904. When silicon is oxidized, some silicon is consumed from the surface to form silicon dioxide. The Pilling-Bedworth (P-B) ratio is the ratio of SiO$_2$ volume grown to Si volume consumed.

a. Derive an equation for calculating the P-B ratio in terms of Si and SiO$_2$ molecular weights and densities.
   i. Calculate the P-B ratio given:

<table>
<thead>
<tr>
<th>Material</th>
<th>MW</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO$_2$</td>
<td>60.08</td>
<td>2.18</td>
</tr>
<tr>
<td>Si</td>
<td>28.09</td>
<td>2.33</td>
</tr>
</tbody>
</table>

b. Draw to scale cross-sections of a silicon wafer before and after growing 1000Å of SiO$_2$. Align the drawings using the original Si surface as a reference. Label the diagram completely, including the original surface, the oxide surface, and the Si-SiO$_2$ interface.

905. Crystalline silicon contains 5 x 10$^{22}$ atoms/cm$^3$. When a wafer is doped the dopant atom replaces a silicon atom in the lattice. What is the ratio of dopant atoms to silicon lattice sites for the following doping levels? Express in terms of % dopant and parts per million (ppm)/billion (ppb)/trillion (ppt).

Example: 5 x 10$^{14}$ dopant atoms/cm$^3$ = 0.000001% dopant or 10 ppb dopant

a. 5 x 10$^{15}$ dopant atoms/cm$^3$
b. 2.5 x 10$^{16}$ dopant atoms/cm$^3$
c. 5 x 10$^{18}$ dopant atoms/cm$^3$
d. 5 x 10$^{20}$ dopant atoms/cm$^3$

906. A Class 10 (10 particles/ft$^3$ >5µm diameter) cleanroom is designed with 9-foot high ceilings. To maintain this level of cleanliness, 50 air exchanges per hour are required (the total volume of air in the room is replaced with new air 50 times/hour).

a. What is the total number of particles that would hit a surface one square foot in area perpendicular to the airflow in 1 minute? 1 hour? 24 hours? Hint: find the velocity of the airflow first.
b. How many particles would hit an 8” diameter wafer over the same time periods?

907. Redraw the process flow-chart presented in class.

a. List all the steps required for the fabrication of a basic diffused p-n junction diode. Draw cross-sections of the silicon wafer after each of the steps. Draw and label the mask set for this process.
b. List all the steps required for the fabrication of a basic diffused npn bipolar junction transistor. Draw cross-sections of the silicon wafer after each of the steps. Draw and label the mask set for this process.
c. List all the steps required for the fabrication of a basic diffused MOSFET. Draw cross-sections of the silicon wafer after each of the steps. Draw and label the mask set for this process.

908. Consider the advanced device processes described in class.

a. Outline the selective oxidation (LOCOS) process
b. Describe how the self-aligned gate offers a process advantage
c. Describe the process for chemical mechanical polishing. Why is it useful in IC processing?