The deuterium gas exposure experiments were evaluated by Thermal Desorption Spectroscopy (TDS) under the heating rate of 5 K/min. Comparing both the TDS results, the possibility of hot atom reactions of tritium produced in the Li$_{17}$Pb$_{83}$ eutectic alloy was investigated. Figure shows the TDS spectra of hydrogen isotopes for Li$_{17}$Pb$_{83}$ exposed to D$_2$ gas or irradiated with thermal neutron. It was observed that a major release stage of hydrogen isotopes was appeared in the temperature region just a little higher than the melting point (508 K) of the Li$_{17}$Pb$_{83}$ alloy. Major hydrogen isotope release was found to be governed by diffusion process in the liquid phase of Li$_{17}$Pb$_{83}$. The tritium and deuterium diffusion coefficients agreed with each other and the literature values. The deuterium solubility was also determined as $S = 6.56 \times 10^{-7} \exp(-0.11 \text{[eV]} / kT)$ [at. fr, Pa$^{0.5}$], from the results for deuterium gas exposure experiments. An additional tritium release stage was observed around 600 K, for the thermal neutron-irradiated alloy while no deuterium release was found in the same temperature region for the thermally doped alloy. The amount of additional tritium release was about 5% of total tritium. From the kinetic analyses for the additional release peak, the activation energy of tritium release at 600 K was determined to be about 1.4 eV, which is almost consistent with the decomposition energy of LiH, showing that LiT could be formed in the Li$_{17}$Pb$_{83}$ eutectic alloy by hot atom reactions of tritium produced by the nuclear reactions. It is, therefore, important to consider the possibility of the formation of LiT to estimate tritium inventories in Li$_{17}$Pb$_{83}$ blanket systems. Especially, in the liquid state of Li$_{17}$Pb$_{83}$ under the operation temperature, LiT would be the major source of tritium retention in Li-Pb system and the tritium inventory would be underestimated with regardless of the formation of LiT.