ICE Table Calculations

Solubility is a common method for AP to test equilibrium. Expect this type of question

1. Silver sulfate is added to 500mL of water at 298K. The mixture is stirred and after a period of time a solid remains on the bottom of the beaker. Ksp = 1.0E-5.
   a. Write out the equilibrium reaction and ksp expression.

$Ksp = [Ag^+]^2[SO_4^{-2}]$

$Ag_2SO_4 \rightleftharpoons 2Ag^+ + SO_4^{-2}$

Video

   b. Determine the concentration of each ion in the solution.

	Ag_2SO_4	$\rightleftharpoons$	$2Ag^+$	+	SO_4^{-2}
I	–		0		0
S	–		$+x$		$+y$
E	–		$2x$		x

$1.0E-5 = 4x^3$

$x = 0.0135M$

   c. Student hypothesis: A solution 1L has the ability to dissolve more silver sulfate and this will result in a higher solubility.

No, Solubility is temp dependant
- Same Ratio

   d. Student hypothesis: A 500mL solution of 0.1M Na_2SO_4 has a lower solubility of silver sulfate then distilled water.

True, .1M SO_4^{-2} is present lowering Solubility

   e. Calculate the solubility of silver sulfate in the solution mentioned in "d".

$1.0E-5 = (2x)^2 \cdot .1$

$1.0E-5 = 4x^2 \cdot .1$ $\quad x = 0.005$

	Ag_2SO_4	$\rightleftharpoons$	$2Ag^+$	+	SO_4^{-2}
I	–		0		.1
S	–		$+2x$		$+x$
E	–		$2x$		.1+x

   f. 50mL of 0.1M Na_2SO_4 is mixed with 50mL of 0.05M of $AgNO_3$. Will a precipitation occur? Justify with calculations.

$Q = [Ag^+]^2[SO_4^{-2}]$

$(.025)^2(.05)$

$= 3.1E-5$

$Ag^+ = .05 \rightarrow .025$

$SO_4^{-2} = .1 \rightarrow .05$

Q > K

yes

2. Ethanoic acid (vinegar CH_3COOH) establishes equilibrium very quickly upon being dissolved in water.
   a. Write the hydrolysis reaction for vinegar.

$HC_2H_3O_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_2^-$

	$HC_2H_3O_2$		H_3O^+		$C_2H_3O_2^-$
I	.5		0		0
S	$-x$		$+x$		$+x$
E	.5		x		x

   b. For a given temperature, a 0.5M solution created a pH of 3.6.
      i. Determine the [ ] of each species at equilibrium.
      ii. Determine the Ka of the reaction.
      iii. Determine the percent ionization of the acid at this concentration.

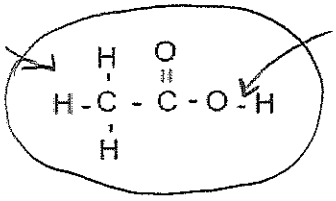
a) $10^{-3.6} = 2.5E-4$

b) $\frac{(2.5E-4)^2}{.5}$

$K_a = 1.26E-7$

c) $\frac{2.5E-4}{.5} \times 100 = 0.05\%$

   c. One of the two chemicals listed below are acidic, which one and why?

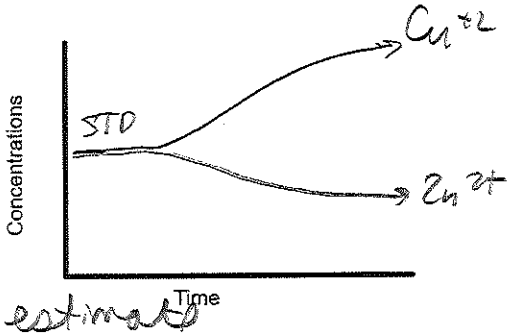


weak Bond is caused by Nearby O atom drawing e⁻ away.

3. A standard Copper/zinc battery used in most electronics via the following reaction.

$$Cu + Zn^{2+} \Leftrightarrow Cu^{2+} + Zn$$

a. The reaction has a standard voltage of 1.1V. Tracking this reaction at STP create a graph on the chart provided showing the relative concentrations as equilibrium is established.



b) $\Delta G = -RT\ln K$

$-212300 = -8.31(298)\ln K$

b. Determine the equilibrium constant for this reaction.

$\Delta G° = -nFE$

$-2(96500)1.1 = -212300\,J$

c. If all substances start at 1M, can you calculate the concentration of each substance at equilibrium.

$K = 1.70E37$ ← You can estimate

This went to completion $Cu^{2+} \rightarrow 2M$ $Zn^{2+} = 0$

4. 0.5mol SO_2 gas is introduced into a 2L vessel with containing 1mol of oxygen gas and allowed to react. At equilibrium the concentration of SO_2 was equal to ~~2.5~~M.

$$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$$

$\frac{.5}{2L} = .25$

	SO_2	O_2	SO_3
I	.25	.5	0
S	−.2	−.1	+.2x
E	.05	.4	.2

0.2

$x = 0.1$

a. Write the equilibrium ~~k~~ expression.

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

b. Determine the concentration of each substance at equilibrium.

c. Determine ~~Kp~~ K_c

$$\frac{(.1)^2}{(.05)^2(.4)^1} = 10$$

d. This reaction is running at the specified temperature, does it have to be exothermic to run?

$\Delta G = \Delta H - T\Delta S$ (−, +) yes need $-\Delta H$

5. $Ca(OH)_2$ Calcium also called slacked lime in industry is used frequently throughout the food industry. It is non-toxic and mildly basic. Ksp = 5.5E-6

a. Write the ~~equation~~ RXN responsible for the basic properties of calcium hydroxide.

$Ca(OH)_2 \rightarrow Ca^{+2} + 2OH^-$

b. Determine the pH of a saturated solution of slacked lime.

		Ca^{+2}	OH^-
I	−	0	0
S	−	+x	+2x
E	−	x	2x

$5.5E-6 = x(4x^2)$

$= 4x^3$

$x = 0.0111$

$-\log(\downarrow) = 1.95$

$14 - 1.95 =$ **12.0**

c. Which of the following could reduce the solubility of slacked lime?

i. Additional water. No

ii. Addition of a catalyst No

iii. NaOH(aq). No

iv. HCl(aq) yes. Removes OH^- allows more HCl to dissolve.