Study of Evaporation Heat of Cadmium by Laser Resonant Photoionization Method

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In this work we use laser resonant step photoionization of atoms for the study of heat of evaporation. The experiment was carried out on a laser photoionization spectrometer. In a vacuum (~10^{-5}torr) is formed the beam under Cd vapor effusion through the atomizer channel in the temperature range 350 to 535 K. The beams of dye lasers cross the atom beam of Cd and excite the Cd atoms according to the scheme:

$$5s^{2\,1}S_0 \xrightarrow{\lambda_1=321{,}1\,нм} 5p^3P_1 \xrightarrow{\lambda_2=479{,}9\,нм} 6s^3S_1 \xrightarrow{\lambda_3=488{,}16\,нм} 17p^3P_2$$

Excited atoms are ionized by an impulse electric field (E=12 kV/cm) and photons are detected. The dependence of photoionic signal of cadmium versus time at T=534 K for mass 112 mg. On the basis of this experiment was obtained the rate of Cd evaporation as follows:

$$\theta = m/\chi A_S t = 5{,}834\cdot 10^{-2}(M/T)^{1/2}\cdot p$$

where $\chi = 3l/8r = 2{,}5$ is a correction factor, A_s the area of atomizer channel, t the time of evaporation, m the mass of Cd, p the saturated vapor pressure (torr), M the molar mass of Cd, T the temperature of evaporation. The rate of evaporation $\Theta=5{,}539\cdot 10^{-4}$ *g/cм²s,* the vapor pressure was $p=2{,}068\cdot 10^{-2}$ *torr*. The values of pressure in range of 350 to 535K are described by the empirical equation $\log p = (8{,}384 \pm 0{,}1) - (5472 \pm 100)\cdot T^{-1}$, and at T= 300 to 340 K by $\log p = 7{,}384 - 5472\cdot T^{-1}$. From dependence of photoions output and of atoms number in interaction zone of laser emission with Cd atoms versus temperature the super low vapor pressure of Cd was obtained by caliber method (by detection of single atoms). At T=300K the Cd vapor pressure and known values of thermodynamic potentials for condensed and gas state by relationship

$$R\ln P = +\Delta\phi^*(T) + \Delta H_0^0(T)/T\,,$$

where $\Delta\phi^*(T) = \phi^*_{газ}(T) + \phi^*_{конд}(T)$ - the change of vapor free energy. The numerical value $H^0_0(T)=(26720\pm160)$cal/mol is in good agreement with data from the literature.