ABSTRACT

The interaction of nitrogen with a tantalum filament has been studied over wide ranges of pressure (10^{-8} to 10^{-1} torr) and of temperature (300 to 2500°K). At room temperature, the initial sticking probability on the clean surface is 0.33 and adsorption leads to a saturated surface layer of about 5.10^{14} atoms.cm^{-2}. At high temperatures the sticking probability is about 0.08 independent of pressure and temperature, and the gas diffuses into the bulk of the metal so fast that the surface coverage remains small. The dependence of the observed sorption rates on pressure and at intermediate temperatures is very complex and is discussed in terms of adsorption and diffusion of the surface layer into the bulk of the metal.

The pressure-temperature-concentration equilibrium is studied for low concentrations of nitrogen in the metal. The solution exhibits ideal behaviour, that is Sieverts' law is obeyed over the pressure-temperature-concentration ranges studied. The empirical expression describing the solution of nitrogen in tantalum is,

$$c = 4.4.10^{-4} \sqrt{p_e} \exp E_{sol}/RT$$

where c is in atomic % and p_e is the equilibrium pressure in torr. The heat of solution E_{sol} is $-(95 \pm 3)$ kcal.mol^{-1} and the entropy of solution at one atomic % concentration is $-(15.5 \pm 3)$ cal.deg^{-1}K.gatom^{-1}. This value is in good agreement with a theoretical entropy calculated from disorder and vibrational contributions.

The outgassing of nitrogen from tantalum is studied over a wide range of pressures and temperatures. A theory is developed to explain the pressure-time variations, based upon the assumption that the rate controlling process is one of desorption of gas from the surface of the metal and not diffusion of the gas within the bulk. The theoretical predictions (a) that the reciprocal of the square root of the pressure should be a linear function of the time and (b) that the activation energy controlling this process is the heat of solution are both confirmed by the experimental results. The second-order rate constant for the desorption of nitrogen from tantalum was estimated to be 9.10^{-4} cm^2 $atom^{-1}$ sec^{-1}. A criterion for the outgassing process to be either predominantly surface or diffusion controlled is established and its implications discussed.