3.091 Fall Term 2009

Homework #9c

November 3(to be tested November 10)

from Averill text

Ch. 14: 27, 30, 50, 54, 58, 62, 71, 81

1. The decomposition of hydrogen peroxide, H_2O_2 , can be represented by the following reaction:

$$2\ H_2O_2\ (aq) \rightarrow 2\ H_2O\ (l) + O_2\ (g)$$

The table below reports data taken at room temperature (300 K).

Table 1. Decomposition of H_2O_2 (*aq*) at 300 K.

$conc_{H_2O_2}$ (mol/liter)	time (seconds)
2.32	0
2.01	200
1.72	400
1.49	600
0.98	1200
0.62	1800
0.25	3000

(a) Show that the reaction is first order.

(b) Calculate the value of the half-life of this reaction.

(c) Suppose that the initial concentration of H_2O_2 were 3.5 M. How long would it take at 300 K to reduce the concentration of H_2O_2 to 25% of its initial value?

2. The decay rate of ^{14}C in living tissue is 15.3 disintegrations per minute per gram of carbon. Experimentally, the decay rate can be measured to ±0.1 disintegrations per minute per gram of carbon. The half-life of ^{14}C is 5730 years.

(a) What is the maximum age of a sample that can be dated and what is the uncertainty associated with this measurement?

(b) What is the minimum age of a sample that can be dated and what is the uncertainty associated with this measurement?

3. A membrane is to be manufactured to the following specifications. At 700°C the leak rate of hydrogen is not to exceed 10^{-3} mol cm^{-2} hr^{-1} when the concentrations of hydrogen are maintained at 1.5×10^{19} atoms cm^{-3} on one side of the membrane and effectively zero on the other side. What is the minimum thickness of iron foil that will meet these requirements? The diffusion coefficient of atomic hydrogen in iron at 700°C is 3.091×10^{-4} cm^2 s^{-1}.

4. To increase its corrosion resistance, chromium is diffused into steel at 980°C. If during diffusion the surface concentration of chromium remains constant at 100%, how long will it take (in days) to achieve a Cr concentration of 1.8% at a depth of 0.002 cm below the steel surface? (D_o = 0.54 cm^2/s; E_A = 286 kJ/mol)

5. By planar diffusion of antimony (Sb) into p-type germanium, a p-n junction is obtained at a depth of 3×10^{-3} cm below the surface. What is the donor concentration in the bulk germanium if diffusion is carried out for three hours at 790°C? The surface concentration of antimony is held constant at a value of 8×10^{18} cm^{-3}; $D_{790°C} = 4.8 \times 10^{-11}$ cm^2 s^{-1}.

6. You wish to dope a single crystal of silicon with boron. The specification reads 5×10^{16} boron atoms cm^{-3} at a depth of 25 μm from the surface of the silicon. What must be the effective concentration of boron in units of atoms cm^{-3} if you are to meet specification within a time of 90 minutes? Assume that initially the concentration of boron in the silicon crystal is zero. The diffusion coefficient of boron in silicon has a value of 7.23×10^{-9} cm^2 s^{-1} at the processing temperature.

5. A slab of plate glass containing dissolved helium is placed in a vacuum furnace at a temperature of 400°C to remove the helium from the glass. Before vacuum treatment, the concentration of helium is constant throughout the glass. After 10 minutes in vacuum at 400°C, at what depth from the surface of the glass has the concentration of helium decreased to 1/3 of its initial value? The diffusion coefficient of helium in the plate glass at the processing temperature has a value of 3.091×10^{-6} cm^2 s^{-1}.