Problem 14.3

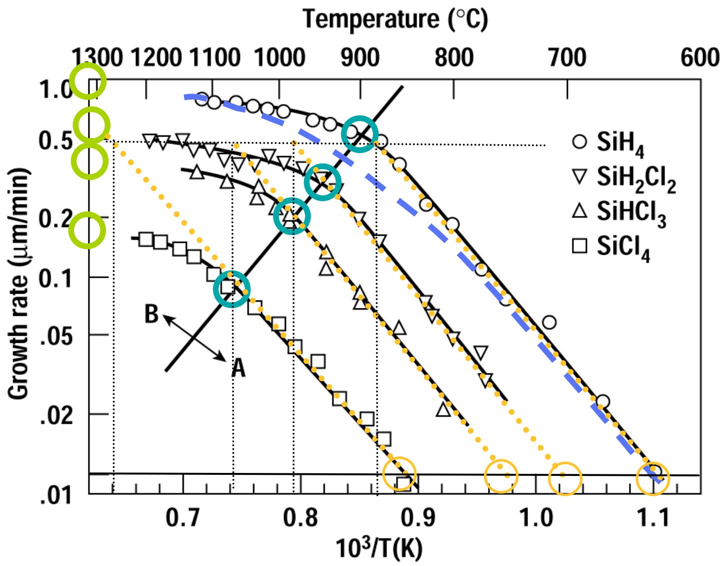


Figure 14.8 Arrhenius behavior of a variety of silicon-containing growth species *(after Eversteyn, reprinted by permission, Philips).*

Eq. 14.2 gives the growth rate, R, as

$$R = \frac{k_s h_g}{k_s + h_g}\frac{C_g}{N} \quad [1] \quad [*]$$

At high temperatures this becomes mass transport limited, i.e. limited by gas phase diffusion, and $h_g << k_s$. We then have

$$R \approx h_g \frac{C_g}{N} \quad [2]$$

The reaction ate limited regime is when $k_s << h_g$, which occurs at low temperatures

$$R \approx k_s \frac{C_g}{N} \quad [3] \qquad k_s = k_0 \exp\left(-\frac{E_a}{kT}\right) \quad [4]$$

Identification of temperature when becomes mass transport limited can be read off Fig. 14. 8

SiH_4: 900 C; SiH_2Cl_2: 950 C, $SiHCl_3$: 1000 C; $SiCl_4$: 1080 C

At low temperature the rate is $R=R_0\exp(-E_a/kT)$.
We find activation energy E_a and R_0 from drawing best straight line. $\ln(R)=\ln(R_0)-(E_a/10^3 k)\cdot(10^3/T)$.
The slopes of the curves are similar yielding $E_a \sim 1.4$ eV; see table

The value of k_o is found from $k_0=R_0 \cdot N/C_g = R_0 \cdot 5e22/1e15$, See table

	SiH4	SiH2Cl2	SiHCl3	SiCl4
1e3/T1	1.1	1.026	0.975	0.885
R1(µm/min)	0.01	0.01	0.01	0.01
1e3/T2	0.864	0.795	0.742	0.64
R2(µm/min)	0.5	0.5	0.5	0.5
Ea(eV)	1.43	1.46	1.45	1.38
R0(µm/min)	8.3E+05	3.5E+05	1.3E+05	1.4E+04
k0(µm/min)	4.1E+13	1.8E+13	6.4E+12	6.9E+11
Rg(µm/min)	1	0.65	0.44	0.17
hg(µm/min)	5.0E+07	3.3E+07	2.2E+07	8.5E+06

Reading points R_i, $10^3/T_i$ off Fig 14.8

$$E_a = -k \ln\left(\frac{R_2}{R_1}\right)\left(\frac{1}{T_2} - \frac{1}{T_1}\right)^{-1}$$

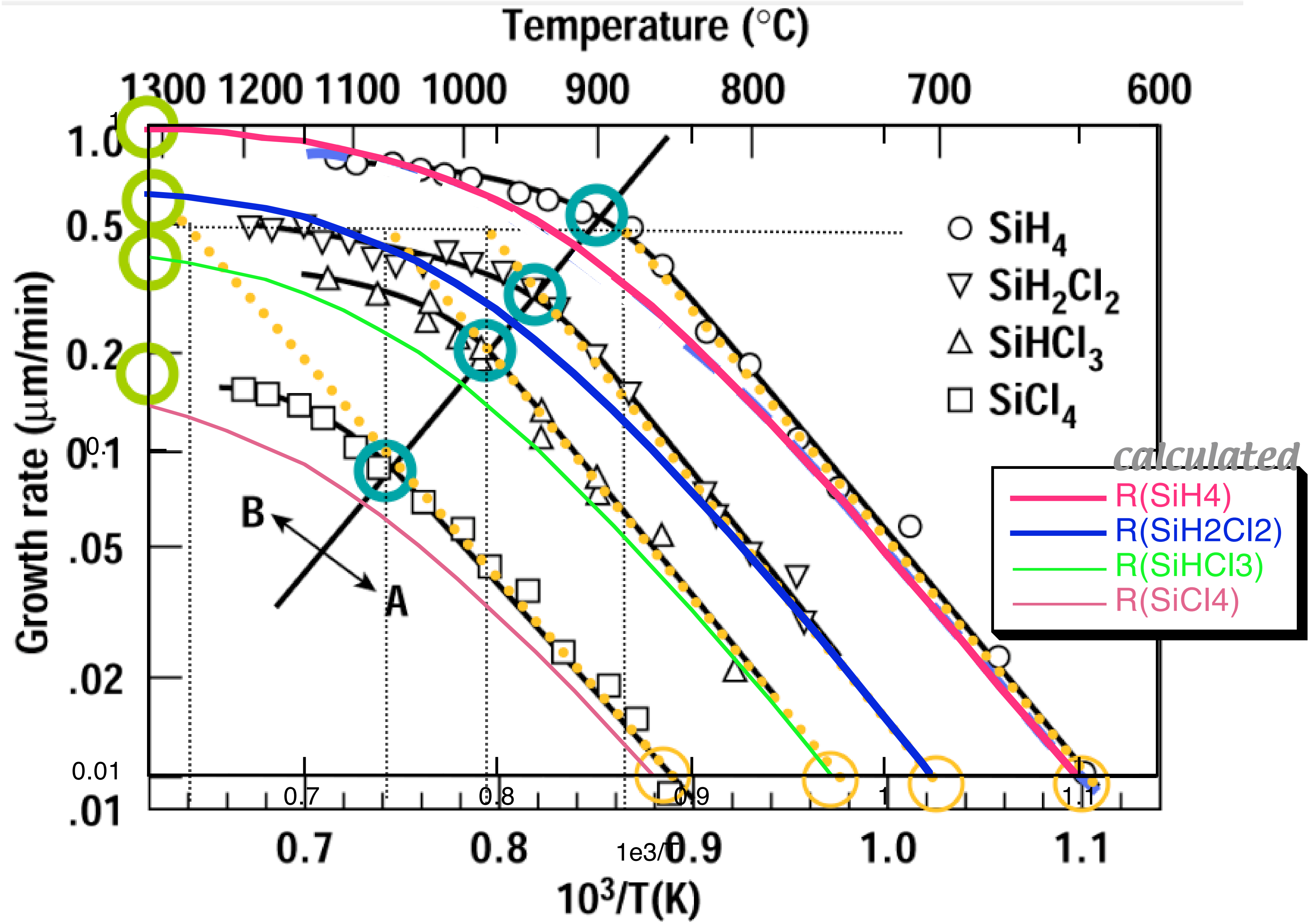
$$R_0 = R_1 * \exp\left(\frac{E_a}{kT_1}\right)$$

$$k_0 = R_0 \frac{N}{C_g}$$

h_g can be found by from [2] reading off the graph the asymptotic value for R at high temperature, R_g You could also do a curve fit. You will notice that the curve shape does not match all that well; see blue curve and next page.

[*]: You may compare this to an equation for current flow in an electric circuit. It is a series connection of two conductors with conductance 1/h and 1/k The equation is also written

$$R = \frac{1}{\frac{1}{h_g} + \frac{1}{k_s}} \frac{C_g}{N}$$



Comparison measured values and calculated using determined parameters