Sound Air Motion — ANSWERS

You've answered all the questions and have confidence in your answers. Go through the questions one at time. (I.e., don't jump to the end.) If you aren't within an order of magnitude of what I give below, you might consider re-thinking what you did. If you can fix that one, then re-do the subsequent questions.

1. Google says ~500m/s and refers to https://pages.mtu.edu/~suits/SpeedofSound.html, which also gives the speed of sound as ~343 m/s. No, they're not equal, but sound travels in air because the molecules are already moving, and the sound speed is the result of how they pass on the sound information from one to the next through elastic collisions.

2. It's easy to find definitions of "decibel." Very important but usually missed facts are related to its being a logarithmic measure of loudness, energy, or pressure. In particular, being a log scale, it has an arbitrary (or convention-dependent) zero and an arbitrary overall scale. (http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/db.html and https://en.wikipedia.org/wiki/Decibel) (Do you understand what's "arbitrary" or convention-dependent about decibels?)

3. 100 dB is pretty deafening; 85 dB is already VERY unpleasant and dangerous. P(100dB)/P(0dB) = 100,000.

4. 1 atm is about 100,000 Pascals. 95 dB is about 1 Pascal (*greater than that)*; see, e.g., http://www.sengpielaudio.com/calculator-soundlevel.htm. So ***LOUD!*** corresponds to an over-pressure of about 1/100,000. (1 Pa = 1 N/m^2)

5a. I like 2 ft = 24 inches as a wavelength. (That's in the vicinity of the low note on a soprano recorder, which is about a foot long.) The frequency is about 563 Hz.

5b. So, the imagined cylinder (active volume) is 6 inches long. To increase the pressure by a part in 100,000, you'd have to decrease that length by a part in 100,000, i.e., 6 x 10^(-5) in. That's about 1.5 microns.

5c. 563 Hz means a period (full cycle) of 1.8 x 10^(-3) sec. So a quarter period is about 0.4 x 10^(-3) sec. So the piston average speed is 6/0.4 x 10^(-2) in/sec = 0.15 in/sec = 0.004 m/s, i.e., about 1/100,000 of the speed of sound or the molecule speed.

Newton, having invented physics with actual equations (and calculus to go along with it) derived the speed of sound under the assumption that the expansion and contraction of the air was at fixed temperature. He came within about 20% of the measured value. It was only later realized that the fixed temperature assumption was the flaw in the derivation. Sound that we can hear vibrates too fast for the air to come to thermal equilibrium. A vastly improved derivation is based on the approximation that thermal energy in each bit of air remains constant in the process.