Answer on Question #75825, Chemistry / General Chemistry

A 1.00 liter solution contains 0.37 M ammonia and 0.28 M ammonium iodide.

If 0.14 moles of perchloric acid are added to this system,
indicate whether the following statements are true or false.

(Assume that the volume does not change upon the addition of perchloric acid.)
A. The number of moles of NH3 will remain the same.

B. The number of moles of NH4+ will remain the same.

C. The equilibrium concentration of H3O+ will decrease.

D. The pH will decrease.

E. The ratio of [NH3] / [NH4+] will decrease.

Solution

$V_{solution}$ = 1L

$c(NH_3)$=0.37M

c (NH_4I) = 0.28 M

n ($HClO_4$) = 0.14 moles

A. The number of moles of NH3 will remain the same – false

   $c(NH_3)$=0.37M i.e. 0.37 mol of NH_3 in 1 L of solution.

   When ammonia gets in water it forms $NH_3.H_2O$

   When perchloric acid is added the chemical reaction takes place:

   $NH_3 \cdot H_2O + HClO_4 = NH_4ClO_4 + H_2O$

   According to equation $n(NH_3 \cdot H_2O) = n(HClO_4)$.

   $n(NH_3 \cdot H_2O)$ = 0.37 moles, $n(HClO_4)$ = 0.14 moles $\Rightarrow$ $n(NH_3 \cdot H_2O) > n(HClO_4) \Rightarrow HClO_4$ is a limiting reactant.

   $n(NH_3 \cdot H_2O)$ expended in reaction is 0.14 moles, $n(NH_3 \cdot H_2O)$ left after reaction is 0.37-0.14 = 0.23 mol.

B. The number of moles of NH4+ will remain the same – false.

   Ions NH_4^+ in initial solution are formed in the process of dissociation of NH_4I:

$NH_4I \rightarrow NH_4^+ + I^-$

$n(NH_4^+) = n(NH_4I) = 0.28$ mol.

In new solution a chemical reaction takes place:

$NH_3 \cdot H_2O + HClO_4 = NH_4ClO_4 + H_2O$,

where NH_4ClO_4 is formed. This salt dissociate in water and gives NH_4^+:

$NH_4ClO_4 \rightarrow NH_4^+ + ClO_4^-$

$n(NH_4^+) = n(NH_4ClO_4) = 0.14$ mol ($HClO_4$ is a limiting reactant, according to chemical equation $n(HClO_4) = n(NH_4ClO_4) = 0.14$ mol).

$n_{total} = 0.28 + 0.14 = 0.42$ (mol).

C. The equilibrium concentration of H3O+ will decrease – false.

Initial solution: ammonia solution is basic, pH>7

$NH_3 \cdot H_2O \leftrightarrow NH_4^+ + OH^-$

When perchloric acid is added the chemical reaction takes place:

$NH_3 \cdot H_2O + HClO_4 = NH_4ClO_4 + H_2O$

After reaction: $c(NH_3 \cdot H_2O) = 0.37 - 0.14 = 0.23$ mol/L

$c(HClO_4) = 0$

$c(NH_4ClO_4) = 0.14$ mol/L

In initial solution $c(NH_3 \cdot H_2O) = 0.37$ mol/L

We can see that concentration of ammonia decreased, consequently $c(OH^-)$ decreased but $c(H^+)$ increased as $[H^+] \cdot [OH^-] = 14$ is constant, when concentration of OH^- decreases concentration of H^+ increases.

H^+ exists in water in form of H_3O^+.

D. The pH will decrease – true.

$pH = -lg[H^+]$. As concentration of H^+ increases pH decreases.

E. The ratio of [NH3] / [NH4+] will decrease – true.

In initial solution: $c(NH_3) = 0.37$ mol/L, $c(NH_4^+) = 0.28$ mol/L, then $[NH_3]/[NH_4^+] = 0.37/0.28 = 1.32$.

In new solution: $c(NH_3) = 0.23$ mol/L , $c(NH_4^+) = 0.42$mol/L, then $[NH_3]/[NH_4^+] = 0.23/0.42 = 0.55$

$0.55 < 1.32$

Answer: A – false

B- false

C- false

D – true

E - true