Why does this matter?

Why does counting and thinking about how much of stuff you're using by using chemistry and moles?

Why does that matter?

Well, let's take an example.

Let's take an example of nothing less than the number of humans on this planet.

This is the population of humans.

And you can see that it wasn't all that much until lately.

But let's focus in on this part here.

Let's focus in on that part there.

Right.

So that's billions of people.

So if I zoom in on this, there's a change.

Look at that.

It's kind of going a little bit up.

But now, it really kicks up.

What happened during that time?

What happened is a very important chemical reaction, became easy to do or a lot easier.

OK?

And the process that enabled that is called the Haber-Bosch process.

But it is what allowed us to feed billions of people in a sustainable way.

It's arguable whether we're doing that sustainably but in a way where we could actually produce enough-- enough what?

Enough ammonia.

And here's the deal you see, because plants need nitrogen to grow.

Right?

And there's 70% of the atmosphere is nitrogen.

But it's useless, because it's N2.

And N2 is one of the strongest bonds in nature.

And plants can't break it.

Now, we knew how to break it before.

We knew how to do this before, right?

This is called fixing-- fixing nitrogen. And the way it works is you go N2 plus h.

This is a reaction, goes to NH3.

What is wrong with this?

[inaudible]

It's not balanced.

Thank you.

Did anybody say, balancing is the same as mole ratio.

Balancing and mole ratio's the same-- counting.

Remember, we talk about that.

But balancing is counting.

So let's see-- oh, 2 here.

OK, that helps me with the nitrogen.

Oh, but this is H2.

I meant to put that in the first place.

And then so this is a 3.

That reaction was known and doable.

But it took tremendous amounts of energy.

So it's very difficult to scale.

And Haber-Bosch came up with a way using catalysis to do it at much lower temperatures.

Catalysis is something we'll learn later in the semester.

But how do we answer this question?

What's my question?

My question is how long can we keep going?

50% of every protein you put in your body-- 50% come from this-- comes from some plant that was grown using this process.

That's how important it is.

It's 500 million tons of nitrogen is made this way every year.

Well, it's just counting.

One mole of ammonia is 17 grams.

Oh, we're doing the same thing.

How did I know that?

Periodic table.

That's how I knew that.

One mole-- if that many molecules of ammonia, I've got 17 grams of it.

Let's say I just need to make the same amount of-- it says so times 10 to the 6 tons.

I need that much tons of NH3 per year.

That's our-- yeah, per year-- per year.

OK, so that sets up my problem.

I know how much I need.

I know how many atoms we're talking about in one mole.

Now, I can actually understand how many moles-- so I'm just going to not do the detailed math but how many moles I have.

So I've got 30 times 10 to the 12th moles.

This is how many moles I needed per year.

How much do I have?

Well, we know how much the atmosphere weighs-- it turns out.

We know how much the atmosphere weighs.

The mass of the atmosphere is something like 5 times 10 to the 21st grams.

And if I take 78% of that as my N2, so 78% is N2, then I can tell you that I've got-- let's see, 1.4 times 10 to the 20th moles of N2.

That's how much I have available.

OK?

So if I keep on taking N2 out of the atmosphere, then I can now answer the question just like the candle.

All right, how long do you have?

I can answer the question, how long can we keep taking N2 out of the atmosphere and using Haber-Bosch, right?

Oh, well, you would use the balanced reaction.

So for every mole event do I take, I get two moles of ammonia.

That's good.

And you can work backwards.

And you can learn that you're good.

We're good for now.

We have roughly 100 million years.

OK?

We have 100 million years that we could keep consuming.

And then we'll run out of N2 in the atmosphere.

How fun was that?

OK, I love doing this.

Now, when I get excited-- wow.

Wait, before I get excited, what's the limiting reagent?

[? add ?] enough N2.

Is it N2?

How do you know?

How could you show?

How can you prove?

Limiting range, it means what runs out first?

Well, oh, I'll just take H2 from the atmosphere, right?

Na, uh.

There's no H2 in the atmosphere.

Where's the H_2?

Di da, it's over here-- H_2O.

It's in the oceans.

How much H_2O do I have?

Well-- [laughter]

It turns out you've got a lot.

10 to the 23rd-ish moles of H_2O, right?

10 to the 23rd-ish moles.

And so because of those coefficients of the reaction, you know exactly which one is going to run out first.

You know it's N_2, so your answer over there was correct.

N_2 is the limiting-- I love that little dance.

I'm going to try to learn that.

I'm going to learn that later.

If you try this, you go 100 million years.

You run out of N_2-- plenty of H_2 left.