eeting 5 **Chemistry in Art!**
ct. 4

oserve what happens then explain:

a) First add the about 2/3 of the pink solution to the colorless solution in the larger vial. Use a glass Pasteur pipette for the transfer of solutions.
The pink solution is cobalt (II) chloride in water.
The colorless solution is sodium phosphate.

b) Now add the remaining 1/3 of the pink solution to the smaller vial containing a (different) colorless solutio
The pink solution is cobalt (II) chloride in water.
The colorless solution is sodium nitrate.

Explain what happens in (a) and in (b).

) When the pink cobalt chloride solution is added to the sodium phosphate solution, a deep ultramarine blue ecipitate forms. The precipitate is a new species, most likely the product of cobalt(II) ions plus phosphate ions.

) When the pink cobalt chloride solution is added to the sodium nitarte solution, no precipitate forms; the final lution is still pink. No reaction appears to occur.

Write a balanced equation for the reaction in (a). (s)

$$2Na_3PO_4 + 3CoCl_2 \rightarrow 6Na^+ + 6Cl^- + Co_3(PO_4)_2\ (s)$$

Write the net reaction for (a).

$$2PO_4^{3-} + 3Co^{2+} \rightarrow Co_3(PO_4)_2\ (s)$$

ie precipitate formed in reaction (a) is a paint pigment, sold as "**cobalt violet**". You have probably already deduced its rmula as $Co_3(PO_4)_2$. I found on a website another "recipe" for making cobalt violet pigment which uses 2.00 g $CoCl_2 \cdot$ H_2O dissolved in water and added to 1.3 g $Na_2HPO_4 \cdot 10\ H_2O$. The product has the same formula, $Co_3(PO_4)_2$.

Which will produce the greatest mass of cobalt violet pigment, A or B? (Do calculations on back of page)

A: 2.00 g $CoCl_2 \cdot 6H_2O$ dissolved in water and added to 1.3 g Na_3PO_4.
B: 2.00 g $CoCl_2 \cdot 6H_2O$ dissolved in water and added to 1.3 g $Na_2HPO_4 \cdot 10\ H_2O$.

: **2.00 g $CoCl_2 \cdot 6H_2O$ x (1 mol $CoCl_2 \cdot 6H_2O$ / 238 g) = 8.4×10^{-3} mol $CoCl_2$**
1.3 g Na_3PO_4 x (1 mol Na_3PO_4/ 163.9 g) = 7.9×10^{-3} mol Na_3PO_4

Now the amount of Na_3PO_4 needed to react exactly with 8.4×10^{-3} mol $CoCl_2$ is:

8.4 x 10^{-3} mol Co^{2+} x (2 mol PO_4^{3-} / 3 mol Co^{2+}) = 5.6 x 10^{-3} mol Na_3PO_4

This is ***less*** than the amount of phosphate in the 1.3 g, so that means the Co will react completely and there is ıosphate in excess. The amount of cobalt violet produced, #g $Co_3(PO_4)_2$, will be:

8.4 x 10^{-3} mol Co^{2+} x (1 mol $Co_3(PO_4)_2$/ 3 mol Co^{2+}) x (366.7 g /1 mol $Co_3(PO_4)_2$) = 1.03 g $Co_3(PO_4)_2$

We know already that 2.00 g $CoCl_2 \cdot 6H_2O$ = 8.4 x 10^{-3} mol $CoCl_2$
And we know the amount of Na_3PO_4 needed to react exactly with 8.4 x 10^{-3} mol $CoCl_2$ is:

8.4 x 10^{-3} mol Co^{2+} x (2 mol PO_4^{3-} / 3 mol Co^{2+}) = 5.6 x 10^{-3} mol Na_3PO_4 needed.

How much phosphate is available from the 1.3 g $Na_2HPO_4 \cdot 10\ H_2O$?

1.3 g $Na_2HPO_4 \cdot 10\ H_2O$ x (1 mol $Na_2HPO_4 \cdot 10\ H_2O$ / 322 g) = 4.0 x 10^{-3} mol PO_4^{3-}

This is ***less*** than is needed to completely react with the 8.4 x 10^{-3} mol Co^{2+}
So now some of the cobalt will be leftover. At this point we already know that less cobalt violet can be formed.

Mass of cobalt violet, $Co_3(PO_4)_2$ formed is:

4.0 x 10^{-3} mol PO_4^{3-} x (1 mol $Co_3(PO_4)_2$/ 2 mol PO_4^{3-}) x (366.7 g /1 mol $Co_3(PO_4)_2$) = 0.79 g $Co_3(PO_4)_2$

ıe answer is: A will produce more cobalt violet pigment than B.

Here's another cobalt violet production problem a chemist might have:
What mass of solid Na_3PO_4 should be dissolved in 100 mL of water to completely react with 50.0 mL of a 2 M $CoCl_2$ solution in water? ('Completely react' means no leftover reagents.)

)50 L x (2 mol/L Co) x (2 mol **PO_4^{3-}** / 3 mol **Co^{2+}**) x 163.9 g / 1 mol Na_3PO_4. = 10.9 g Na_3PO_4.

ɔte how the units cancel:
)50 ~~L~~ x (2 ~~mol/L Co~~) x (2 ~~mol PO_4^{3-}~~ / 3 ~~mol Co^{2+}~~) x 163.9 g / ~~1 mol Na_3PO_4~~. = 10.9 g Na_3PO_4.

ıe Reason Fresco Paintings Deteriorate

me solubilities

ı(SO_4)	3 x 10^{-3} M	0.41 g /L	0.041 g / 100mL
ı(CO_3)	6 x 10^{-5} M	0.006 g /L	0.0006 g / 100mL
ı$_3(PO_4)_2$	1.5 x 10^{-6} M	0.00047 g /L	0.000047 g / 100mL
ıCl_2	?		75 g /100 mL water

$a_2(SO_4)$	?		20 g /100 mL water
$a(SO_4)$	1×10^{-5} M	0.0023 g /L	0.00023 g / 100mL

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hich is most soluble? **$CaCl_2$ @ 75 g /100 mL water**

hich is least soluble? **$Ca_3(PO_4)_2$ @ 0.000047 g / 100mL**

ow is molar solubility of calcium sulfate converted to a mass solubility?

y multiplying by the molar mass: 3×10^{-3} mol/L x 136 g/ 1 mol $Ca(SO_4)$ = 0.41 g /L

y view of solubility trends: $\Delta E_{total} = \Delta E_{solvation} - \Delta E_{lattice}$

his is like what you plotted last week to explain the exothermicity or endothermicity.

Solution most favorable when $\Delta E_{total} < 0$ (exothermic), so when $\Delta E_{solvation} >> \Delta E_{lattice}$

And $\Delta E_{lattice}$ depends on q+ q-/d so it is largest for multiply charged ions.

Review Table 2.3: Which data are consistent with that?

ll the $\Delta E_{lattice}$ values for 2+ cations at more than twice as large as $\Delta E_{lattice}$ values for 1+ cation salts.

hat happens when a fresco (= $Ca(CO_3)$) is in contact with pure water?

tiny amount of $Ca(CO_3)$ will dissolve into the water, until the calcium and carbonate concentration is exactly 6 x $)^{-5}$ M (see numbers at top).

hat happens when a fresco (= $Ca(CO_3)$) is in contact with water that has sulfate ion dissolved in it?

ow more calcium will dissolve because the solubility of $Ca(SO_4)$ is greater (i.e., more soluble) until calcium ncentration is 3×10^{-3} M.

$a(SO_4)$ is the mineral gypsum that precipitates within the fresco. Because its crystal lattice is larger than $Ca(CO_3)$ of the esco base, to causes cracks to form.

he "barium treatment" is one method to "save" frescos; to prevent further deterioration. How might adding Ba^{2+} ions lp?

arium sulfate is very insoluble, so the Ba2+ acts to "trap" the sulfate and prevent it from aiding calcium carbonate, i.e. th esco, dissolution.