A charming calculator-free worksheet concerning $K_{sp}$, $K_w$, $K_a$ & $K_b$ and strong acids and bases.

1. Define $K_{sp}$ for the dissolution of the following salts in water. If necessary, write a balanced chemical equation for the dissolution first.
   a. RbI,
   b. Ca(NO$_3$)$_2$,
   c. K$_3$PO$_4$,
   d. SrS,
   e. Fe$_2$(SO$_4$)$_3$,
   f. K$_3$Fe(C$_2$O$_4$)$_3$,

2. Consider each of the salts below. Express each salt's molar solubility (we'll call it x) in terms of $K_{sp}$. It might be useful to first write a balanced equation for each salt's dissolution and complete a RICE diagram.
   a. Cu$_3$(PO$_4$)$_2$,
   b. MgSe,
   c. Li$_3$PO$_4$,
   d. K$_3$Fe(C$_2$O$_4$)$_3$,

3. Estimate the actual molar solubilities of the following salts in water based on their $K_{sp}$ values.
   a. Barium Sulfate, BaSO$_4$, $K_{sp} = 1.08 \times 10^{-10}$,
   b. Cadmium Phosphate, Cd$_3$(PO$_4$)$_2$, $K_{sp} = 2.53 \times 10^{-33}$,
   c. Lithium Carbonate, Li$_2$CO$_3$, $K_{sp} = 1.73 \times 10^{-3}$,
   d. Magnesium Ammonium Phosphate, MgNH$_4$PO$_4$, $K_{sp} = 2.5 \times 10^{-13}$,

4. Estimate the actual molar solubilities of the following salts in the following solutions based on the provided concentrations and $K_{sp}$ values. It might be useful to first write a balanced equation for each salt's dissolution and complete a RICE diagram.
   a. Mercuric Bromide, HgBr$_2$, $K_{sp} = 8 \times 10^{-20}$, in 2 M Hg(NO$_3$)$_2$,
   b. Silver Chloride, AgCl, $K_{sp} = 1.56 \times 10^{-10}$, in 15 M KCl,
   c. Barium Iodate, Ba(IO$_3$)$_2$, $K_{sp} = 6.5 \times 10^{-10}$, in 2.5 M KIO$_3$,

5. Match the $K_w$ values on the left with their corresponding pH values on the right. Assume you have a sample of completely pure water.

\[
\begin{array}{c|c}
K_w (e^{-14}) & pH \\
0.114 & 7.08 \\
0.293 & 7.27 \\
0.681 & 6.14 \\
1.008 & 6.92 \\
1.471 & 7.47 \\
2.916 & 6.63 \\
5.476 & 7.00 \\
51.3 & 6.77 \\
\end{array}
\]
6. Answer the following questions concerning the autoprotolysis of water;
   a. Is the autoprotolysis of water endothermic or exothermic?
   b. What would be a simple experiment to verify this?
   c. What would be a simple way to calculate \( \Delta H_{\text{autoprotolysis}} \)?

7. List the 7 strong acids from memory.

8. List the 8 strong bases from memory.

9. List the 14 spectator ions from memory. The answers to questions 7 and 8 are a really good starting point for this problem.

10. Decide whether each of the species below is a weak acid or weak base. Note that it is possible to know this based on a chemical's name, and generally possible based on its formula.
    a. pyridinium,
    b. oxalate,
    c. HIO₃,
    d. NH₃,
    e. formic acid,
    f. hydrazine,
    g. ClO⁻,
    h. NH⁴⁺,

11. Complete the following table: (Hint: \(-\log 0.4 = 0.4\), this is a good and easy reference point to remember for the log function.)

<table>
<thead>
<tr>
<th></th>
<th>([H^+]) (M)</th>
<th>pH</th>
<th>([OH^-]) (M)</th>
<th>pOH</th>
</tr>
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<tr>
<td>Solution A</td>
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<tr>
<td>Solution B</td>
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<tr>
<td>Solution C</td>
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<td>Solution D</td>
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<tr>
<td>Solution E</td>
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<tr>
<td>Solution J</td>
<td></td>
<td>10⁻⁹</td>
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</tr>
</tbody>
</table>

12. What would be the pH of the following solutions?
    a. 0.01 M HClO₄,
    b. 0.05 M Ba(OH)₂,
c. \(10 \text{ M } \text{HNO}_3\), 
d. \(10 \text{ M } \text{LiOH}\),

13. What would be the pOH of the following solutions?
   a. \(0.1 \text{ M } \text{RbOH}\), 
b. \(0.5 \text{ M } \text{Sr(OH)}_2\), 
c. \(0.001 \text{ M } \text{HClO}_3\), 
d. \(0.4 \text{ M } \text{HI}\),

14. What would be the pH of the following solutions? You may approximate if necessary; you should not need a calculator.
   a. \(0.25 \text{ M } \text{HNO}_2, \text{ } K_a = 4.0 \times 10^{-4}\),
   b. \(5.55 \text{ M } \text{NH}_3, \text{ } K_b = 1.8 \times 10^{-5}\),
   c. \(0.0125 \text{ M ascorbic acid}, \text{ } K_a = 7.9 \times 10^{-5}\),
   d. \(0.0135 \text{ M trimethylamine}, \text{ } K_b = 7.4 \times 10^{-5}\),
   e. \(0.3 \text{ M HOCl}, \text{ } K_a = 3.5 \times 10^{-8}\),

15. Consider each of the acids and bases below. Write the formula or name for each species' conjugate and calculate the \(K_a\) or \(K_b\) for that conjugate. Approximate if necessary.
   a. ammonium, \(K_a = 5.55 \times 10^{-10}\),
   b. OCl\(^-\), \(K_b = 2.5 \times 10^{-7}\),
   c. pyridine, \(K_b = 1.6 \times 10^{-9}\),
   d. HCN, \(K_a = 4.0 \times 10^{-10}\),