

# MASSACHUSETTS INSTITUTE OF TECHNOLOGY

## Kinetic Processes in Materials

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Problem Set 4: Due Fri. March 16, Before 5PM in 13-5049

### Exercise 4.1

Use the interdiffusivity data provided in Exercise 1.4 (The last problem of Problem Set 2) to compute the composition vs. distance profile in a Au–Ni diffusion couple held at 900° C for 10<sup>6</sup> s. Assume that the diffusion couple is infinite with initially pure Au for  $x < 0$  and Ni for  $x > 0$ .

### Exercise 4.2

A sealed spherical metal tank with 5 mm wall thickness and 20 cm diameter holds hydrogen gas maintained at an internal pressure of  $5 \times 10^6$  MPa.

The equilibrium solubility of hydrogen dissolved in the metal is  $2.5 \times 10^6$  cm<sup>3</sup>(STP) g<sup>-1</sup> (note this is at 10<sup>5</sup> MPa). Assume Sievert's law holds.

If the diffusivity of hydrogen in the metal is  $5 \times 10^{-10}$  m<sup>2</sup> s<sup>-1</sup>, calculate the steady-state rate of hydrogen loss (cm<sup>3</sup>(STP) s<sup>-1</sup>) from the pressurized tank when the exterior of the tank is at 10<sup>5</sup> MPa of air.

### Exercise 4.3

A 0.25 inch thick plate of 1080 plain-carbon steel is tightly clamped to a pure iron sheet 0.125 inch thick, then hot-isostatically pressed (HIPed) at 1000° C for 10 hrs. Assuming a carbon diffusivity of  $3 \times 10^{-11}$  m<sup>2</sup> s<sup>-1</sup>, and that there is no carbon loss from either surface of the material to the atmosphere, calculate the expected carbon content at both surfaces of the pressed assembly.

### Exercise 4.4

Solve the isotropic, uniform diffusivity diffusion equation on an infinite cylindrical wedge with a vertex angle of  $2\pi/5$ :  $0 < \theta < 2\pi/5$ ,  $-\infty < z < \infty$ ,  $0 < r < \infty$ . with the following initial

$$c(r, \theta, z, t) = \begin{cases} C_0 & 0 < r < R_i \\ C_S & R_i < r < R_o \\ C_0 & R_o < r < \infty \end{cases}$$

and boundary conditions

$$J(r, \theta = 0, z, t) = J(r, \theta = 2\pi/5, z, t) = J(r = \infty, \theta, z, t) = J(r, \theta, z = \pm\infty, t) = 0$$