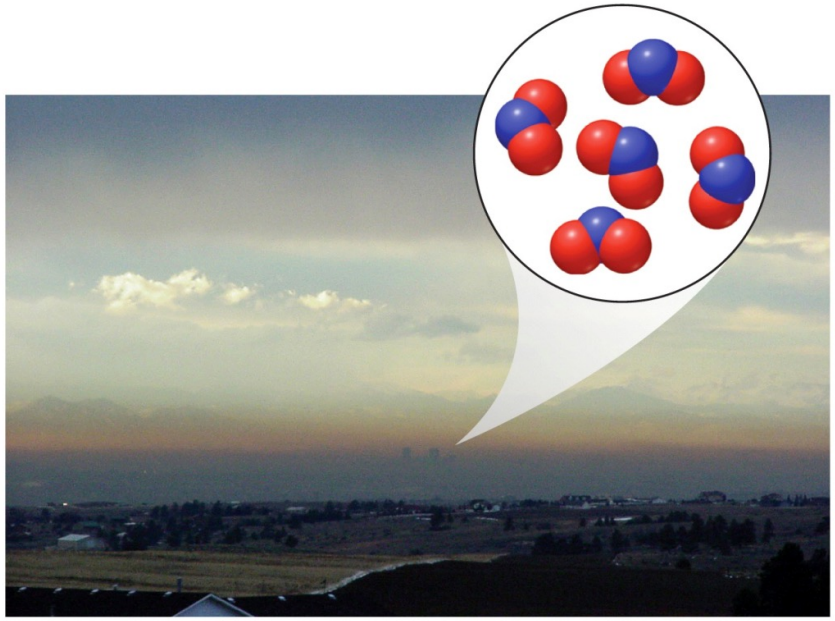
Reaction Rates

Chemical kinetics is the study of how fast reactions take place.

Some happen almost instantaneously, while others can take millions of years.

Increasing the *rate* of a reaction is important to many industrial processes.

Salt Lake City, UT



Discuss!

If you start with 100g of carbon-14, there will be 50g of carbon-14 left after 5730 years.

Is this process spontaneous?

What are we measuring in this case?

Discuss!

If you start with 100g of carbon-14, there will be 50g of carbon-14 left after 5730 years.

Is this process spontaneous? yes

What are we measuring in this case?

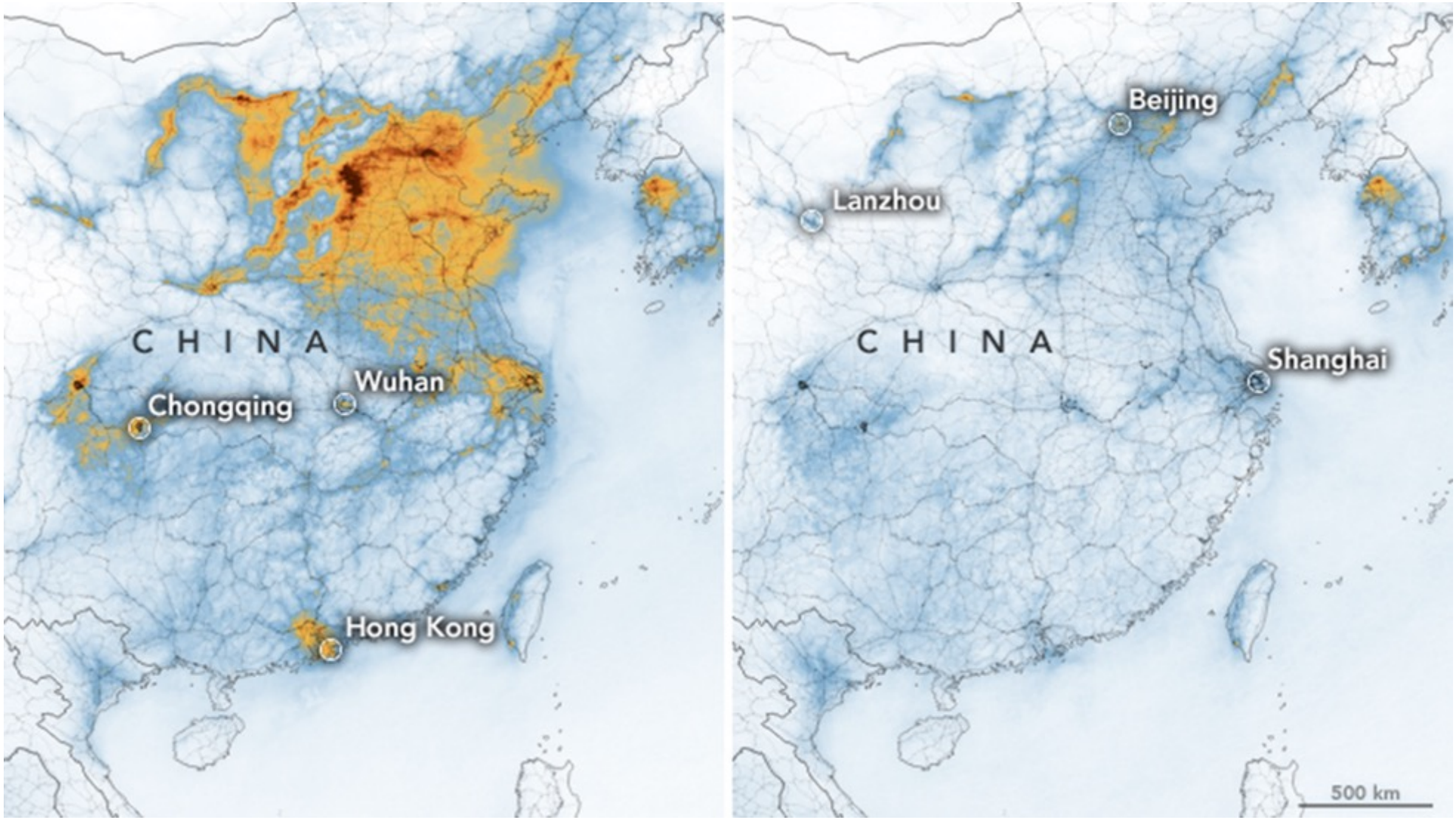
A change in amount over a period of time (this change in amount over time is “rate”)

Important Reactions in Smog

- $N_2(g) + O_2(g) \rightarrow 2\ NO(g)$ $\Delta H^\circ = 180.6$ kJ
- $2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$ $\Delta H^\circ = -114.2$ kJ

- Internal combustion engines provide heat energy needed for the reaction to occur. This is associated with industrial processes and cars. The EPA estimates 55% of NO_x are from anthropogenic sources. There are also some natural (but less significant) sources, such as lightning.

Note: Products of some reactions are reactants in other reactions.



Nitrogen Dioxide Pollution in China

NASA and European Space Agency pollution monitoring satellites have detected significant decreases in nitrogen dioxide over China that researchers think is connected to the economic slowdown caused by the outbreak of coronavirus. The maps above show NO2 values across China from January 1-20, 2020, (before the quarantine) and February 10-25 (during the quarantine). (NASA Earth Observatory images by Joshua Stevens, using modified Copernicus Sentinel 5P data processed by the European Space Agency)

Discuss!

The air is roughly 80% N_2 and 20% O_2.

$N_2(g) + O_2(g) \rightarrow 2\,NO(g)$ $\Delta H^\circ = 180.6$ kJ

Why doesn't NO form all the time?

For this reaction, is solar power (sunlight) enough to power it to a significant degree?

Discuss!

The air is roughly 80% N_2 and 20% O_2.

$N_2(g) + O_2(g) \rightarrow 2\ NO(g)\ \Delta H^\circ = 180.6\ kJ$

Why doesn't NO form all the time? Needs a lot of heat to get it to happen!

For this reaction, is solar power (sunlight) enough to power it to a significant degree? No – we can tell since it is not found in high amounts under natural circumstances.

Important Reactions in Smog

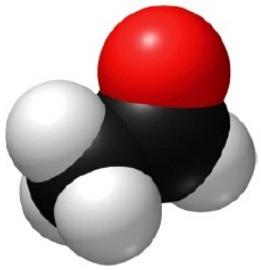
- $NO_2(g) \xrightarrow{\text{sunlight}} NO(g) + O(g)$
- $O_2(g) + O(g) \rightarrow O_3(g)$
- $O(g) + H_2O(g) \rightarrow 2\ OH(g)$

Note: Products of some reactions are reactants in other reactions. This can become fairly complicated.

Photochemical smog involves sunlight as an energy source for some reactions.

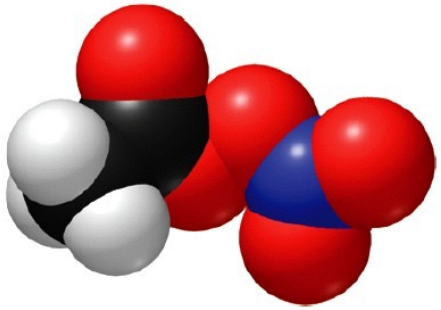
VARIATIONS OF SMOG COMPOSITION

$$N_2(g) + 3\,O_2(g) + OH(g) + CH_3CHO(g) \rightarrow$$



Acetaldehyde

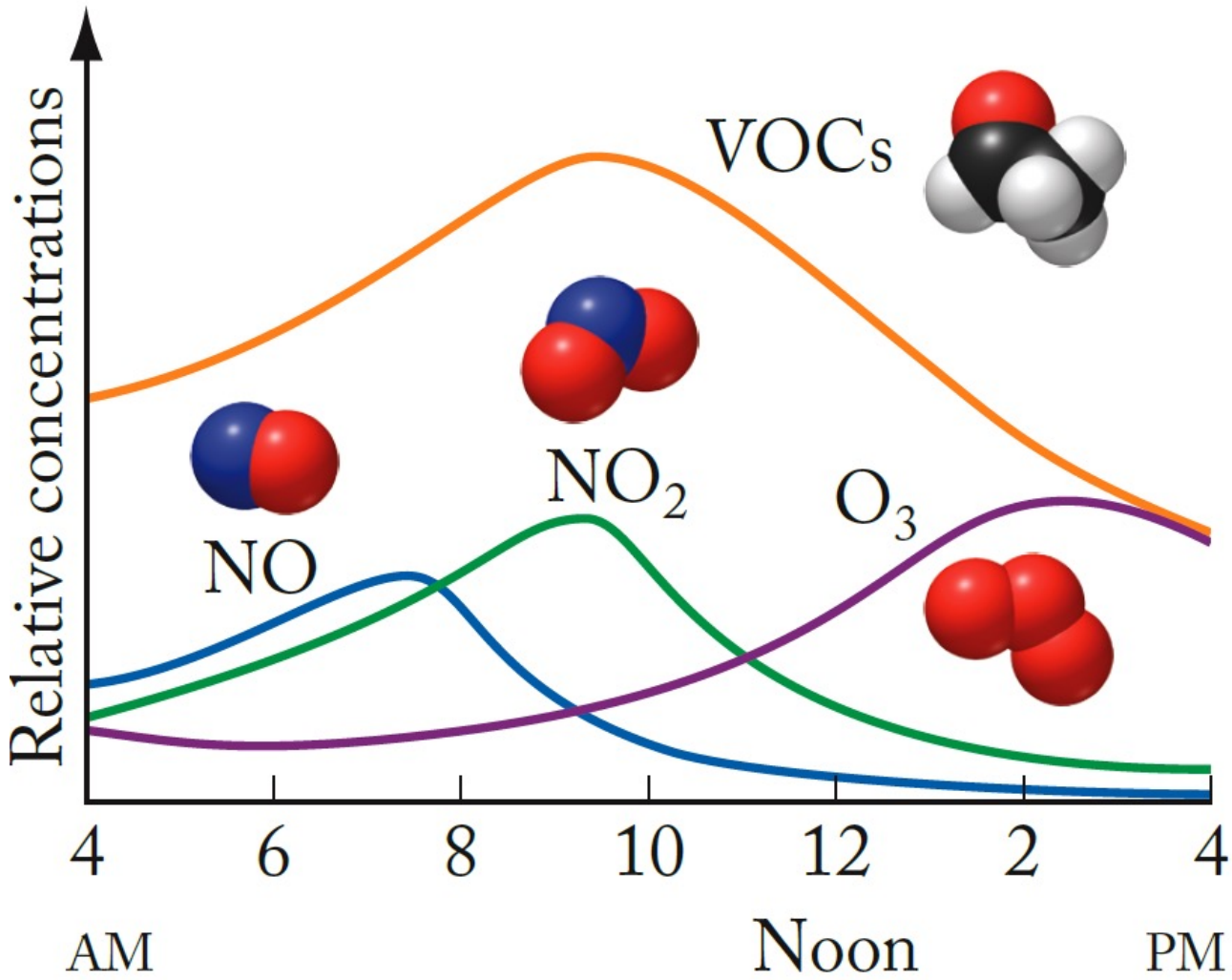
$$CH_3C(O)O_2NO_2(g) + H_2O(g) + NO_2(g)$$



Peroxyacetyl nitrate

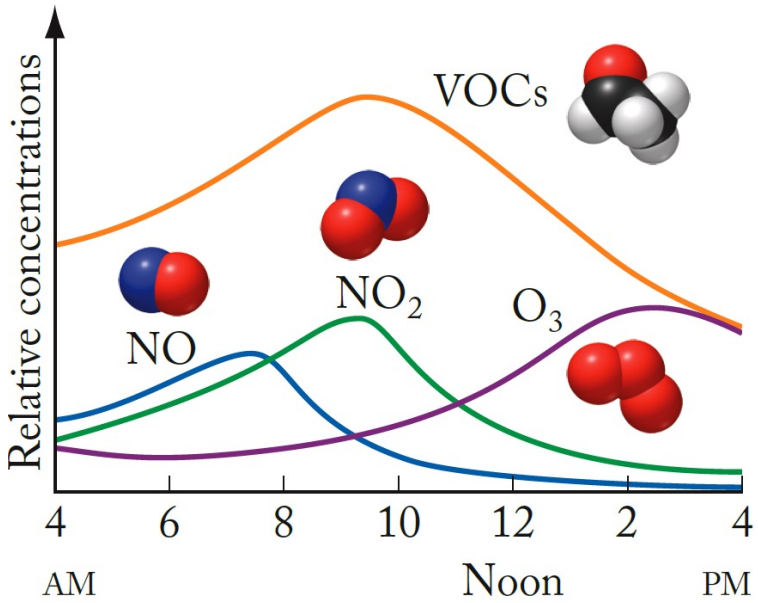
acetaldehyde (common VOC – volatile organic compound) makes PAN (this product that is highly irritating to eyes, throat, nose – respiration)

DAILY VARIATIONS - SMOG COMPOSITION



Photodecomposition of NO_2 leads to high levels of O_3 in the afternoon. Extra sunlight in summer leads to seasonal extra ozone formation.

Discuss!



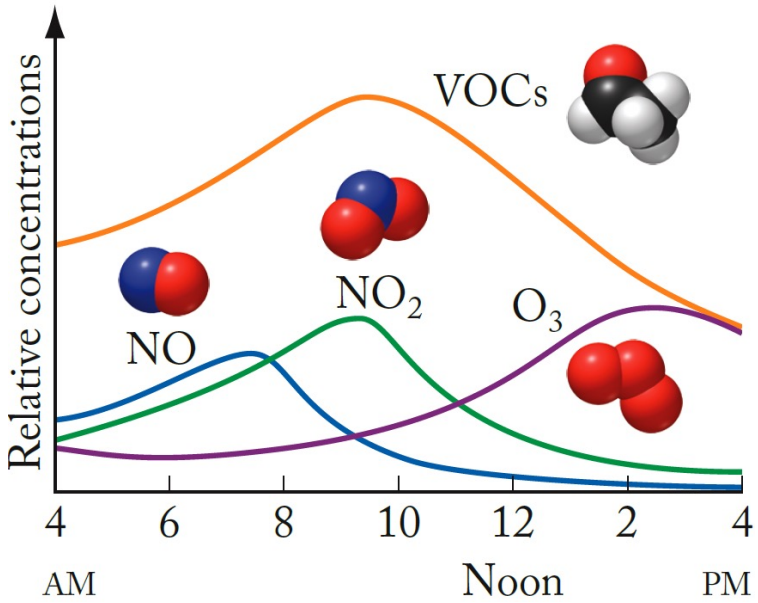
Are the concentrations of gases such as NO and O_3 constant values?

Are the changes in concentration over time constant values?

Why might this be useful to know?

Discuss!

Are the concentrations of gases such as NO and O_3 constant values? No. Not a straight line.



Are the changes in concentration over time constant values?

No – they irregularly curve up and down because of a series of complex factors.

Why might this be useful to know? We breathe! Might influence decisions on when to drive, or what to drive.

14.2 *Collision Theory of Chemical Reactions*

Most reactions happen faster at higher temperature.

Chemical reactions generally occur as a result of collisions between reacting molecules.

According to ***collision theory*** of chemical kinetics, the reaction rate is directly proportional to the number of molecular collisions per second:

$$\text{rate} \propto \frac{\text{number of collisions}}{\text{s}}$$

Discuss!

If you have a reaction that you want to speed up, what are some things you can try?

A) finely divide any solids
B) put all reactants in the gas phase
C) heat it up
D) increase the concentrations of reactants
E) all of these

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