Problem 1 (Kinetic Gas Theory)
A silicon wafer sits on a bench in the laboratory at a temperature of 300K and a pressure of 1 atm. Assume that the air consists of 100% oxygen. How long does it take to deposit one atomic layer of oxygen on the wafer surface, assuming 100% adhesion.

Problem 2 (Thin Film Deposition)
A wafer 100mm in diameter is mounted in a point-source evaporation system. The distance from the wafer to the source is 80cm. Please estimate (in microns) the worst-case variation in film thickness between the center and edges for an evaporated aluminum film 1-μm thick.

Problem 3 (MEMS)
Buffered HF and unbuffered HF solutions have different etching rate for SiO2 and PSG (SiO2 containing phosphorus). Let us assume that

1. Buffered HF etches PSG 5 times faster than SiO2
2. Unbuffered HF etches PSG 20 times faster than SiO2
3. Both buffered and unbuffered HF etch at a rate proportional to the HF concentration
4. 20% HF in H2O etches SiO2 at 10Å/sec
5. 20% HF in NH4F buffered solution etches SiO2 at 15Å/sec

(a) Two identical silicon wafers are coated identically with x Å of SiO2 covered by y Å of PSG. One wafer is etched in 20% HF in NH4F buffer (solution 1): it takes 400 seconds to etch to a completely bare (no oxide left) surface. The other wafer is etched in 10% HF in H2O (solution 2): it takes 375 seconds to etch to a completely bare surface. Find the original thickness, x and y, in microns.

(b) In surface micromachining, the final step is usually to etch away the sacrificial layer. If the lateral etch rate under a surface-micromachined plate is the same as the vertical etch rate

i. How long will it take for solutions 1 & 2 above to etch away a SiO2 sacrificial layer underneath a 100x60 μm² polysilicon plate? Report your etch times in seconds.

ii. How long will it take for solutions 1 & 2 above to etch away a PSG sacrificial layer underneath a 100x60 μm² polysilicon plate? Report your etch times in seconds.

Problem 4 (MEMS)
Please read through the internet readings about the foundry services for surface micromachining: Sandia-MEMS.

(a) State in less than 150 words for the process about the important features and differences with the MUMPs process.

(b) Can your MUMPs design project benefit by using this service? Why?