Answer on Question #76488, Chemistry / General Chemistry

As a project in Chemistry 30, Pat was assigned the task of proving that equilibrium is dynamic. The teacher provided Pat with a saturated solution of lead(II) sulphate in a test tube (some solid lead(II) sulphate remained on the bottom of the test tube), a small sample of solid lead(II) sulphate which contained radioactive , and a stopper that fit the test tube. Pat placed the radioactive sample in the test tube containing the saturated solution of lead(II) sulphate, stoppered the test tube, and agitated it vigorously for several minutes. Pat then let the mixture settle overnight, filtered it, and tested both the filtrate and the residue for radioactivity.

Evidence: Both the residue and the filtrate gave a positive test for radioactivity. Also, the mass of the residue remained constant.

Complete the analysis for this investigation. How does the investigation show that equilibrium is dynamic?

Solution

In a saturated solution of lead (II) sulphate equilibrium is established:

$PbSO_4(s) \leftrightarrow Pb^{2+}(aq) + SO_4^{2-}(aq)$

When the radioactive sample of lead (II) sulphate is added, the test tube stoppered, and agitated vigorously for several minutes, then the mixture was left to settle overnight the prosesses of dissolution of radioactive sample of lead (II) sulphate and combing of ions (both from radioactive sample and from initial solution) took place:

let oxygen to be a radioactive atom O^*:

(radioactive sample): $PbSO^*_4(s) \leftrightarrow Pb^{2+}(aq) + SO^*_4{}^{2-}(aq)$ (a)

(initial saturated solution + residue of $PbSO_4$): $PbSO_4(s) \leftrightarrow Pb^{2+}(aq) + SO_4^{2-}(aq)$ (b)

$Pb^{2+}(aq) + SO^*_4{}^{2-}(aq) \leftrightarrow PbSO^*_4(s)$ (c)

Equation (a) shows that radioactive atoms (in the form of $SO^*_4{}^{2-}$) get into the filtrate due to the dissolution process of radioactive sample of $PbSO^*_4$. Equation (c) shows that the ions that are formed in both equations (a) and (b) are combined to give radioactive residue. As both the residue and the filtrate gave a positive test for radioactivity we can make a conclusion that residue and solution are in the dynamic equilibrium. That means that two reactions take place simultaneously at the same rate: forward reaction and backward reaction. These two reactions do not stop, they are in the dynamic equilibrium. This is the reason why there is radioactive atoms are both in the residue and in the solution.

The quantitative characteristic of the state of chemical equilibrium is equilibrium constant K.

For the reaction in question $K=K_{sp}=[Pb^{2+}][SO_4^{2-}]$. The value of K_{sp} is constant under constant condition (temperature, pressure). We can see that the mass of residue remained constant, then the equilibrium concentrations of $[Pb^{2+}]$ and $[SO_4^{2-}]$ are also constant and K_{sp} did not change. The system is in the state of dynamic equilibrium.