Physics 9 — Friday, October 26, 2018

- Turn in HW6. Pick up HW7 handout.
- So far two people plan to come along with me to Acentech's "3D Listening" demo Monday, 4pm, on 17th Street.
- I found a way to run both Odeon and CATT-Acoustic on MacOS without a virtual machine! Stay tuned.
- By the way, my goal is that you will see every important idea from this course at least three times: first in the reading; then in class; then on the homework — in that order.
- I always begin the semester intending to keep the reading only about a day ahead of what we do in class, but somehow eventually class inevitably winds up about a week behind the reading.
- I deliberately keep the homework a week or so behind what we do in class, so that you never (unless I really mess up) see something on the homework that we didn't somehow discuss in class. If I break this rule, you are right to call me out on it!

Giancoli's illustration of solid / liquid / gas

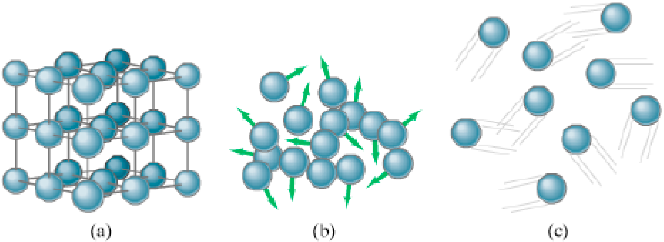

FIGURE 13–2 Atomic arrangements in (a) a crystalline solid, (b) a liquid, and (c) a gas.

Atomic mass unit (u):

$$1\ \mathrm{u} \quad = \quad 1\ \frac{\mathrm{gram}}{\mathrm{mole}} \quad = \quad 1.66 \times 10^{-27}\ \mathrm{kg}$$

This is very close (within 1%) to the mass of a proton:

$$m_{\mathrm{proton}} = 1.67 \times 10^{-27}\ \mathrm{kg}$$

A dozen eggs is 12 eggs. A mole of protons is $N_A = 6.022 \times 10^{23}$ protons.

A $^{12}\mathrm{C}$ nucleus contains 6 protons + 6 neutrons. So a carbon atom has a mass of 12 u, or 12 g/mol.

A mole of protons has a mass (within 1%) of 1.0 gram. A mole of $^{12}\mathrm{C}$ atoms has a mass (by definition of mole) of exactly 12 grams.

An oxygen nucleus contains

$$8 \text{ protons} + 8 \text{ neutrons} = 16 \text{ nucleons}$$

A hydrogen nucleus contains just 1 proton (and no neutrons). What is the mass of a mole of water ($\mathrm{H_2O}$) molecules?

(A) 0.016 kg
(B) 0.017 kg
(C) 0.018 kg
(D) 0.020 kg
(E) 0.034 kg

Ideal gas law

Anybody remember this from high school chemistry?

$$PV = nRT$$

$$R = 8.315 \ \frac{\mathrm{J}}{\mathrm{mol} \cdot \mathrm{K}}$$

$$R = 0.0821 \ \frac{\mathrm{L} \cdot \mathrm{atm}}{\mathrm{mol} \cdot \mathrm{K}}$$

Notice that temperature is measured in K (kelvin). To get temperature in K, take temperature in $^\circ$C and add 273.15.

By the way, how does a temperature difference $\Delta T = 1$ K compare with a temperature difference $\Delta T = 1^\circ$C?

(A) A temperature difference of 1 kelvin is bigger than a temperature difference of 1 degree Celsius.

(B) A temperature difference of 1 kelvin is smaller than a temperature difference of 1 degree Celsius.

(C) A temperature difference of 1 kelvin is the same as a temperature difference of 1 degree Celsius.

By the way, how does a temperature difference $\Delta T = 1^{\circ}$F compare with a temperature difference $\Delta T = 1^{\circ}$C?

(A) A temperature difference of 1 degree Farenheit is $1.8\times$ as large as temperature difference of 1 degree Celsius.

(B) A temperature difference of 1 degree Celsius is $1.8\times$ as large as temperature difference of 1 degree Farenheit.

(C) A temperature difference of 1 degree Farenheit is the same as a temperature difference of 1 degree Celsius.

What is the final pressure P_f of a sealed bottle of air after you raise its temperature from 27°C to 57°C?

(A) $P_f = 0.47\ P_i$

(B) $P_f = 0.9\ P_i$

(C) $P_f = 1.1\ P_i$

(D) $P_f = 2.1\ P_i$

(E) not enough information to decide

A cylinder initially contains one liter of air at atmospheric pressure. I then compress the gas *isothermally* (i.e. at constant temperature) to half its initial volume. What is the final pressure of the gas (in atmospheres)?

(A) $P_f = 0.50$ atm

(B) $P_f = 0.71$ atm

(C) $P_f = 1.00$ atm

(D) $P_f = 1.41$ atm

(E) $P_f = 2.00$ atm

(F) not enough information to decide

Dry air is 78% $\mathrm{N_2}$, 21% $\mathrm{O_2}$, 1% Ar, 0.04% $\mathrm{CO_2}$, ...
For simplicity, let's call it 80% $\mathrm{N_2}$ and 20% $\mathrm{O_2}$.

What is the density of $\mathrm{N_2}$ gas at $T = 22^\circ\mathrm{C}$? (Each nitrogen **atom** contains 7 protons and 7 neutrons.)

How do you find the mass of one mole of $\mathrm{N_2}$ molecules?

How do you find the volume of one mole of $\mathrm{N_2}$ molecules?

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How do you find the volume of one mole of N_2 molecules?

I get $m = 28$ g, $V = \frac{nRT}{P} = (.0821)(295) = 24.22$ L, so density $m/V = 1.16$ g/L $= 1.16$ kg/m^3.

Same thing for O_2: one oxygen **atom** contains 8 protons and 8 neutrons.

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Same thing for $\mathrm{O_2}$: one oxygen **atom** contains 8 protons and 8 neutrons. I get $1.32\ \mathrm{kg/m^3}$.

So for dry room-temperature air:
$(0.8)(1.16) + (0.2)(1.32) = 1.19\ \mathrm{kg/m^3}$.

The ideal gas law you learned in high school chemistry was:

$$PV = nRT$$

$$R = 8.315 \ \frac{\mathrm{J}}{\mathrm{mol} \cdot \mathrm{K}}$$

$$R = 0.0821 \ \frac{\mathrm{L} \cdot \mathrm{atm}}{\mathrm{mol} \cdot \mathrm{K}}$$

The analogous ideal gas law in terms of number of molecules (N) rather than number of moles (n) is:

$$PV = Nk_B T$$

where k_B is *Boltzmann's constant*

$$k_B = 1.38 \times 10^{-23} \ \frac{\mathrm{J}}{\mathrm{K}}$$

Q: what do you get when you divide 8.315 $\frac{\mathrm{J}}{\mathrm{mol} \cdot \mathrm{K}}$ by $6.022 \times 10^{23} / \mathrm{mol}$?

Boltzmann's constant

$$k_B = 1.38 \times 10^{-23}\ \mathrm{J/K}$$

$\frac{1}{2}k_B T$ is the average thermal energy per *degree of freedom.* A single atom of monotomic gas can move from place to place in three dimensions, but can't rotate or vibrate, so it has 3 d.o.f.

$$\frac{1}{2}mv_{\mathrm{rms}}^2 = \frac{3}{2}k_B T$$

The average energy of an atom or molecule is directly proportional to temperature. v_{rms} means the "root mean squared" speed.

$$v_{\mathrm{rms}} = \sqrt{\frac{3k_B T}{m}}$$

for an ideal gas. The lighter molecules tend to move faster!

Boltzmann's constant

$$v_{\rm rms} = \sqrt{\frac{3k_BT}{m}}$$

for an ideal gas. The lighter molecules tend to move faster! For helium gas (4 g/mol) at room temperature,

$$v_{\rm rms} \approx 1360 \text{ m/s}$$

For nitrogen gas (N_2, 28 g/mol) at 298 K,

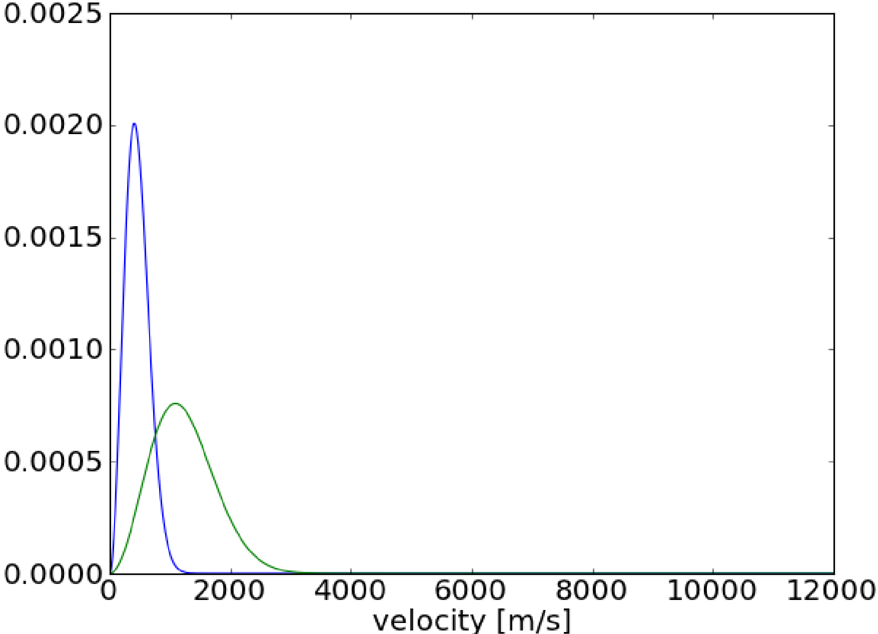
$$v_{\rm rms} \approx 520 \text{ m/s}$$

For gasoline vapor (C_8H_{18}, 114 g/mol) at 298 K,

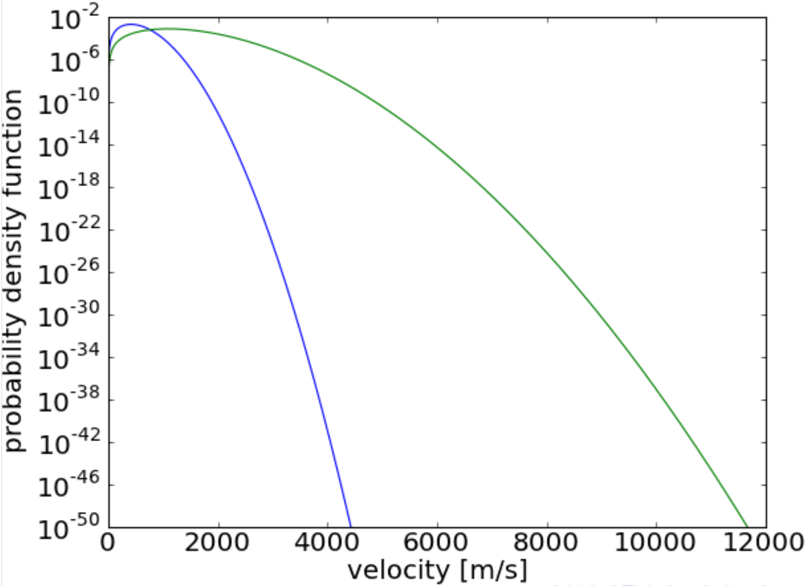
$$v_{\rm rms} \approx 260 \text{ m/s}$$

Richard Muller pointed out that this is why the helium escaped from Earth's atmosphere: some small fraction of the helium atoms move fast enough (11200 m/s) to escape Earth's gravity.

One of these two curves is the velocity distribution (at $T = 288\ \mathrm{K}$) for $\mathrm{N_2}$ (nitrogen) and one is for He (helium). Which is which?



If you make the vertical axis logarithmic, you can see that indeed some tiny fraction of the helium atoms move faster than the 11 km/s “escape velocity” of Earth’s gravity.



Nitrogen (N_2) makes up about 78% of the air we breathe, while oxygen (O_2) accounts for approximately 21%. On average, are the nitrogen or the oxygen molecules moving faster? (The mass of an N_2 molecule is 28 amu, while the mass of an O_2 molecule is 32 amu.)

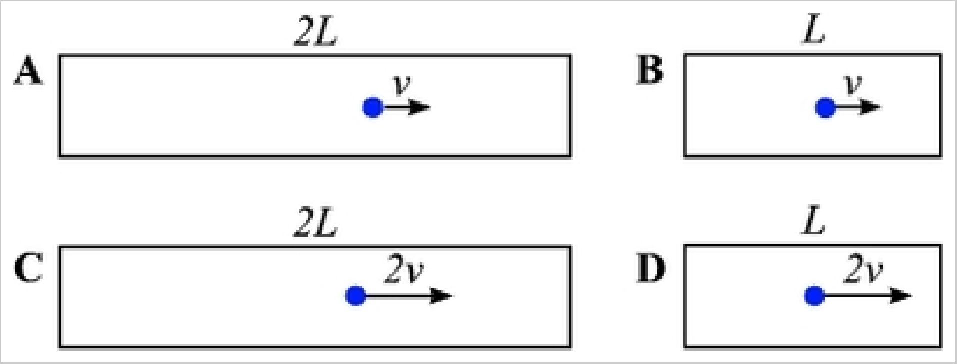
(A) The rms speed of the N_2 molecules is $\frac{32}{28}$ as large as the rms speed of the O_2 molecules, so the N_2 molecules move slightly faster, on average.

(B) The rms speed of the N_2 molecules is $\sqrt{\frac{32}{28}}$ as large as the rms speed of the O_2 molecules, so the N_2 molecules move slightly faster, on average.

(C) The rms speed of the O_2 molecules is $\frac{32}{28}$ as large as the rms speed of the N_2 molecules, so the O_2 molecules move slightly faster, on average.

(D) The rms speed of the O_2 molecules is $\sqrt{\frac{32}{28}}$ as large as the rms speed of the N_2 molecules, so the O_2 molecules move slightly faster, on average.

A gas atom of mass m moves in a straight line with speed v or $2v$ in a box with length L or $2L$, as shown below. The atom collides elastically with the right wall, travels to the left wall, collides elastically, returns to the right wall and repeats this process. In which case does the atom exert the largest average force on the walls?



Bigger thermal energy $\rightarrow$ higher rms speed $\rightarrow$ larger force per unit area (pressure)

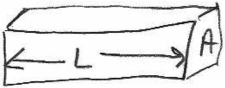
Smaller volume $\rightarrow$ particles collide more often with walls $\rightarrow$ larger force per unit area (pressure)

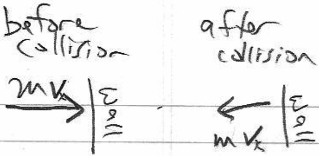
More particles in container $\rightarrow$ collisions with walls occur more often $\rightarrow$ larger force per unit area (pressure)

$$P = \frac{Nk_B T}{V}$$

$$\frac{1}{2} m v_{\mathrm{rms}}^2 = \frac{3}{2} k_B T$$

"Deriving" the ideal-gas law is not as difficult as you may think





$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

$$\text{force}_x = \frac{\Delta\,\text{momentum}_x}{\Delta\,\text{time}} = \frac{2mv_x}{2L/v_x} = \frac{mv_x^2}{L}$$

$$\rightarrow \underset{\text{(due to one molecule)}}{\text{pressure}} = \frac{mv_x^2}{L\cdot A} = \frac{mv_x^2}{\text{volume}} = \frac{k_BT}{\text{volume}}$$

$$\frac{1}{2}m\overline{v_x^2} = \frac{1}{2}m\overline{v_y^2} = \frac{1}{2}m\overline{v_z^2} = \frac{1}{2}k_BT \Leftrightarrow \frac{1}{2}m\overline{v^2} = \frac{3}{2}k_BT$$

$$\rightarrow \boxed{P = \frac{Nk_BT}{V}}$$

(Digression: connect energy/heat/power physics units to real life.)

A commonly used energy unit in chemistry is the calorie:

$$1 \text{ cal} = 4.18 \text{ J}$$

Even more common is the food Calorie:

$$1 \text{ Cal} = 1000 \text{ cal} = 4180 \text{ J}$$

and remember that power is measured in watts:

$$1 \text{ W} = 1 \text{ J/s}$$

Q: A person typically consumes about 2000 food calories per day. Roughly how many watts of power are required to power a person?

(A) 1 W (B) 10 W (C) 100 W (D) 1000 W (E) 10000 W

We just worked out that a person's daily intake of 2000 dietary Calories implies that it takes on average about 100 watts to power a person.

$$\frac{2000 \times 4180 \text{ J}}{24 \times 60 \times 60 \text{ s}} = 97 \text{ W}$$

Former energy secretary Steven Chu was fond of pointing out that since the USA has an overall energy usage of about 3×10^{12} W (including industry, etc.) and a population of about 300M people, that's an average of 10 kW per person in the USA, or roughly 100 "energy helpers" per person. (I think he used a more pejorative word for "helper.")

In other words, US energy use per person (including industry, etc.) is about 100× a typical person's 100 W metabolic rate.

Heat capacity

As you increase the temperature of a substance, its molecules move faster. So its thermal energy increases. This thermal energy is just an "incoherent" form of kinetic energy: you're adding up a whole bunch of $\frac{1}{2}mv^2$, but the velocities are all pointing in different directions, so the substance as a whole is not moving even though the individual molecules are moving.

The internal thermal energy of a monatomic gas (like helium or argon) is $\frac{3}{2}k_B T$ per molecule, or $\frac{3}{2}RT$ per mole.

You sometimes need to know how much energy is needed to heat an object (like a brick wall, or an old metal baseboard radiator, or a swimming pool) by some number of degrees. Tables usually list **energy per unit mass per degree C**. This is known as **specific heat capacity** (or more commonly just "specific heat").

$$Q = m c \Delta T$$

where c is the "**specific heat**," whose SI units are $\frac{\mathrm{J}}{\mathrm{kg}^\circ\mathrm{C}}$

TABLE 14–1 Specific Heats
(at 1 atm constant pressure and 20°C unless otherwise stated)

Substance	Specific Heat, c kcal/kg·C°	Specific Heat, c J/kg·C°	Substance	Specific Heat, c kcal/kg·C°	Specific Heat, c J/kg·C°
Aluminum	0.22	900	Alcohol (ethyl)	0.58	2400
Copper	0.093	390	Mercury	0.033	140
Glass	0.20	840	Water		
Iron or steel	0.11	450	Ice (−5°C)	0.50	2100
Lead	0.031	130	Liquid (15°C)	1.00	4186
Marble	0.21	860	Steam (110°C)	0.48	2010
Silver	0.056	230	Human body (average)	0.83	3470
Wood	0.4	1700	Protein	0.4	1700

For example: how many joules of heat are needed to raise 10 kg of water from 20°C to 30°C? How many watts of power are needed to do this in 1000 s (about 17 minutes)?

Latent heat

At the boiling point, the internal energy of the gas phase is higher than that of the liquid phase: need to overcome the forces that keep molecules close together in a liquid.

Similarly, the internal energy of the liquid phase is higher than that of the solid phase at the melting point.

So even at a fixed temperature, you need to add some energy to turn a solid into a liquid, or to turn a liquid into a gas. "Latent heat." Called *heat of fusion* or *heat of vaporization*.

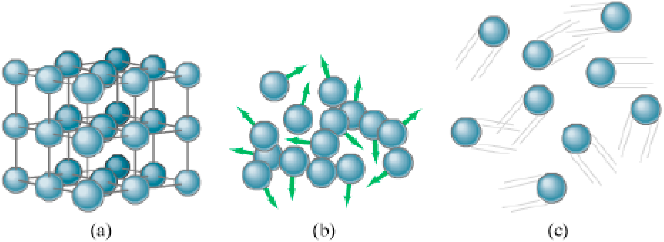


FIGURE 13–2 Atomic arrangements in (a) a crystalline solid, (b) a liquid, and (c) a gas.

Latent heat is extremely useful. For instance, your body takes advantage of the latent heat (heat of vaporization) of water when you sweat.

Suppose that by exercising you double your metabolic rate, from about 100 watts to about 200 watts.

How many milliliters of water ($1\ \mathrm{mL} = 1\ \mathrm{cc} \approx \frac{1}{30}$ ounce) do you need to sweat per minute, in order for your body to remove these extra 100 W by letting the sweat evaporate from your skin?

The latent heat of vaporization for water is 2260 kJ/kg = 2260 J/g. The density of water is 1 g/mL. See if you and your neighbor can work out an answer (in milliliters per minute):

(A) 0.027 mL/min (B) 0.27 mL/min (C) 2.7 mL/min
(D) 27 mL/min (E) 270 mL/min (F) 2700 mL/min

I get

$$\frac{100\ \mathrm{J/s}\ \times\ 60\ \mathrm{s/min}}{1.0\ \mathrm{g/mL}\ \times\ 2260\ \mathrm{J/g}} = 2.65\ \mathrm{mL/minute}$$

which is about an ounce every 11 minutes, i.e. a glass of water every hour or two while exercising. Seems like a plausible number.

Conduction of heat (thermal conductivity)

TABLE 14–4
Thermal Conductivities

Substance	Thermal Conductivity, k $\frac{\text{kcal}}{(\text{s}\cdot\text{m}\cdot\text{C}^\circ)}$	Thermal Conductivity, k $\frac{\text{J}}{(\text{s}\cdot\text{m}\cdot\text{C}^\circ)}$
Silver	10×10^{-2}	420
Copper	9.2×10^{-2}	380
Aluminum	5.0×10^{-2}	200
Steel	1.1×10^{-2}	40
Ice	5×10^{-4}	2
Glass	2.0×10^{-4}	0.84
Brick	2.0×10^{-4}	0.84
Concrete	2.0×10^{-4}	0.84
Water	1.4×10^{-4}	0.56
Human tissue	0.5×10^{-4}	0.2
Wood	0.3×10^{-4}	0.1
Fiberglass	0.12×10^{-4}	0.048
Cork	0.1×10^{-4}	0.042
Wool	0.1×10^{-4}	0.040
Goose down	0.06×10^{-4}	0.025
Polyurethane	0.06×10^{-4}	0.024
Air	0.055×10^{-4}	0.023

$$\frac{\mathrm{d}Q}{\mathrm{d}t} = \frac{kA}{\ell}(T_1 - T_2) = \frac{A}{R}(T_1 - T_2)$$

"R value" is

$$\frac{\ell}{k} = \frac{\text{thickness}}{\text{thermal conductivity}}$$

(often given in US customary units, unfortunately)

- more area (in cross-section, perpendicular to heat flow) $\rightarrow$ faster heat conduction
- bigger temperature difference $\rightarrow$ faster
- bigger thermal conductivity $\rightarrow$ faster
- thicker insulating layer $\rightarrow$ slower
- bigger "R value" $\rightarrow$ slower

I keep the inside of my house at $20^\circ\mathrm{C}$. If the thermal power $\mathrm{d}Q/\mathrm{d}t$ conducted through the walls of my house is 10 kilowatts when the outdoor temperature is $10^\circ\mathrm{C}$, what will be the thermal power conducted through the walls of my house when the outdoor temperature is $-10^\circ\mathrm{C}$?

(Hint: this is why the gas company often tells you the number of "degree days" for the winter months. Your heating bill should scale like the inside-outside temperature difference, integrated over time.)

(A) 5 kW (B) 10 kW (C) 20 kW (D) 30 kW

By the way: 1 kW = 3400 BTU/hour. 1 BTU = 1055 J. Anyone know the conventional definition of a BTU?

Concrete has a thermal conductivity k that is about $8.4\times$ that of wood. How thick a layer of concrete would I need to use in order to provide thermal insulation equivalent to that of a 2 cm layer of wood?

(A) 0.12 cm (B) 2 cm (C) 8.4 cm (D) 16.8 cm

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The "R value" goes like (thickness) / (thermal conductivity). So if the thermal conductivity is multiplied $\times 8.4$, then the thickness also needs to be multiplied $\times 8.4$. So I need 16.8 cm of concrete to get the same thermal insulation as 2 cm of wood.

If 10 kilowatts of power (heat per unit time) is conducted through the 10 $\mathrm{m} \times 10\,\mathrm{m}$ roof of my house on a given winter day, how much power would be conducted through a similar roof (same kind of insulation, same thickness, etc.) that is 20 $\mathrm{m} \times 20\,\mathrm{m}$ on the same winter day?

(A) 2.5 kW (B) 10 kW (C) 20 kW (D) 40 kW

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(A) 2.5 kW   (B) 10 kW   (C) 20 kW   (D) 40 kW

The area is quadrupled, so the conducted heat per unit time is quadrupled. I get 40 kW.

If you buy fiberglass insulation at Home Depot, the "R value" is written on the paper backing.

TABLE 14–5 *R*-values

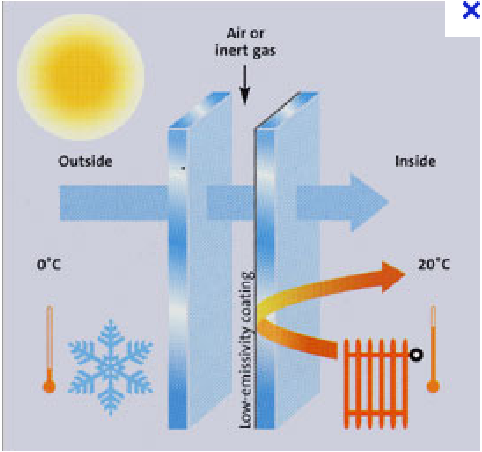
Material	Thickness	*R*-value ($\mathrm{ft^2 \cdot h \cdot F^\circ/Btu}$)
Glass	$\frac{1}{8}$ inch	
Brick	$3\frac{1}{2}$ inches	0.6–1
Plywood	$\frac{1}{2}$ inch	0.6
Fiberglass insulation	4 inches	12

$$R = \frac{\ell}{k}$$

A U.S. customary R value of 1 is (in metric units) $0.176\ \frac{\mathrm{m^2{}^\circ C}}{W}$.

R values add: twice the thickness means twice the R value, which means half as much heat conducted per unit time.

R values add: double-glazed window



$$R = \frac{\ell}{k}$$

$$k_{\mathrm{glass}} = 0.84 \ \frac{\mathrm{W}}{\mathrm{m}^\circ\mathrm{C}}$$

$$k_{\mathrm{air}} = 0.026 \ \frac{\mathrm{W}}{\mathrm{m}^\circ\mathrm{C}}$$

$$k_{\mathrm{argon}} = 0.018 \ \frac{\mathrm{W}}{\mathrm{m}^\circ\mathrm{C}}$$

What is ℓ/k for 6 mm of glass? How about 3 mm of glass, then 10 mm of air, then 3 mm of glass?

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What is ℓ/k for 6 mm of glass? How about 3 mm of glass, then 10 mm of air, then 3 mm of glass?

$$\frac{0.006 \ \mathrm{m}}{0.84 \ \frac{\mathrm{W}}{\mathrm{m}^\circ\mathrm{C}}} = 0.0071 \ \frac{\mathrm{m}^{2\circ}\mathrm{C}}{\mathrm{W}} \qquad \frac{0.010 \ \mathrm{m}}{0.026 \ \frac{\mathrm{W}}{\mathrm{m}^\circ\mathrm{C}}} = 0.38 \ \frac{\mathrm{m}^{2\circ}\mathrm{C}}{\mathrm{W}}$$

So in theory, two 3 mm panes of glass separated by 10 mm of air will *conduct* about 1/50 as much heat per unit time as a single 6 mm pane of glass. (But we ignored convection and radiation. And in real life, even a single layer of glass will build up an insulating layer of cool air next to it, increasing its effectiveness.)

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What important constituent of ordinary air are we missing?

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The fraction of water vapor in the air varies from region to region (climate) and from day to day (weather). The maximum possible fraction of water vapor in the air (before you get rain, snow, fog, etc.) varies with temperature.

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To discuss the quantity of one gas (e.g. water vapor) that is dissolved in another gas (e.g. air), it helps to introduce the concept of **partial pressure,** which is the pressure due to that constituent alone.

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Example: air at 1 atm is 21% O_2. What is the partial pressure of oxygen (in atmospheres)?

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Example: air at 1 atm is 21% O_2. What is the partial pressure of oxygen (in atmospheres)?

Answer: 0.21 atm, which is about 21300 $\mathrm{N/m^2}$.

TABLE 13–3 Saturated Vapor Pressure of Water

Temperature (°C)	Saturated Vapor Pressure: torr (= mm-Hg)	Saturated Vapor Pressure: Pa (= N/m^2)
−50	0.030	4.0
−10	1.95	2.60×10^2
0	4.58	6.11×10^2
5	6.54	8.72×10^2
10	9.21	1.23×10^3
15	12.8	1.71×10^3
20	17.5	2.33×10^3
25	23.8	3.17×10^3
30	31.8	4.24×10^3
40	55.3	7.37×10^3
50	92.5	1.23×10^4
60	149	1.99×10^4
70†	234	3.12×10^4
80	355	4.73×10^4
90	526	7.01×10^4
100‡	760	1.01×10^5
120	1489	1.99×10^5
150	3570	4.76×10^5

† Boiling point on summit of Mt. Everest.
‡ Boiling point at sea level.

At a given temperature, the maximum possible partial pressure of water vapor is called the "**(saturated) vapor pressure of water.**"

When partial pressure of water vapor equals saturated vapor pressure, a pool of standing water is in equilibrium with water vapor: rate of evaporation (liquid to gas) equals rate of condensation (gas to liquid).

If partial pressure of water vapor exceeds the saturated vapor pressure (e.g. if you take saturated air and cool it), precipitation occurs.

Below this partial pressure, standing water will evaporate.

When saturated vapor pressure equals external atmospheric pressure, boiling occurs!

TABLE 13–3 Saturated Vapor Pressure of Water

Temperature (°C)	Saturated Vapor Pressure torr (= mm-Hg)	Saturated Vapor Pressure Pa (= N/m²)
−50	0.030	4.0
−10	1.95	2.60×10^2
0	4.58	6.11×10^2
5	6.54	8.72×10^2
10	9.21	1.23×10^3
15	12.8	1.71×10^3
20	17.5	2.33×10^3
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30	31.8	4.24×10^3
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† Boiling point on summit of Mt. Everest.
‡ Boiling point at sea level.

In humid air, the rate at which sweat can evaporate from your skin (hence cooling your body, via latent heat) is lower than in dry air. So a hot, humid day feels more uncomfortable than a hot, dry day.

HVAC climate-control systems monitor and regulate "relative humidity" =

$$\frac{\text{partial pressure of water vapor}}{\text{saturated water vapor pressure}} \times 100\%$$

R.H. $\sim$ 40%-50% is most comfortable.

Q: if $T = 30°\mathrm{C}$ and R.H.=50%, what is partial pressure of water vapor (in $\mathrm{N/m^2}$)?

In that case, what fraction of molecules in the air are H_2O molecules?

Physics 9 — Friday, October 26, 2018

- Turn in HW6. Pick up HW7 handout.
- So far two people plan to come along with me to Acentech's "3D Listening" demo Monday, 4pm, on 17th Street.
- I found a way to run both Odeon and CATT-Acoustic on MacOS without a virtual machine! Stay tuned.
- By the way, my goal is that you will see every important idea from this course at least three times: first in the reading; then in class; then on the homework — in that order.
- I always begin the semester intending to keep the reading only about a day ahead of what we do in class, but somehow eventually class inevitably winds up about a week behind the reading.
- I deliberately keep the homework a week or so behind what we do in class, so that you never (unless I really mess up) see something on the homework that we didn't somehow discuss in class. If I break this rule, you are right to call me out on it!