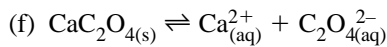


Well #	A	B	C	D	E
1	$1.0 \times 10^{-1}$	$1 \times 10^{-1}$	$5.00 \times 10^{-2}$	$5.00 \times 10^{-2}$	$3 \times 10^{-3}$
2	$5.00 \times 10^{-2}$	$1 \times 10^{-1}$	$2.50 \times 10^{-2}$	$5.00 \times 10^{-2}$	$1 \times 10^{-3}$
3	$2.50 \times 10^{-2}$	$1 \times 10^{-1}$	$1.25 \times 10^{-2}$	$5.00 \times 10^{-2}$	$6 \times 10^{-4}$
4	$1.25 \times 10^{-2}$	$1 \times 10^{-1}$	$6.25 \times 10^{-3}$	$5.00 \times 10^{-2}$	$3 \times 10^{-4}$
5	$6.25 \times 10^{-3}$	$1 \times 10^{-1}$	$3.13 \times 10^{-3}$	$5.00 \times 10^{-2}$	$2 \times 10^{-4}$
6	$3.13 \times 10^{-3}$	$1 \times 10^{-1}$	$1.56 \times 10^{-3}$	$5.00 \times 10^{-2}$	$8 \times 10^{-5}$
7	$1.56 \times 10^{-3}$	$1 \times 10^{-1}$	$7.81 \times 10^{-4}$	$5.00 \times 10^{-2}$	$4 \times 10^{-5}$
8	$7.81 \times 10^{-4}$	$1 \times 10^{-1}$	$3.91 \times 10^{-4}$	$5.00 \times 10^{-2}$	$2 \times 10^{-5}$
9	$3.91 \times 10^{-4}$	$1 \times 10^{-1}$	$1.95 \times 10^{-4}$	$5.00 \times 10^{-2}$	$1 \times 10^{-5}$
10	$1.95 \times 10^{-4}$	$1 \times 10^{-1}$	$9.77 \times 10^{-5}$	$5.00 \times 10^{-2}$	$5 \times 10^{-6}$
11	$9.77 \times 10^{-5}$	$1 \times 10^{-1}$	$4.88 \times 10^{-5}$	$5.00 \times 10^{-2}$	$2 \times 10^{-6}$
12	$4.88 \times 10^{-5}$	$1 \times 10^{-1}$	$2.44 \times 10^{-5}$	$5.00 \times 10^{-2}$	$1 \times 10^{-6}$

(extra digits carried in the calculation of columns A, C, and D)



$$K_{sp} = [\text{Ca}_{(aq)}^{2+}][\text{C}_2\text{O}_{4(aq)}^{2-}]$$

- (g) Well #11 was the last well in which a precipitate was observed. Therefore, the actual value of  $K_{sp}$  must lie between  $1 \times 10^{-6}$  and  $2 \times 10^{-6}$ .

### Evaluation

- (i) Air bubbles can easily be drawn into the pipet. This decreases the volume of solutions transferred to the next well. Doubling the volumes of all solutions initially should reduce the risk of drawing into the pipet without affecting the calculations.
- (j) The accepted value of  $K_{sp}$  for calcium oxalate is  $2.3 \times 10^{-9}$ . The result obtained from this experiment is approximately 1000 times larger than the accepted value. Since similar results were obtained by most of my classmates, I have confidence in my data.

## INVESTIGATION 7.6.2 DETERMINING $K_{sp}$ FOR CALCIUM HYDROXIDE

(Page 519)

### Question

- (a) What is the  $K_{sp}$  for calcium hydroxide?

### Prediction

- (b) The accepted value for the solubility product of calcium hydroxide is  $7.9 \times 10^{-6}$ .

### Experimental Design

- (c) A filtered solution of calcium hydroxide is titration with a hydrochloric acid solution of known concentration to a bromophenol blue endpoint.

### Materials

- (d) 0.10 mol/L hydrochloric acid,  $\text{HCl}_{(aq)}$   
 bromophenol blue indicator  
 filtered calcium hydroxide  
 buret, stand, and clamp  
 125-mL Erlenmeyer flask  
 funnel  
 two 250-mL beakers  
 10-mL pipet and filler

### Safety Precautions

The solutions in this experiment are corrosive. Eye protection and a laboratory apron must be worn. Leftover acid or base should be disposed of in a container provided by the teacher.

### Procedure

- (e)
1. Clean the buret with water. Check that the buret drains appropriately.
  2. Fill the buret with the acid solution.
  3. Pipet 10.00 mL of calcium hydroxide into the flask.
  4. Add about 20 mL of distilled water to the flask.
  5. Add 3 drops of bromophenol blue indicator to the flask.
  6. Titrate the base to a bromophenol blue endpoint.
  7. Repeat the titration until reproducible results are obtained.
  8. Dispose of the solutions as directed by the teacher.

### Analysis

- (f) Average volume of 0.10 mol/L HCl used: 2.50 mL  
volume of calcium hydroxide: 10.00 mL

$$\begin{aligned}n_{\text{HCl(aq)}} &= 0.10 \text{ mol/L} \times 2.50 \text{ mL} \\&= 0.25 \text{ mmol} \\&= n_{\text{OH}^-\text{(aq)}} \\C_{\text{OH}^-\text{(aq)}} &= \frac{0.25 \text{ mmol}}{10.00 \text{ mL}} \\C_{\text{OH}^-\text{(aq)}} &= 0.025 \text{ mol/L} \\C_{\text{Ca}^{2+}\text{(aq)}} &= \frac{C_{\text{OH}^-\text{(aq)}}}{2} \\C_{\text{Ca}^{2+}\text{(aq)}} &= 0.0125 \text{ mol/L (extra digits carried)}\end{aligned}$$

$$[\text{Ca}^{2+}_{\text{(aq)}}][\text{OH}^-\text{(aq)}]^2 = (0.0125)(0.025)^2$$

$$[\text{Ca}^{2+}_{\text{(aq)}}][\text{OH}^-\text{(aq)}]^2 = 7.8 \times 10^{-6}$$

The solubility product for calcium hydroxide is  $7.8 \times 10^{-6}$ .

### Evaluation

(g) % difference =  $\frac{7.9 \times 10^{-6} - 7.8 \times 10^{-6}}{7.9 \times 10^{-6}} \times 100\%$

$$\% \text{ difference} = 1.3\%$$

- (h) The experimental value is judged to be acceptable because it is very close to the reference value for calcium hydroxide. Some error in the lab could be attributed to concentration of the hydrochloric acid solution. The concentration of the solution could be first determined experimentally by titrating the acid with a primary standard such as potassium hydrogen phthalate.