The Temperature Dependence of K_w

Consider the simple dissociation of water:

$$H{-}OH \rightleftharpoons H^+ + OH^-$$

1. Is the dissociation of water an endothermic or exothermic process? Why? (Hint: is a bond breaking or forming?)

   Breaking (or ENDing) a bond is always endothermic!
   (need to input energy to break the attraction)

2. Rewrite the dissociation of water as a thermochemical equation:

   $$H_2O_{(l)} + heat \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

3. If you cool a solution of pure water,
   a. which direction should the reaction shift and why?

      ↓ T = ↓ reactant ⇒ shift left to produce more heat + re-establish equilibrium

   b. would you expect K_w to increase, decrease, or stay the same? Why?

      ↑ [reactants] = ↓ [products] = ↓ K_w

   c. would you expect [H^+] to increase, decrease, or stay the same? Why?

      ↓ [products] = ↓ [H^+]

   d. would you expect pH to increase, decrease, or stay the same? increase! (↓ [H^+] = ↑ pH)
   e. would you expect [OH^-] to increase, decrease, or stay the same? Why?

      ↓ [products] = ↓ [OH^-]

   f. would you expect pOH to increase, decrease, or stay the same? increase! (↓ [OH^-] = ↑ pOH)
   g. does the equation pH + pOH = 14 still hold true? Why or why not? Why?

      Nope! Both pH and pOH increased, so pH + pOH > 14 when pure H_2O gets colder than 25°C.

4. If you heat a solution of pure water,
   a. Would you expect pH to increase, decrease, or stay the same? decrease! (shift right = ↑ [H^+])
   b. Does this mean your solution of water is now more acidic, more basic, or still neutral? Explain.

      Still neutral! Although [H^+] ↑, [OH^-] ↑ too ⇒ [H^+] = [OH^-]

Soooooo important to know: The dissociation of water is endo thermic!