Root-Mean-Square Velocity Problems

1) What is the RMS velocity for water vapor at 300^0 C? R = 8.314 $kg \cdot m^3/s^2 \cdot K \cdot mol$).

   966 m/sec

2) What is the RMS velocity for hydrogen gas at 30^0 C?

   1943 m/sec

3) Compare the answers from problems 1 and 2. Are they surprising to you in any way? Explain.

4) Why do gas molecules tend to move more quickly at high temperatures than at low temperatures?

5) If gas molecules move so quickly (on the order of 1 kilometer per second), how come it takes so long to smell a jar of pickles when it's opened across the room?

Root-Mean-Square Velocity Answers

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3) Compare the answers from problems 1 and 2. Are they surprising to you in any way? Explain.

They may be surprising. After all, the water vapor is nearly twice the temperature of hydrogen (in Kelvins), so you might expect it to move more quickly than the hydrogen. The reason it doesn't is that water vapor has a molar mass of 18 grams/mole, while hydrogen has a molar mass of only 2 grams/mole. Since hydrogen is lighter, it moves more quickly.

4) Why do gas molecules tend to move more quickly at high temperatures than at low temperatures?

When you heat something up, you're adding energy to it. This energy can be used to do a number of different things – one of them is to make the molecules move more quickly. Since there's more energy at high temperatures than low temperatures, molecules move more quickly at high temperatures.

5) If gas molecules move so quickly (on the order of 1 kilometer per second), how come it takes so long to smell a jar of pickles when it's opened across the room?

Gas molecules don't move in a straight line. If there were no air molecules between you and the pickle jar, you would smell the pickles almost instantaneously after somebody opened the jar. However, there are air molecules present, and the pickle smell molecules bounce backwards off the air molecules back in the direction they came. Over the long haul, the smell molecules eventually get to your nose, but it takes much longer because the molecules bounce around a lot in the meantime.