[TP] Predict the effect of intermolecular attraction on the pressure exerted by a gaseous molecule in a collision with the wall of its container. The stronger the attraction, the ...

20%	1. greater the pressure
20%	2. smaller the pressure
20%	3. The pressure will not be affected
20%	4. Cannot answer without knowing the temperature
20%	5. Cannot answer without knowing the polarity of the molecule

Response Counter

10

Lecture 7 CH102 A1 (MWF 9:05 am)

Wednesday, February 6, 2019

- Review: Maxwell-Boltzmann distribution: CDF https://goo.gl/VkRrsg
- Real gases: Effect of molecular attraction
- Real gases: Effect of molecular size

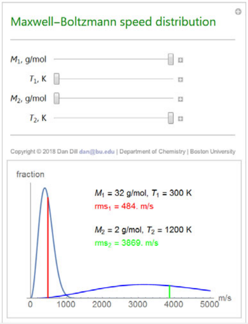
Next: van der Waals equation; Phase diagrams

Distribution of molecular speeds

The resulting distribution, known as the Maxwell-Boltzmann (MB) distribution.

For a given u_{rms} it is always the same.

CDF https://goo.gl/gzgjQE



Effect of intermolecular attraction

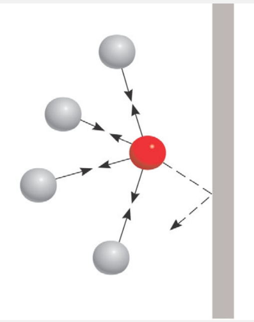
Gas particles attract one another: van der Waals a

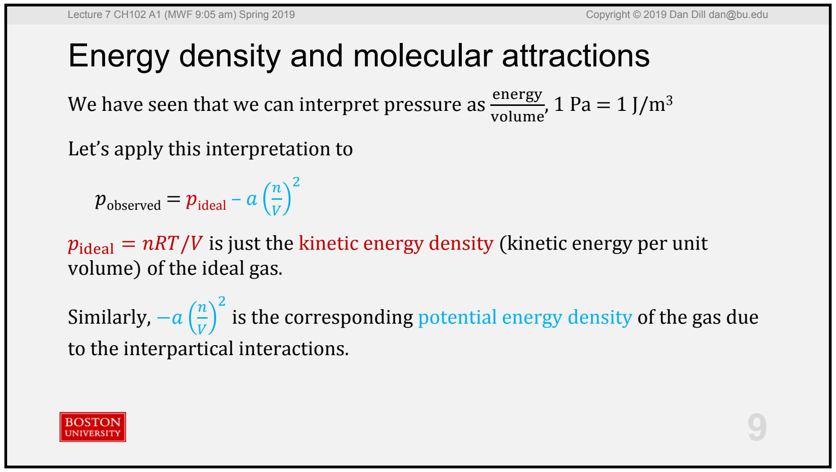
$$\#\text{ hitting wall} \propto \frac{n}{V}$$

$$\#\text{ pulling back} \propto \frac{n}{V}$$

$$\text{combined effect} \propto \left(\frac{n}{V}\right)^2$$

$$p_{\text{observed}} = p_{\text{ideal}} - a\left(\frac{n}{V}\right)^2$$





Energy density and molecular attractions

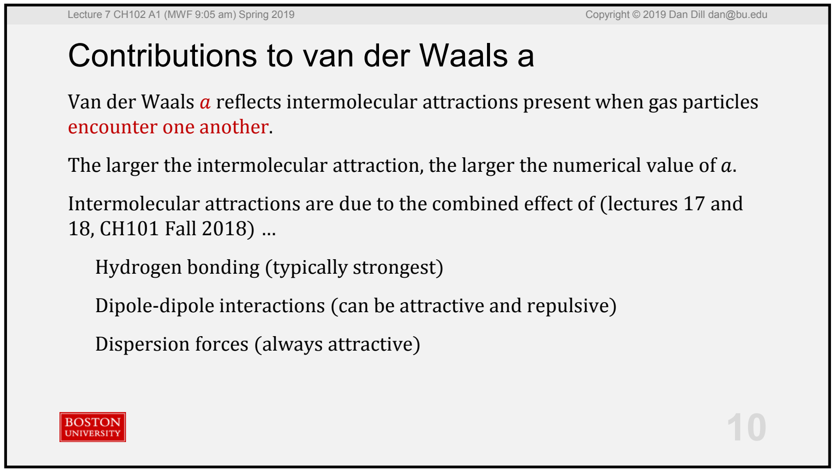
We have seen that we can interpret pressure as $\frac{\text{energy}}{\text{volume}}$, $1\ \text{Pa} = 1\ \text{J/m}^3$

Let's apply this interpretation to

$$p_{\text{observed}} = p_{\text{ideal}} - a\left(\frac{n}{V}\right)^2$$

$p_{\text{ideal}} = nRT/V$ is just the kinetic energy density (kinetic energy per unit volume) of the ideal gas.

Similarly, $-a\left(\frac{n}{V}\right)^2$ is the corresponding potential energy density of the gas due to the interparticle interactions.



Contributions to van der Waals a

Van der Waals a reflects intermolecular attractions present when gas particles encounter one another.

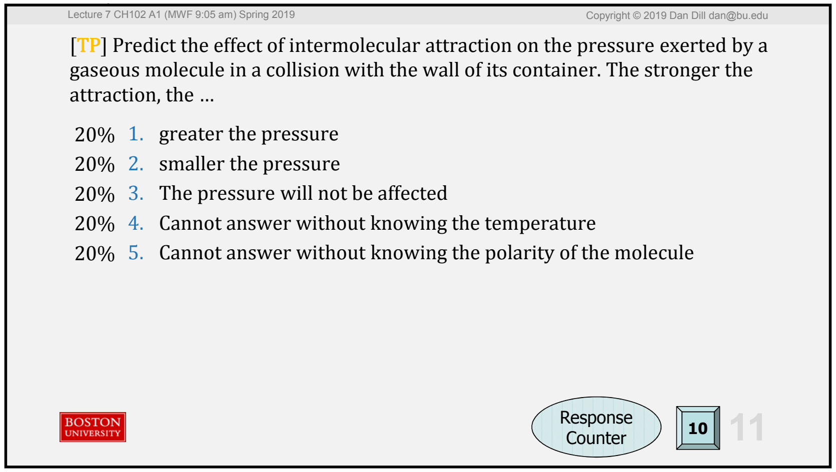
The larger the intermolecular attraction, the larger the numerical value of a.

Intermolecular attractions are due to the combined effect of (lectures 17 and 18, CH101 Fall 2018) ...

Hydrogen bonding (typically strongest)

Dipole-dipole interactions (can be attractive and repulsive)

Dispersion forces (always attractive)



[TP] Predict the effect of intermolecular attraction on the pressure exerted by a gaseous molecule in a collision with the wall of its container. The stronger the attraction, the ...

20% 1. greater the pressure
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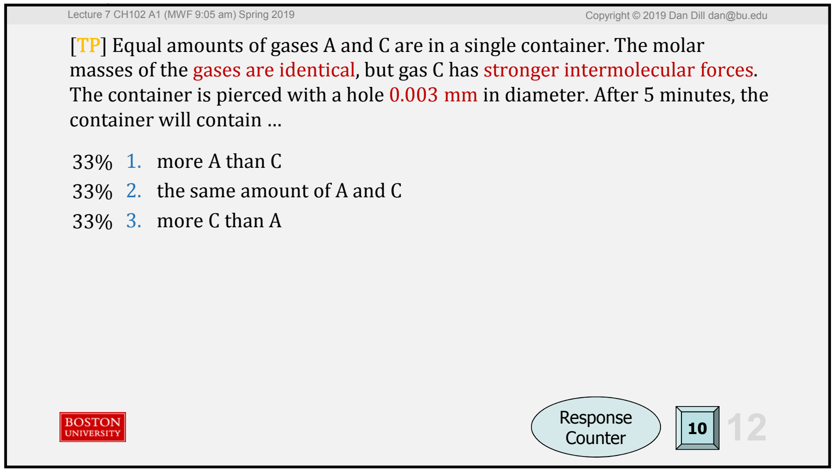
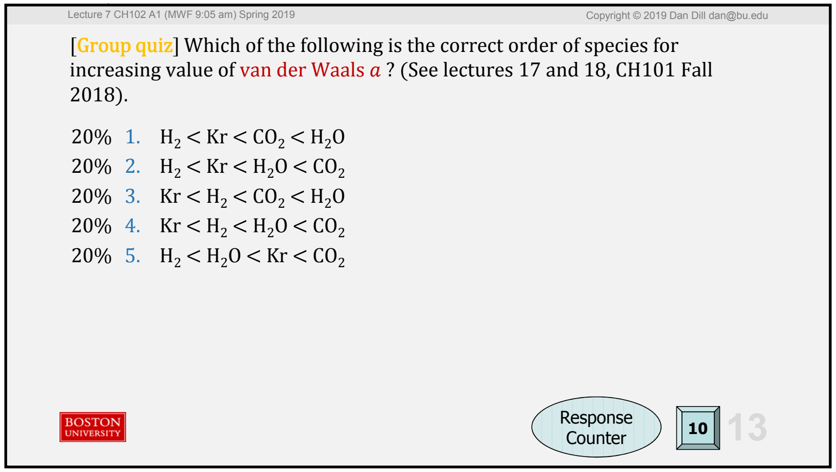
Response Counter 10



[TP] Equal amounts of gases A and C are in a single container. The molar masses of the gases are identical, but gas C has stronger intermolecular forces. The container is pierced with a hole 0.003 mm in diameter. After 5 minutes, the container will contain ...

33% 1. more A than C
33% 2. the same amount of A and C
33% 3. more C than A

Response Counter 10



[Group quiz] Which of the following is the correct order of species for increasing value of van der Waals a ? (See lectures 17 and 18, CH101 Fall 2018).

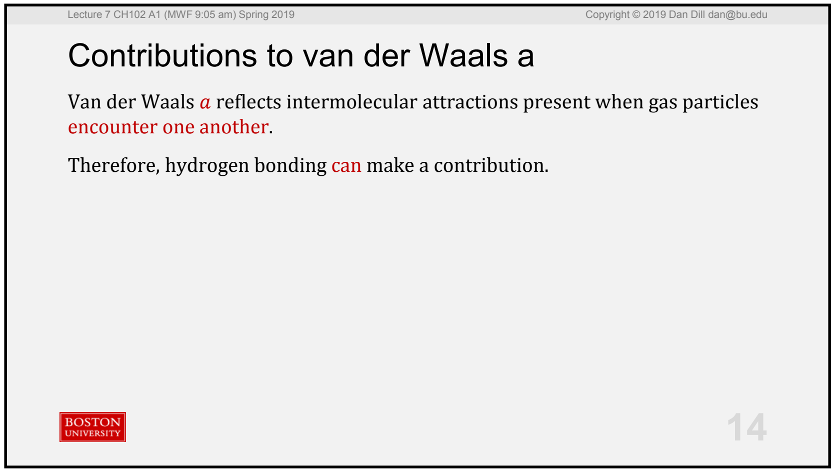
20% 1. $H_2 < Kr < CO_2 < H_2O$

20% 2. $H_2 < Kr < H_2O < CO_2$

20% 3. $Kr < H_2 < CO_2 < H_2O$

20% 4. $Kr < H_2 < H_2O < CO_2$

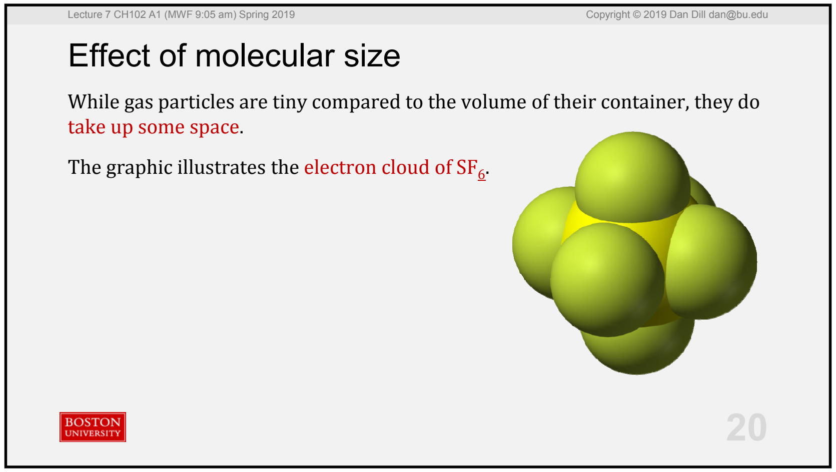
20% 5. $H_2 < H_2O < Kr < CO_2$



Contributions to van der Waals a

Van der Waals a reflects intermolecular attractions present when gas particles encounter one another.

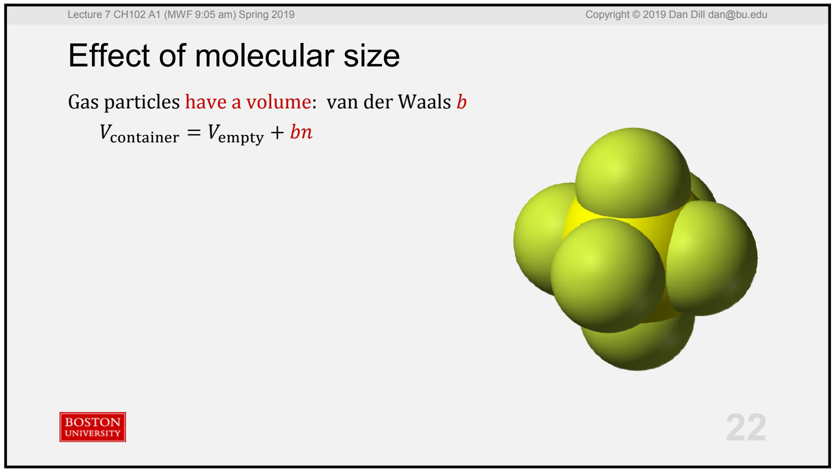
Therefore, hydrogen bonding can make a contribution.



Effect of molecular size

While gas particles are tiny compared to the volume of their container, they do take up some space.

The graphic illustrates the electron cloud of SF_6.



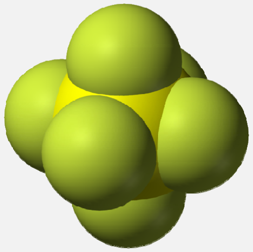
Effect of molecular size

Gas particles have a volume: van der Waals b

$$V_{\text{container}} = V_{\text{empty}} + bn$$

[TP] Gas particles have a volume measured by van der Waals b.
For SF_6, $b = 88\ \text{mL/mol}$. The percent of gas container volume taken up by the SF_6 molecules themselves is …

17%	1.	0.01%
17%	2.	0.05%
17%	3.	0.1%
17%	4.	0.5%
17%	5.	1%
17%	6.	5%



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Effect of molecular size

Gas particles have a volume: van der Waals b

$$V = V_{\text{container}} = V_{\text{empty}} + bn$$

For SF_6, $b = 88\ \text{mL/mol}$

% of molar gas volume …

$$\approx (\,0.088\ /\ 22\,) \times 100\% = 0.40\%$$

A gas law for "real" gases: van der Waals equation

We know the ideal gas law $pV = nRT$ where p does not account for inter-particle attractions …

$$p = p_{\text{ideal}} = p_{\text{observed}} + a\left(\frac{n}{V_{\text{container}}}\right)^2$$

and V does not account for particle volume …

$$V = V_{\text{empty}} = V_{\text{container}} - bn$$

Combine these two expressions into an equation relating p_{observed}, $V_{\text{container}}$, and T.