A) Which is the correct equilibrium expression for Reaction 1?

Reaction 1 $\frac{1}{2}\ Ca(HO)_2\ (s) \Leftrightarrow \frac{1}{2}\ Ca^{2+}(aq) + HO^-(aq)$ $Kc1 = 2{,}55\ 10^{-3}$

Reaction 2 $2\ H_2O(l) \Leftrightarrow 2H^+(aq) + 2HO^-(aq)$ $Kc2 = 1{,}0\ 10^{-28}$

Answer: $Kc1 = [Ca^{2+}]^{1/2} . [HO^-]$ (Solids are not included in the equilibrium expression)

B) Which (if any) of the reactions is product favored?

Answer: Neither React 1 nor React 2. (Kc1 and Kc2 are <1 => reactant favored)

C) From the data above, determine the equilibrium constant for the following reaction:

Reaction 3 $\frac{1}{2}\ Ca^{2+}(aq) + H_2O(l) \Leftrightarrow \frac{1}{2}\ Ca(HO)_2\ (s) + H^+(aq)$ Kc = ?

We need to rearrange React 1 and React 2, and use Kc1 and Kc2 to obtain Kc.

1. In reaction 1, Ca^{2+} ions are on the right and $Ca(HO)_2$ is on the left. We need to invert this equation and calculate the new K

$\mathbf{\frac{1}{2}\ Ca^{2+}(aq) + HO^-(aq) \Leftrightarrow \frac{1}{2}\ Ca(HO)_2\ (s)}$ $\mathbf{Kc1^{new}} = 1/\ Kc1 = 1/2{,}55\ 10^{-3}$

$= 392$

2. Only one molecule of water is on the left and only one proton is on the right on Reaction 3. We need to multiply Reaction 2 by (1/2).

$(1/2).\ 2\ H_2O(l) \Leftrightarrow 2H^+(aq) + 2HO^-(aq) = \mathbf{H_2O(l) \Leftrightarrow H^+(aq) + HO^-(aq)}$

$\mathbf{Kc2^{new}} = (Kc2)^{(1/2)} = (1.0\ 10^{-28})^{(1/2)}$

$= 1.0\ 10^{-14}$

3. The close analysis of the obtained reactions shows that by the simple addition of them we will obtain reaction 3.

$$\mathbf{\frac{1}{2}\ Ca^{2+}(aq) + HO^-(aq) \Leftrightarrow \frac{1}{2}\ Ca(HO)_2\ (s)}$$
$$\mathbf{H_2O(l) \Leftrightarrow H^+(aq) + HO^-(aq)}$$

$$\mathbf{\frac{1}{2}\ Ca^{2+}(aq) + \underline{HO^-(aq)} + H_2O(l) \Leftrightarrow \frac{1}{2}\ Ca(HO)_2\ (s) + H^+(aq) + \underline{HO^-(aq)}}$$

If a compound is in both sides of the equation, we can cancel them out of the equation, and finally we obtain Reaction 3!!!

$\mathbf{\frac{1}{2}\ Ca^{2+}(aq) + H_2O(l) \Leftrightarrow \frac{1}{2}\ Ca(HO)_2\ (s) + H^+(aq)}$ $\mathbf{Kc = Kc1^{new}.Kc2^{new} =}$

$\mathbf{= 392\ .\ 1.0\ 10^{-14} = \boxed{3.9\ 10^{-12}}}$