Exercise 4.1.

For following oxides, write down the defect formation processes (Schottky, Anti-Schottky, Frenkel, Anti-Frenkel) and suitable reaction constant for each:

- Cu$_2$O
- Cr$_2$O$_3$
- TiO$_2$
- V$_2$O$_3$

Exercise 4.2.

For Cu$_2$O, knowing that the main type of defects are Frenkel defects and knowing values of $K_S$, $K'_S$, $K'_F$, find concentration of interstitial copper ions.

Exercise 4.3.

Find all defect concentrations ($[V_{Ti}^{4+}]$, $[V_{O}^{2-}]$, $[Ti^{4+}]$, $[O^{2-}]$) for TiO$_2$. Assume that dominating type of defects are Schottky defects. $K_S$, $K'_S$, $K'_F$ are known.

Exercise 4.4.

For given oxides, write defect formation processes (and reaction constants) assuming nonstochiometry of compounds. For every oxide take under consideration all possible cases:

- Excess of a metal (Me$_{n+y}$X$_m$)
- Shortage of an oxidant (Me$_n$X$_{m-y}$)
- Shortage of a metal (Me$_{n-y}$X$_m$)
- Excess of an oxidant (Me$_n$X$_{m+y}$)

Oxides:

- Cr$_2$O$_3$
- ZrO$_2$
- Cu$_2$O

Exercise 4.5.

Knowing that ZnO usually has an excess of a metal, Zn$_{1+y}$O, find concentrations of every type of defects ($[V_{O}^{2-}]$, $[e^-]$, $[Zn^{2+}]$, $[h^+]$, $[O^{2-}]$, $[V_{Zn}^{2+}]$) as a functions of oxygen pressure. All reaction constantans ($K_1$, $K_2$, $K_3$, $K_4$, $K_f$, $K'_f$, $K_S$, $K'_S$, $K_e$) are known, where:

$$K_e = [h^+][e^-]$$
Exercise 4.6.

Knowing that ZrO$_2$ usually has shortage of oxygen: ZrO$_{2-y}$, find concentrations of every type of defects ([V$^*_{o'}$], [e$^-$], [Zr$^{4+}$], [h$^+$], [O$^{2-}$], [V$^{2+}_{z'}$]) as a functions of oxygen pressure. All reaction constants ($K_1$, $K_2$, $K_3$, $K_4$, $K_{f}$, $K_{s}$, $K_{f}'$, $K_{s}'$, $K_{s}$) are known, where:

\[ K_o = [h^+][e^-] \]