for molarity to determine the number of moles of $CaCl_2$:

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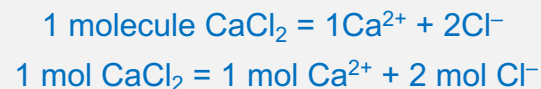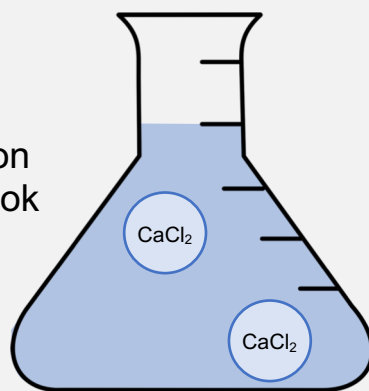We can use the expression for molarity to determine the number of moles of $CaCl_2$:

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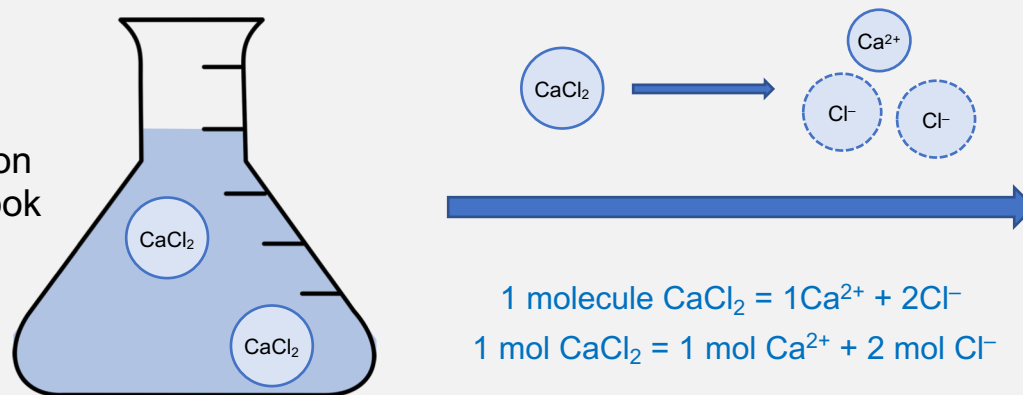
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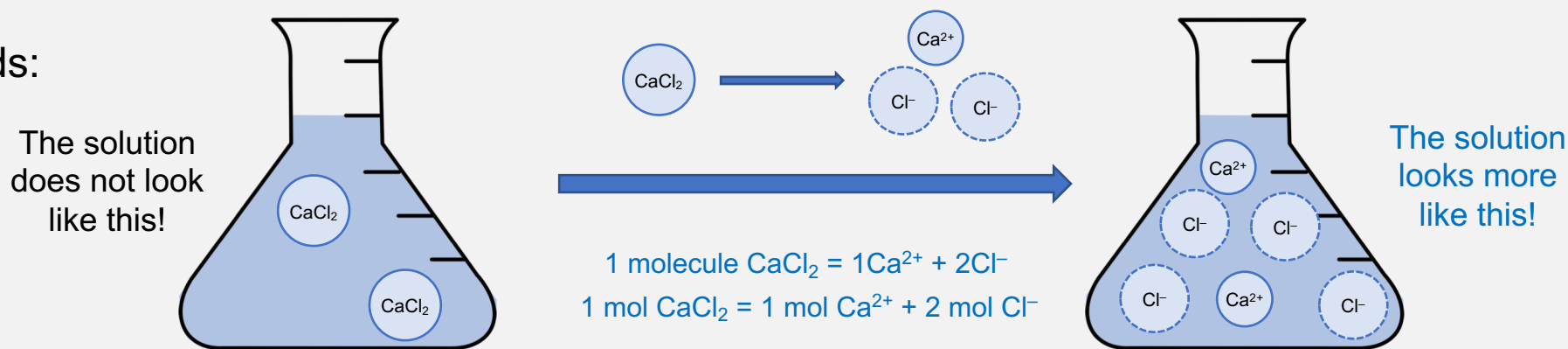$$[CaCl_2] = \frac{\text{\# moles } CaCl_2}{\text{Volume (L)}}$$

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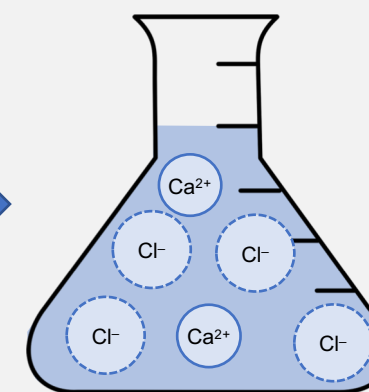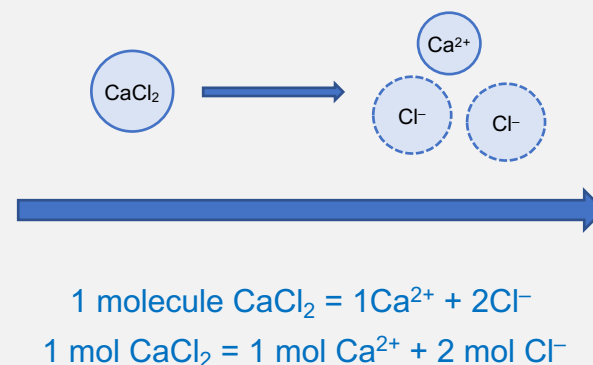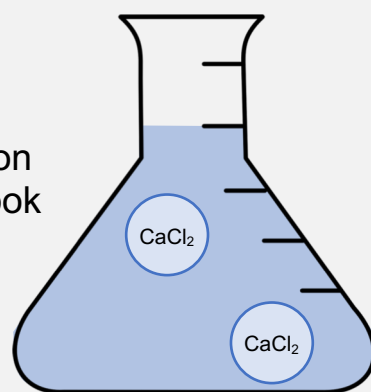
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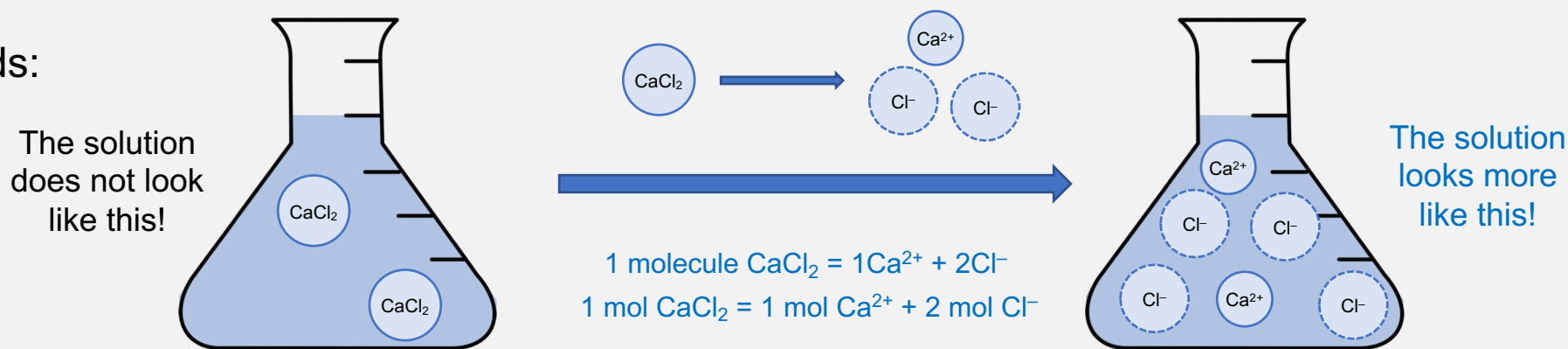
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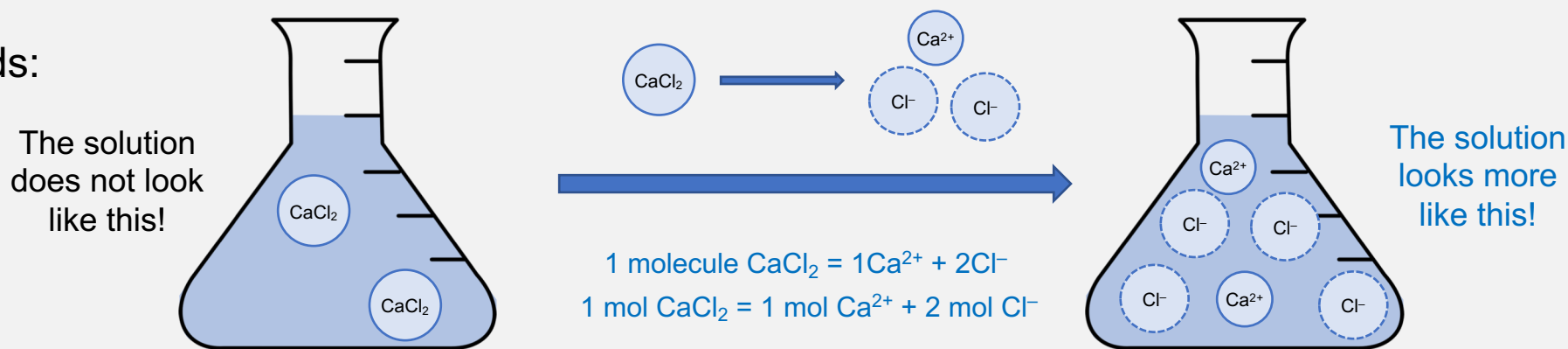$$2.00 \frac{mol}{L} = \frac{x \text{ mol}}{60.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}}$$

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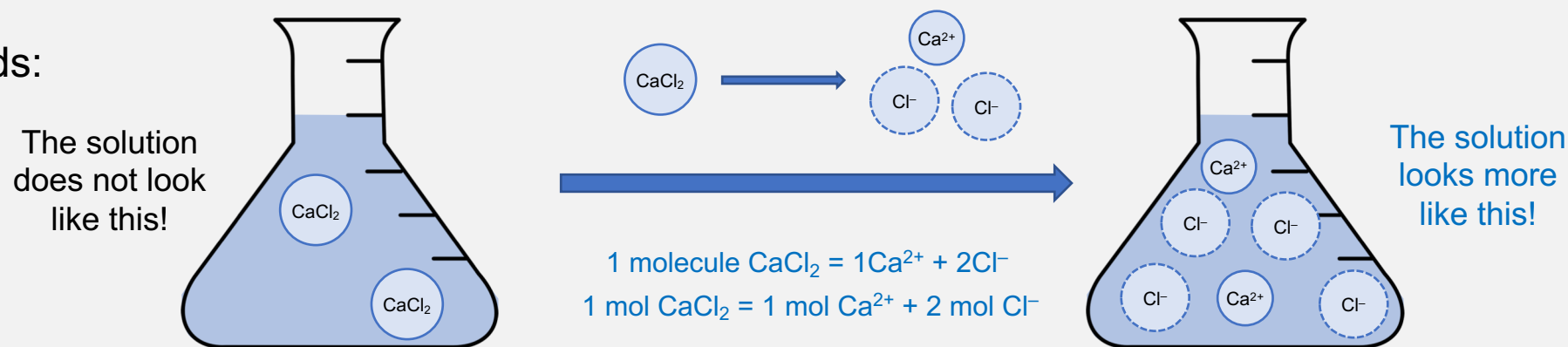$$2.00 \frac{\text{mol}}{\text{L}} = \frac{\text{x mol}}{60.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}}$$

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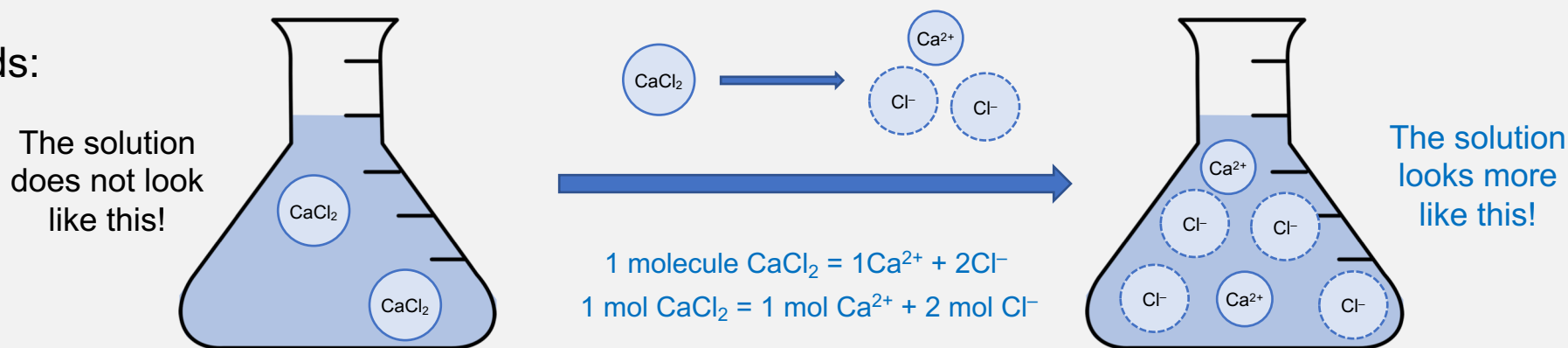$$0.120\text{ mol } CaCl_2 \times \frac{2\text{ mol } Cl^-}{1\text{ mol } CaCl_2} = 0.240\text{ mol } Cl^-$$

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CaCl₂ → Ca²⁺ + 2Cl⁻

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$$[Cl^-] = \frac{0.240\text{ mol } Cl^-}{60.0\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}}} = 4.00\text{ M } Cl^-$$

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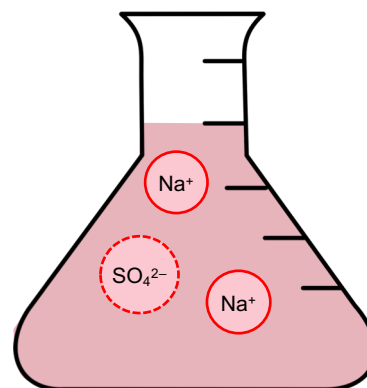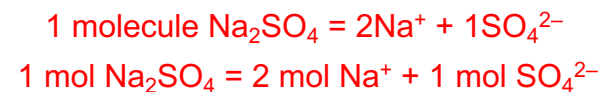We can represent the dissociation of each salt into its ions:

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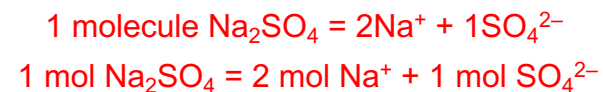$NaBr$ Na_2SO_4 Na_3PO_4

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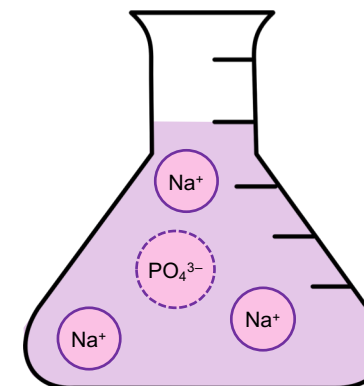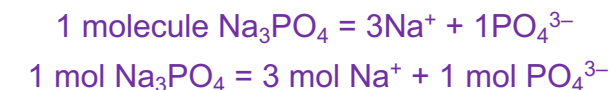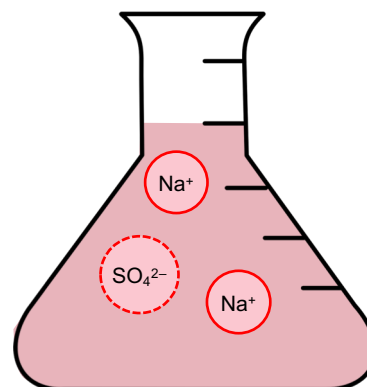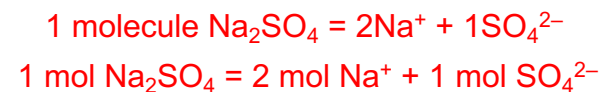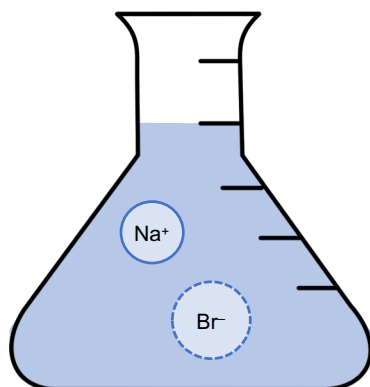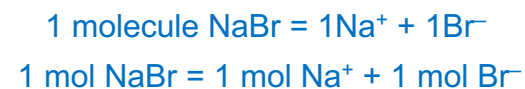
Now it's easier to understand that a solution of Na_3PO_4 would have the highest concentration of dissolved ions (4 ions).

Which of the following has the greatest concentration of dissolved ions in solution?

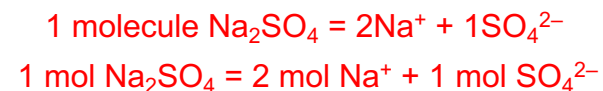**0.25 M NaBr**   **0.25 M Na$_2$SO$_4$**   **0.25 M Na$_3$PO$_4$**

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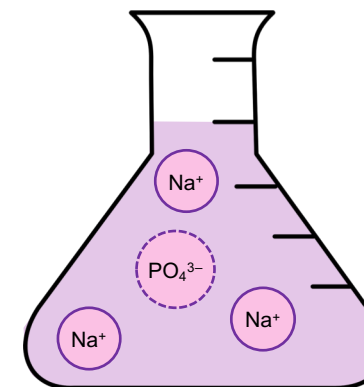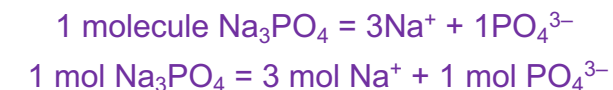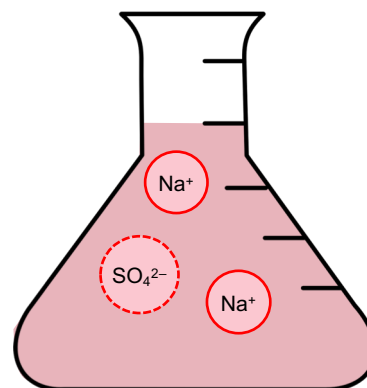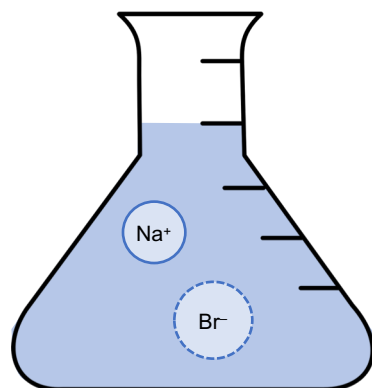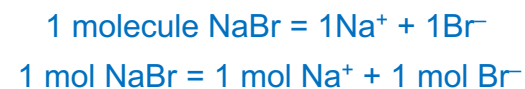
Understand that the concentration of *ions* would be:

1 NaBr : 2 ions   1 Na$_2$SO$_4$: 3 ions   1 Na$_3$PO$_4$: 4 ions

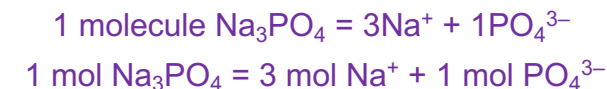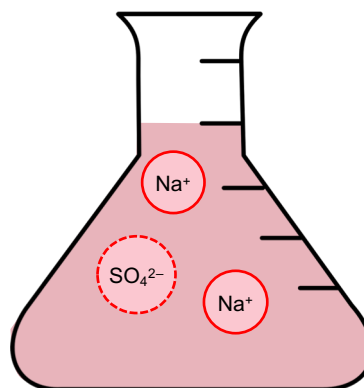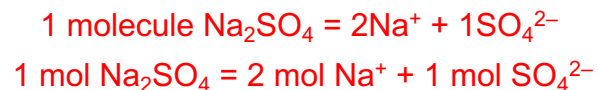# Which of the following has the greatest concentration of dissolved ions in solution?

$$0.25 \text{ M NaBr} \qquad\qquad 0.25 \text{ M Na}_2\text{SO}_4 \qquad\qquad 0.25 \text{ M Na}_3\text{PO}_4$$

These are all soluble salts!

We can represent the dissociation of each salt into its ions:

1 molecule $NaBr = 1Na^+ + 1Br^-$

1 mol $NaBr$ = 1 mol Na^+ + 1 mol Br^-

1 molecule $Na_2SO_4 = 2Na^+ + 1SO_4{}^{2-}$

1 mol Na_2SO_4 = 2 mol Na^+ + 1 mol $SO_4{}^{2-}$

1 molecule $Na_3PO_4 = 3Na^+ + 1PO_4{}^{3-}$

1 mol Na_3PO_4 = 3 mol Na^+ + 1 mol $PO_4{}^{3-}$

Understand that the concentration of *ions* would be:

1 $NaBr$: 2 ions

$[\text{ions}] = 2 \times 0.25 \text{ M} = 0.50 \text{ M}$

1 Na_2SO_4 : 3 ions

$[\text{ions}] = 3 \times 0.25 \text{ M} = 0.75 \text{ M}$

1 Na_3PO_4 : 4 ions

$[\text{ions}] = 4 \times 0.25 \text{ M} = 1.00 \text{ M}$

Which of the following has the greatest concentration of dissolved ions in solution?
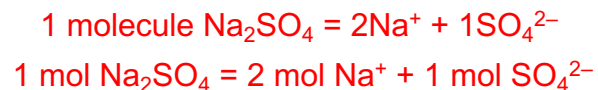
0.25 M NaBr   **0.25 M Na_2SO_4**   **0.25 M Na_3PO_4**

These are all soluble salts!

We can represent the dissociation of each salt into its ions:

1 molecule NaBr = $1Na^+$ + $1Br^-$
1 mol NaBr = 1 mol Na^+ + 1 mol Br^-

1 molecule Na_2SO_4 = $2Na^+$ + $1SO_4^{2-}$
1 mol Na_2SO_4 = 2 mol Na^+ + 1 mol SO_4^{2-}

1 molecule Na_3PO_4 = $3Na^+$ + $1PO_4^{3-}$
1 mol Na_3PO_4 = 3 mol Na^+ + 1 mol PO_4^{3-}

Understand that the concentration of *ions* would be:

1 NaBr : 2 ions
$[\text{ions}] = 2 \times 0.25 \text{ M} = 0.50 \text{ M}$

1 Na_2SO_4 : 3 ions
$[\text{ions}] = 3 \times 0.25 \text{ M} = 0.75 \text{ M}$

1 Na_3PO_4 : 4 ions
$[\text{ions}] = 4 \times 0.25 \text{ M} = 1.00 \text{ M}$