9-5 Suppose that solid iron was able to nucleate homogeneously with an undercooling of only 15°C. How many atoms would have to group together spontaneously for this to occur? Assume that the lattice parameter of the solid BCC iron is 2.92 Å.

Solution: $$r^* = \frac{(2)(204 \times 10^{-7}\ J/cm^2)(1538 + 273)}{(1737\ J/cm^3)(15)} = 283.6 \times 10^{-8}\ cm$$

$V_{uc} = 24.897 \times 10^{-24}\ cm^3$ (see Problem 9-2)

$V_{nuc} = (4\pi/3)(283.6 \times 10^{-8}\ cm)^3 = 95{,}544{,}850 \times 10^{-24}\ cm^3$

number of unit cells = 95,544,850/24.897 = 3.838×10^6

atoms per nucleus = (2 atoms/cells)(3.838×10^6 cell) = 7.676×10^6

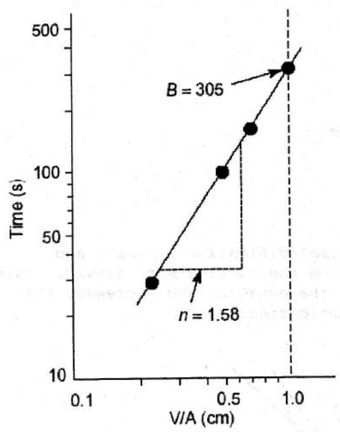
9-13 Find the constants B and n in Chvorinov's rule by plotting the following data on a log-log plot.

Casting dimensions (cm)	Solidification time (s)
1 x 1 x 6	28.58
2 x 4 x 4	98.30
4 x 4 x 4	155.89
8 x 6 x 5	306.15

Solution:

$V(cm^3)$	$A(cm^2)$	V/A (cm)
6	26	0.23
32	64	0.5
64	96	0.67
240	236	1.02

From the graph, we find that $B = 305\ s/cm^2$ and $n = 1.58$.



9-19 A cooling curve is shown in Figure 9-21. Determine (a) the pouring temperature, (b) the solidification temperature, (c) the superheat, (d) the cooling rate just before solidification begins, (e) the total solidification time, (f) the local solidification time, and (g) the probable identity of the metal. (h) If the cooling curve was obtained at the center of the casting sketched in the figure, determine the mold constant, assuming that $n = 2$.

Solution:

(a) $T_{pour} = 475°C$

(b) $T_{sol} = 320°C$

(c) $\Delta T_s = 475 - 320 = 155°C$

(d) $\Delta T/\Delta t = \dfrac{475 - 320}{150 - 0} = 1.0\ °C/s$

(e) $t_s = 470\ s$

(f) $LST = 470 - 170 = 300\ s$

(g) Cd

(h) $t_s = 470 = B[38.4/121.6]^2$
$B = 4713\ s/cm^2$

9-21 Figure 9-23 shows the cooling curves obtained from several locations within a cylindrical aluminum casting. Determine the local solidification times and the SDAS at each location, then plot the tensile strength versus distance from the casting surface. Would you recommend that the casting be designed so that a large or small amount of material must be machined from the surface during finishing? Explain.

Solution: *The local solidification times can be found from the cooling curves and can be used to find the expected SDAS values from Figure 8-7. The SDAS values can then be used to find the tensile strength, using Figure 9-10.*

Surface: $LST = 10\ s \Rightarrow SDAS = 1.5 \times 10^{-3}\ cm \Rightarrow TS = 47\ ksi$

Midradius: $LST = 100\ s \Rightarrow SDAS = 5 \times 10^{-3}\ cm \Rightarrow TS = 44\ ksi$

Center: $LST = 500\ s \Rightarrow SDAS = 10 \times 10^{-3}\ cm \Rightarrow TS = 39.5\ ksi$

You prefer to machine as little material off the surface of the casting as possible; the surface material has the finest structure and highest strength; any excessive machining simply removes the "best" material.