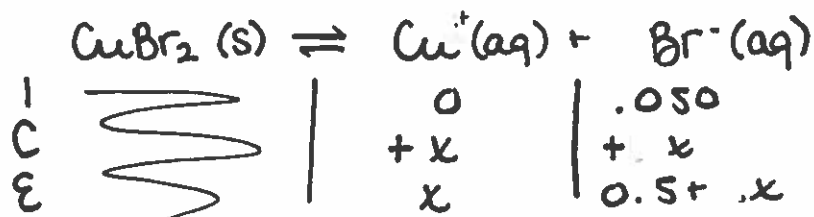


## Week 9 KEY

1. Determine the molar solubility of copper (I) bromide in a 0.050 M solution of NaBr.



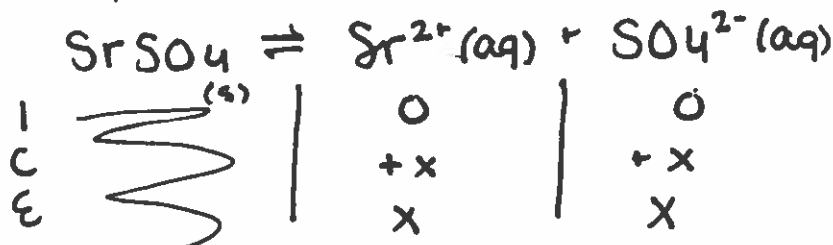
$$K_{sp} = [\text{Cu}^+][\text{Br}^-]$$

$$4.2 \times 10^{-8} = x(0.05 + x)$$

$$x = 8.4 \times 10^{-7} \text{ M}$$

assume negligible  
 $\frac{2x}{.5} \times 100 \checkmark \checkmark \checkmark$   
 passes

2. Calculate the molar solubility of strontium sulfate in  
 a. pure water

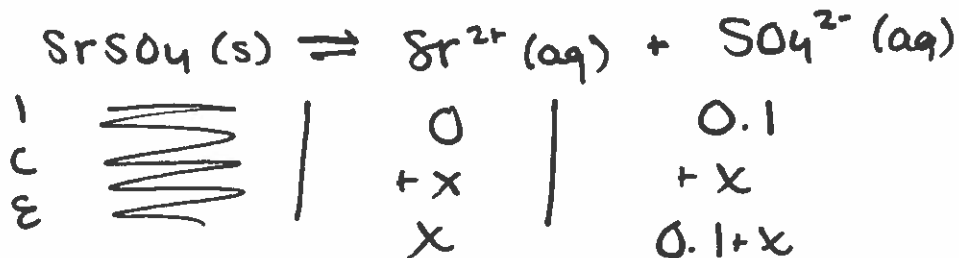


$$K_{sp} = [\text{Sr}^{2+}][\text{SO}_4^{2-}]$$

$$2.8 \times 10^{-7} = x^2$$

$$x = 5.29 \times 10^{-4} \text{ M}$$

- b. in a 0.10 M solution of  $\text{Na}_2\text{SO}_4$ .



$$K_{sp} = [\text{Sr}^{2+}][\text{SO}_4^{2-}]$$

$$2.8 \times 10^{-7} = x(0.1 + x)$$

$$x = 2.8 \times 10^{-6} \text{ M}$$

assume negligible  
 $\frac{x}{.1} \times 100 \checkmark \checkmark \checkmark$   
 passes

3. The molar solubility of  $\text{Ba}(\text{NO}_3)_2$  in water is 0.105 mol/L. Determine the  $K_{sp}$ .

$$K_{sp} = [\text{Ba}^{2+}][\text{NO}_3^-]^2$$

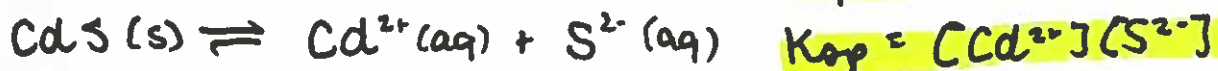
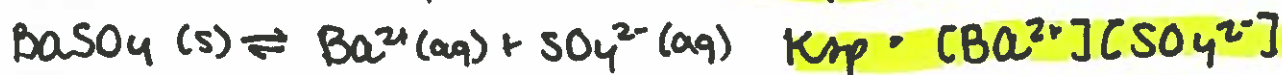
$$= x(2x)^2$$

$$= 4x^3$$

$$= 4(0.105)^3$$

$$K_{sp} = 4.63 \times 10^{-3}$$

4. Write the dissociation reaction and  $K_{sp}$  expression for the following:  $\text{AlPO}_4$ ,  $\text{BaSO}_4$ ,  $\text{CdS}$ , and  $\text{Cu}_3(\text{PO}_4)_2$



Conceptual Problems:

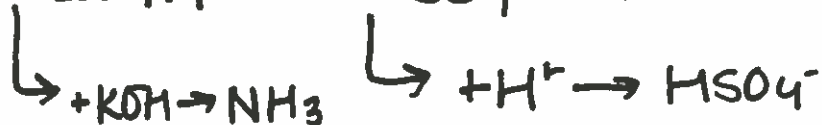
5. Is a compound more or less soluble in a solution that contains a common ion?

less soluble, equilibrium shifts left

6. How does temperature affect solubility?

$T \uparrow$ , solubility  $\uparrow$

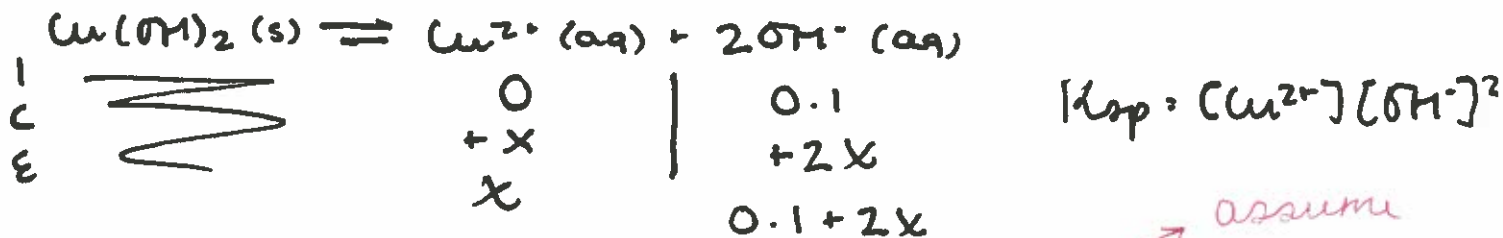
7. How would the addition of  $\text{KOH}$  affect the solubility of ammonium sulfate? How about the addition of  $\text{HCl}$ ?



both increase solubility by reacting with the product ions and shifting eq to the right.

8. You dissolve  $\text{Cu}(\text{OH})_2$  in each of the following aqueous solutions. What is the molar solubility in each?

a. Solution buffered at pH 13  $[\text{OH}^-] = 0.1 \text{ M}$

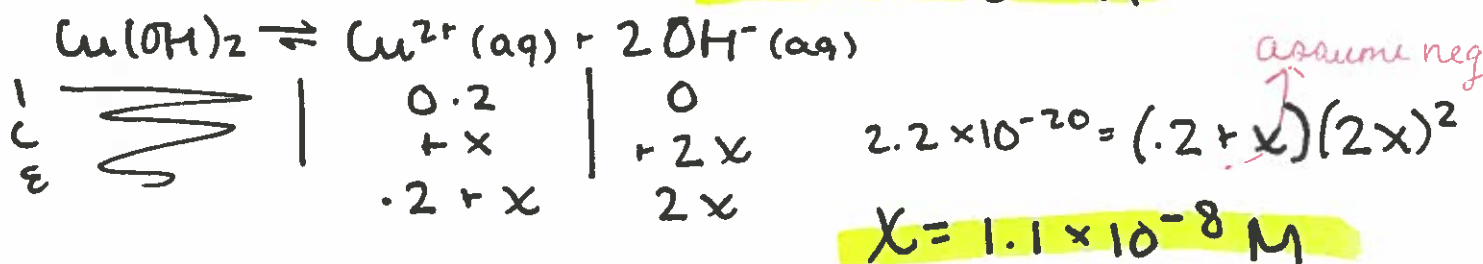


$$2.2 \times 10^{-20} = x(0.1 + 2x)^2$$

$$x = 2.2 \times 10^{-18} \text{ M}$$

assume negligible  
 $\frac{2x}{0.1} \times 100$   
 ✓✓✓

b. 0.2M copper (II) chloride

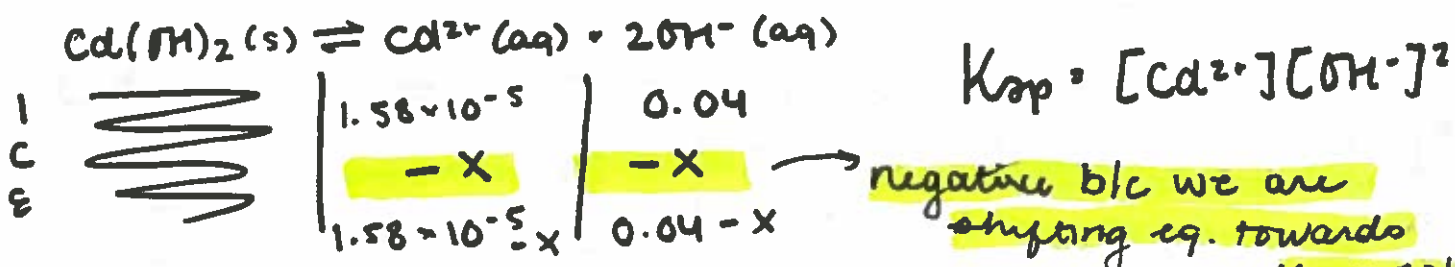


assume neg

9. Cadmium is a highly toxic environmental pollutant that enters wastewaters associated with zinc smelting (Cd and Zn commonly occur together in ZnS ores) and in some electroplating processes. One way of controlling cadmium in effluent streams is to add sodium hydroxide, which precipitates insoluble  $\text{Cd}(\text{OH})_2$ . If 1000 L of a certain wastewater contains  $\text{Cd}^{2+}$  at a concentration of  $1.6 \times 10^{-5} \text{ M}$ , what concentration of  $\text{Cd}^{2+}$  would remain after addition of 10 L of 4 M NaOH solution?

$$\text{Cd}^{2+} = 1.6 \times 10^{-5} \text{ M} \times 1000 \text{ L} = 0.016 \text{ mol} \div 1010 \text{ L}$$

$$\text{OH}^- = 4 \text{ M} \times 10 \text{ L} = 40 \text{ mol} \div 1010 \text{ L}$$



negative b/c we are shifting eq. towards the solid

$$2.54 \times 10^{-14} = (1.58 \times 10^{-5} - x)(0.04 - x)^2$$

assume 0

$$\therefore x \approx 1.58 \times 10^{-5}$$

$$\therefore x \approx 0.04 \quad [\text{Cd}^{2+}] = 1.58 \times 10^{-5} - x$$

$$\therefore \text{Cd}^{2+} \rightarrow \text{about zero}$$

10. The molar solubility of calcium chloride at 35°C is  $1.24 \times 10^{-3}$  M. What is the  $K_{sp}$  at this temperature? What is the solubility (in g/L) in a 0.3M solution of magnesium chloride?

a.  $K_{sp} = [Ca^{2+}][Cl^-]^2 = x(2x)^2 = 1.24 \times 10^{-3} M$

$K_{sp} = 4(1.24 \times 10^{-3})^3 = 8.0 \times 10^{-9} = K_{sp}$

$\frac{2x}{0.6} \times 100$   
✓✓✓ passed



I		0	0.6
C		+x	+2x
E		x	0.6+2x

$8.0 \times 10^{-9} = x(0.6 + 2x)^2$

$x = 2.2 \times 10^{-8} M$

11. What is the pH of a 0.5 L solution made by mixing 1.0 moles of potassium acetate and 1.5 moles acetic acid? What is the pH of this solution if you add 5.0 mL 4.0 M HCl?



I	3	2	0
C	-x	+x	+x
E	3-x	2+x	x

$K_a = \frac{[A^-][H_3O^+]}{[HA]}$

$1.8 \times 10^{-5} = \frac{x(2+x)}{(3+x)}$

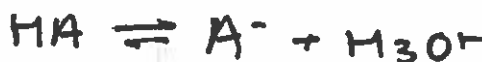
$x = 2.7 \times 10^{-5}$

$\therefore pH = 4.57$

assume neg  
 $\frac{x}{2} \times 100$   
✓✓✓ passed



B	1.0	.02	1.5
R	+.02	-.02	+.02
A	0.98	—	1.52
C	1.94	—	3.01



I	3.01	1.94	0
C	-x	+x	+x
E	3.01-x	1.94+x	x

$1.8 \times 10^{-5} = \frac{x(1.94+x)}{3.01-x}$

$x = 2.74 \times 10^{-5}$

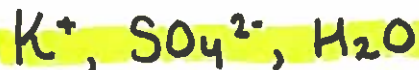
$\therefore pH = 4.56$

assume neg

$\frac{x}{1.94} \times 100$   
✓✓✓ passed

12. Consider the titration of 50.0 mL of 0.200 M  $K_2SO_4$  with 0.40 M HCl (aq)

a. What are the major species present before the addition of titrant?



b. Calculate the pH at the equivalence point and identify the major species at this point?



B	.01	.01	0
R	-.01	-.01	+.01
A	—	—	.01
C	—	—	0.133

÷ 75 mL



1	0.133	0	0
C	-x	+x	+x
E	.133-x	x	x

$$1.2 \times 10^{-2} = x^2 / 0.133 - x$$

$$x = 0.0344$$

$$\therefore pH = 1.46$$

MAJOR SPECIES:



c. Calculate the pH at the halfway point and identify the major species at this point in the titration.

@ halfway point,  $pH = pK_a$

$$\therefore pH = 3.38$$

MAJOR SPECIES:  $H_2O, K^+, HSO_4^-, SO_4^{2-}$

d. Calculate the pH 20.0 mL after the equivalence point and identify the major species at this point in the titration. 20.0 mL past eq = 45 mL added



B	.01	.018	0
R	-.01	-.01	+.01
A	—	.008	.01 ÷ 95 mL
C	—	.084	.105

excess  $[H^+]$  dominates

$$pH = -\log(0.084)$$

$$\therefore pH = 1.08$$

MAJOR SPECIES:  $H_2O, K^+, HSO_4^-, H^+$

e. Which of the above point/points in the titration are buffered? Explain your answer.

part c (the halfway point) is buffered

because both  $SO_4^{2-}$  and  $HSO_4^-$  are present.