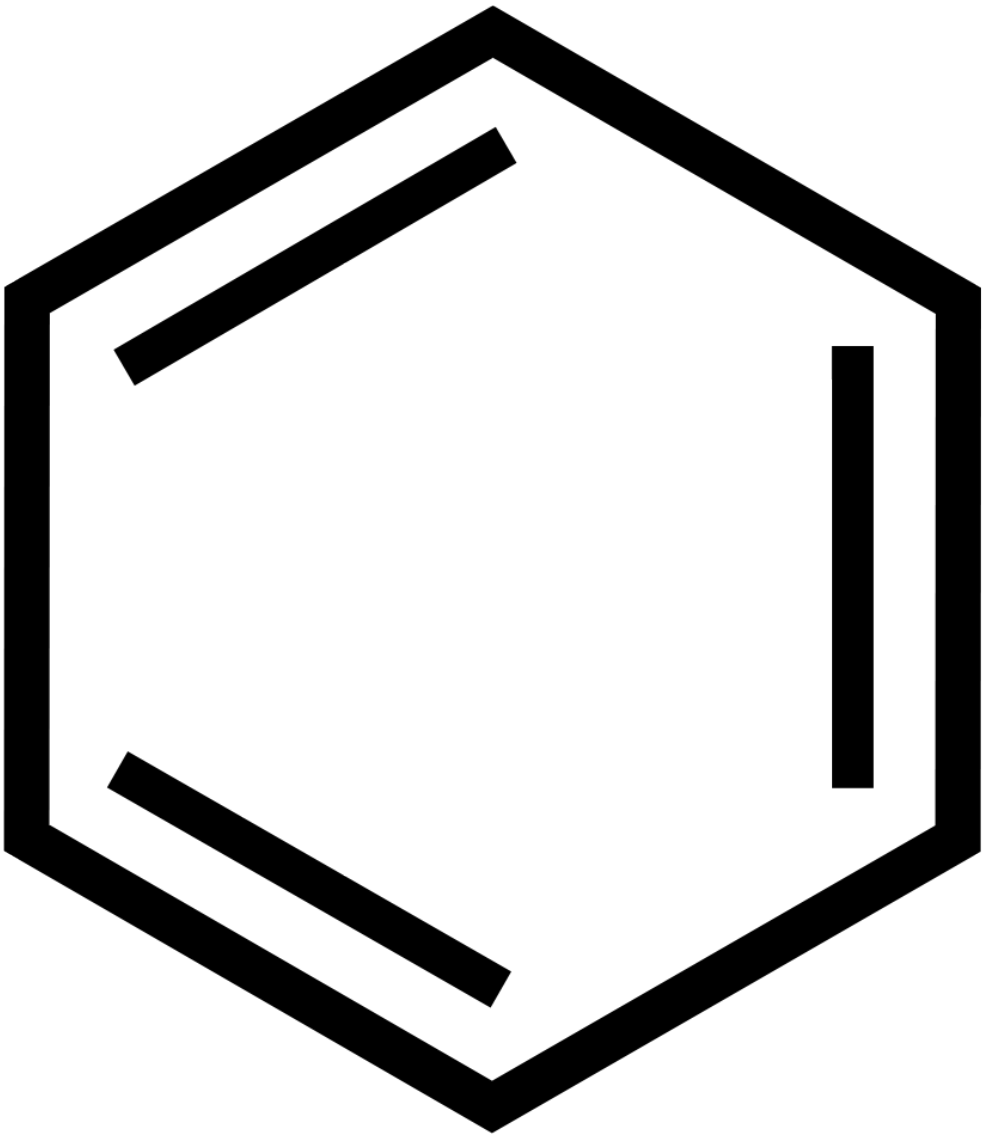

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CONCEPT: IONIC STRENGTH

Consider the dissociation of silver bromide, AgBr, in purified water.

$$AgBr\ (s) \rightleftharpoons Ag^{+}\ (aq) + Br^{-}\ (aq) \qquad K_{sp} = 1.34 \times 10^{-12}$$

Adding 0.10 M NaBr or 0.25 M $AgC_2H_3O_2$ cause the overall solubility of AgBr to _____ as a result of the _____.

$$AgBr\ (s) \rightleftharpoons Ag^{+}\ (aq) + Br^{-}\ (aq)$$

Adding 0.01 M $NaClO_4$ causes the overall solubility of AgBr to _____ as a result of the ***ionic strength***, which is just a measurement of all the ions in the aqueous solution.

$$AgBr\ (s) \rightleftharpoons Ag^{+}\ (aq) + Br^{-}\ (aq)$$

Ionic strength represents interactions between the ions in water and the ions of a solution.

$$\mu = \frac{1}{2}\Sigma\, c_i z_i^2 = \frac{1}{2}(c_1 z_1^2 + c_2 z_2^2 + ...)$$

EXAMPLE: Calculate the ionic strength of the following ionic compound.

0.010 M $CuSO_3$

CONCEPT: IONIC STRENGTH CALCULATIONS

EXAMPLE 1: Calculate the ionic strength for the following ionic compound.

0.030 M $Al_2(CO_3)_3$

EXAMPLE 2: What is the ionic strength of a solution that is 0.1 M Na_3PO_4 and 0.05 M Na_2HPO_4?

PRACTICE: Calculate the ionic strength for the following ionic compound.

0.04 M SnO_2

CONCEPT: ACTIVITY COEFFICIENTS

In order to express the effect of ionic strength on the concentration of species we calculate its activity with the use of an *activity coefficient*, which is given in units of gamma.

$$A_C = [C]\gamma_C$$

A_C = _____ of the compound
$[C]$ = _____ of the compound
γ_C = _____ of the compound

The activity coefficient and ionic strength can be more closely and accurately related by using the extended Debye-Huckel equation:

$$\log\gamma = \frac{-0.51z^2\sqrt{\mu}}{1+\left(\frac{\alpha\sqrt{\mu}}{305}\right)}$$

The effect of ionic strength, ionic charge and ionic size on the activity coefficient:

1. As ionic strength ____ , the activity coefficient will ____ and as the activity coefficient approaches ____ , ionic strength approaches ____.
2. As the size of ionic charge ____ , the more activity coefficient moves away from unity.
3. The smaller the ionic size ____ , the greater the effects of the activity coefficient.

EXAMPLE 1: For the following compound, state the solubility product expression with its activity coefficient.

$Cu_2(SO_4)_3$

EXAMPLE 2: For the following compound, state the solubility product expression with its activity coefficient.

Mo_2S_5

CONCEPT: ACTIVITY COEFFICIENT TABLE

By calculating the ionic strength of a compound the activity coefficient can be determined by the chart given below.

Ion	Ion size (α, pm)	Ionic strength (μ, M) 0.001	0.005	0.01	0.05	0.1
Charge = ±1		*Activity coefficient (γ)*				
H^+	900	0.967	0.933	0.914	0.86	0.83
$(C_6H_5)_2CHCO_2^-$, $(C_3H_7)_4N^+$	800	0.966	0.931	0.912	0.85	0.82
$(O_2N)_3C_6H_2O^-$, $(C_3H_7)_3NH^+$, $CH_3OC_6H_4CO_2^-$	700	0.965	0.930	0.909	0.845	0.81
Li^+, $C_6H_5CO_2^-$, $HOC_6H_4CO_2^-$, $ClC_6H_4CO_2^-$, $C_6H_5CH_2CO_2^-$, $CH_2{=}CHCH_2CO_2^-$, $(CH_3)_2CHCH_2CO_2^-$, $(CH_3CH_2)_4N^+$, $(C_3H_7)_2NH_2^+$	600	0.965	0.929	0.907	0.835	0.80
$Cl_2CHCO_2^-$, $Cl_3CCO_2^-$, $(CH_3CH_2)_3NH^+$, $(C_3H_7)NH_3^+$	500	0.964	0.928	0.904	0.83	0.79
Na^+, $CdCl^+$, ClO_2^-, IO_3^-, HCO_3^-, $H_2PO_4^-$, HSO_3^-, $H_2AsO_4^-$, $Co(NH_3)_4(NO_2)_2^+$, $CH_3CO_2^-$, $ClCH_2CO_2^-$, $(CH_3)_4N^+$, $(CH_3CH_2)_2NH_2^+$, $H_2NCH_2CO_2^-$	450	0.964	0.928	0.902	0.82	0.775
$^+H_3NCH_2CO_2H$, $(CH_3)_3NH^+$, $CH_3CH_2NH_3^+$	400	0.964	0.927	0.901	0.815	0.77
OH^-, F^-, SCN^-, OCN^-, HS^-, ClO_3^-, ClO_4^-, BrO_3^-, IO_4^-, MnO_4^-, HCO_2^-, $H_2citrate^-$, $CH_3NH_3^+$, $(CH_3)_2NH_2^+$	350	0.964	0.926	0.900	0.81	0.76
K^+, Cl^-, Br^-, I^-, CN^-, NO_2^-, NO_3^-	300	0.964	0.925	0.899	0.805	0.755
Rb^+, Cs^+, NH_4^+, Tl^+, Ag^+	250	0.964	0.924	0.898	0.80	0.75
Charge = ±2		*Activity coefficient (γ)*				
Mg^{2+}, Be^{2+}	800	0.872	0.755	0.69	0.52	0.45
$CH_2(CH_2CH_2CO_2^-)_2$, $(CH_2CH_2CH_2CO_2^-)_2$	700	0.872	0.755	0.685	0.50	0.425
Ca^{2+}, Cu^{2+}, Zn^{2+}, Sn^{2+}, Mn^{2+}, Fe^{2+}, Ni^{2+}, Co^{2+}, $C_6H_4(CO_2^-)_2$, $H_2C(CH_2CO_2^-)_2$, $(CH_2CH_2CO_2^-)_2$	600	0.870	0.749	0.675	0.485	0.405
Sr^{2+}, Ba^{2+}, Cd^{2+}, Hg^{2+}, S^{2-}, $S_2O_4^{2-}$, WO_4^{2-}, $H_2C(CO_2^-)_2$, $(CH_2CO_2^-)_2$, $(CHOHCO_2^-)_2$	500	0.868	0.744	0.67	0.465	0.38
Pb^{2+}, CO_3^{2-}, SO_3^{2-}, MoO_4^{2-}, $Co(NH_3)_5Cl^{2+}$, $Fe(CN)_5NO^{2-}$, $C_2O_4^{2-}$, $Hcitrate^{2-}$	450	0.867	0.742	0.665	0.455	0.37
Hg_2^{2+}, SO_4^{2-}, $S_2O_3^{2-}$, $S_2O_6^{2-}$, $S_2O_8^{2-}$, SeO_4^{2-}, CrO_4^{2-}, HPO_4^{2-}	400	0.867	0.740	0.660	0.445	0.355
Charge = ±3		*Activity coefficient (γ)*				
Al^{3+}, Fe^{3+}, Cr^{3+}, Sc^{3+}, Y^{3+}, In^{3+}, lanthanides[a]	900	0.738	0.54	0.445	0.245	0.18
$citrate^{3-}$	500	0.728	0.51	0.405	0.18	0.115
PO_4^{3-}, $Fe(CN)_6^{3-}$, $Cr(NH_3)_6^{3+}$, $Co(NH_3)_6^{3+}$, $Co(NH_3)_5H_2O^{3+}$	400	0.725	0.505	0.395	0.16	0.095
Charge = ±4		*Activity coefficient (γ)*				
Th^{4+}, Zr^{4+}, Ce^{4+}, Sn^{4+}	1 100	0.588	0.35	0.255	0.10	0.065
$Fe(CN)_6^{4-}$	500	0.57	0.31	0.20	0.048	0.021

EXAMPLE: Find the activity coefficient for the ion specified in the following compound:

a) Na^+ in 0.005 M NaCl

CONCEPT: ACTIVITY COEFFICIENT TABLE CALCULATIONS 1

EXAMPLE 1: Find the activity coefficient for the ion specified in the following compound:

CN^- in 1.0 mM RbCN

EXAMPLE 2: Find the activity coefficient for the ion specified in the following compound:

Zr^{4+} in 5.0 mM $Zr(NO_3)_4$

PRACTICE: Calculate the activity coefficient of H^+ using the extended Debye-Huckel equation for a solution comprised of H^+ and I^-. Given that H^+ has a size of 9.00×10^{-10} m and the molar concentration of the solution is 0.075.

$$\log\gamma = \frac{-0.51z^2\sqrt{\mu}}{1+\left(\frac{\alpha\sqrt{\mu}}{305}\right)}$$

CONCEPT: NON-IDEAL IONIC STRENGTH

Sometimes the ionic strength of a dissolvable compound you calculate may not be found on your chart.

- In a case like this you can just use _____ to find the best answer for our activity coefficient.

$$\frac{\text{Unknown } \gamma \text{ interval}}{\Delta\gamma} = \frac{\text{known } \mu \text{ interval}}{\Delta\mu}$$

EXAMPLE: Find the activity coefficient from the given ionic strength, μ, for the following ion.

Ba^{2+} when μ = 0.075

Ion	Ion size (α, pm)	Ionic strength (μ, M) 0.001	0.005	0.01	0.05	0.1
Sr^{2+}, Ba^{2+}, Cd^{2+}, Hg^{2+}, S^{2-}, $S_2O_4^{2-}$, WO_4^{2-}, $H_2C(CO_2^-)_2$, $(CH_2CO_2^-)_2$, $(CHOHCO_2^-)_2$	500	0.868	0.744	0.67	0.465	0.38

PRACTICE: Find the activity coefficient from the given ionic strength, μ, for the following ion.

F^- when μ = 0.0080

Ion	Ion size (α, pm)	Ionic strength (μ, M) 0.001	0.005	0.01	0.05	0.1
OH^-, F^-, SCN^-, OCN^-, HS^-, ClO_3^-, ClO_4^-, BrO_3^-, IO_4^-, MnO_4^-, HCO_2^-, $H_2citrate^-$, $CH_3NH_3^+$, $(CH_3)_2NH_2^+$	350	0.964	0.926	0.900	0.81	0.76

CONCEPT: pH Revisited CALCULATIONS 1

EXAMPLE 1: If at 50 ^{o}C the ionization of pure water, K_w, is 7.94 x 10^{-14} what is the pH of a neutral solution?

a) 7.00

b) 6.55

c) 13.10

d) Since K_w is a constant the number doesn't change.

EXAMPLE 2: What would be the pH of the same pure water when it contains 0.005 M NaBr at 50 ^{o}C?

EXAMPLE 3: Find the pH of a saturated solution of Barium hydroxide, $Ba(OH)_2$ when dissolved in 0.05 $LiNO_2$. The K_{sp} of $Ba(OH)_2$ is 5.0 x 10^{-3}.