1) Label the acid, base, conjugate acid, and conjugate base in the following reaction.

$$\text{HF}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{F}^-_{(aq)}$$

Acid         Base           Conjugate     Conjugate
Acid         Base

2) What is the strongest base in the following reaction?

$$\text{HNO}_3_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{NO}_3^-_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$$

H$_2$O is the strongest base. Strong acids, such as HNO$_3$ have weak conjugate bases, so NO$_3^-$ is a weak base. H$_2$O and NO$_3^-$ compete for H$^+$ ions. H$_2$O acquires the H$^+$ ions most of the time, as we assure the reaction goes to completion.

3) What is the strongest acid in the following reaction?

$$\text{H}_2\text{SO}_4_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{HSO}_4^-_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$$

H$_2$SO$_4$ is a very strong acid. It is one of the ‘Big Six’ strong acids.

4) What is the strongest acid in the following set? Justify your answers.

HCl or HI

HI is the stronger acid. The ionic radius of I$^-$ is larger than that of Cl$^-$. Because of this, the force of attraction between I$^-$ and the H$^+$ ion is less than that between Cl$^-$ and H$^+$. Thus, I$^-$ will lose H$^+$ ions easier than Cl$^-$, although both are strong acids.

5) What is the strongest base in this set? Explain.

I$^-$ or Br$^-$

Both I$^-$ and Br$^-$ are weak bases as they are the conjugate bases of the strong acids HI and HBr. Br$^-$ is, however, the stronger base, as it has a smaller ionic radius and thus has a slightly greater ability to attract H$^+$ ions.

6) What is the strongest acid in the following set? Explain.

HOCl or HOBr

HOCl is the stronger acid. As chlorine is more electronegative than bromine, chlorine reduces the electron density in the H-O bond to a greater degree than bromine. Because the electron density between the hydrogen and the oxygen in HOCl is less than it is in HOBr, the forces of attraction between the hydrogen and the oxygen in HOCl are less than they are in HOBr. Thus, HOCl will lose its H$^+$ ion more easily.
7) What is the strongest acid in the following set? Explain.

\text{HIO}_3\text{ or HIO}_2

HIO\textsubscript{3} is the stronger acid. The pattern of bonding for the two structures is as follows: HOIO\textsubscript{2} and HOIO. HIO\textsubscript{3} has one more highly electronegative terminal oxygen atom attached to the iodine atom than does HOI\textsubscript{2}. The higher concentration of electronegative elements around the iodine in HClO\textsubscript{3} results in a reduced electron density between the oxygen and hydrogen atoms over that of HIO\textsubscript{2}. Because the electron density between the hydrogen and oxygen in HIO\textsubscript{3} is less than it is in HIO\textsubscript{2}, the force of attraction holding onto the hydrogen in HIO\textsubscript{3} is also less.

8) What is the strongest acid in the following set? Explain.

\text{CH}_2\text{ClCOOH or CHCl}_2\text{COOH}

CHCl\textsubscript{2}COOH is the stronger acid. Chlorine is more electronegative than hydrogen. The higher concentration of electronegative chlorine atoms at the opposite end of the structure from the hydrogen that is donated in CHCl\textsubscript{2}COOH means that the electron density between the hydrogen and oxygen in CHCl\textsubscript{2}COOH is less than that of CH\textsubscript{2}ClCOOH. Because the electron density between the hydrogen and oxygen in CHCl\textsubscript{2}COOH is less than it is in CH\textsubscript{2}ClCOOH, the force of attraction holding onto the hydrogen in CHCl\textsubscript{2}COOH is also less.

9) The concentration of H\textsuperscript{+} in a solution is found to be 3.5 \times 10^{-5} \text{ M}. Find [OH\textsuperscript{-}].

\[ K_w = [H_3O^+][OH^-] \]
\[
[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-5}} = 2.9 \times 10^{-10} \text{ M} \]