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Drug kinetics (crammed version)

Rate law

Basically the rate law shows the relationship between rate (r) and concentration on the compound (C or [A] or [B]) via a rate constant (k).

Zeroth order reaction has this rate law:

$$r = k$$

You see, the rate is independent on the concentration, meaning for any concentration, the rate will stay the same. Reaction rate should always has the unit of $\frac{concentration}{time}$(can be $\frac{M}{s}$, or $\frac{M}{h}$, or $\frac{M}{day}$, etc.). This will become handy when we find the unit of rate constant (k), since the two sides of the equation must have the same unit.

First order reaction has this rate law:

$$r = k[A]$$

Let's have a look, since the rate is proportional to the concentration (by a factor of k), you can imagine that if you have more drug A, the faster the rate, and if you have less drug A, the slower the rate. Easy?

Remember what I say about the unit of rate? It should always be $\frac{concentration}{time}$ right? We have already know that [A] has the unit of concentration. Using simple math, we can figure out the unit of rate constant (k):

$$r(\frac{concentration}{time}) = k(\frac{1}{time}) \times [A](concentration)$$

OR put in specific units for simplification:

$$r(\frac{M}{s}) = k(\frac{1}{s}) \times [A](M)$$

Let's try at home with second order whose rate law is:

$$r = k[A]^2$$

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How to determine a reaction order

From the discovery, we all know that we can "guess" the reaction order based on the concentration versus time plot. Depending on which sort of concentration formula we use, we can determine the reaction order.

Zeroth (or zero) order:

- The concentration (C) versus time (t) plot is a straight line on the "normally-scaled" graph (we will get to another type of graph in the next section)
- We use this formula to calculate C_t (concentration at time t):

$$C_t = C_0 - kt$$

- Half-life:

$$t_{1/2} = \frac{C_0}{2k}$$

First order:

- The natural log of concentration (lnC) versus time (t) plot is a straight line in, again, normally-scaled graph.
- Calculate C_t:

$$ln(C_t) = ln(C_0) - kt$$

- Half-life:

$$t_{1/2} = \frac{ln2}{k} = \frac{0.693}{k}$$

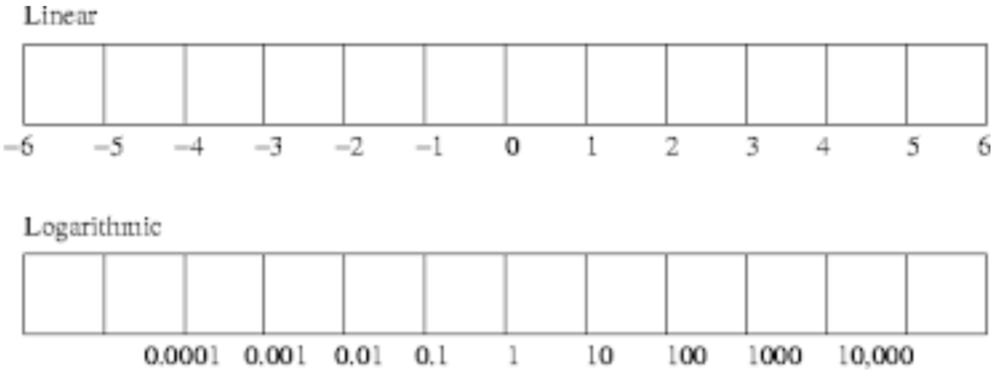
Second order:

- Let's not care about second order reaction now since it is unlikely that it will be tested, although you still need to know the unit of rate constant (k) in case they ask.

The logarithmic (log) scale and semi-log graph

You should be familiar with the normal (linear) graph, or scale. The log scale is a bit different since it is derived from log function.

As you can see, in log scale, the distance between 1 and 10 is the same as between 10 and 100 (I mean there are only 9 numbers between 1 and 10, but there are 90 numbers between 10 and 100, how is that possible). The meaning behind this is because the log scale already contains the log function.



Try this formula:

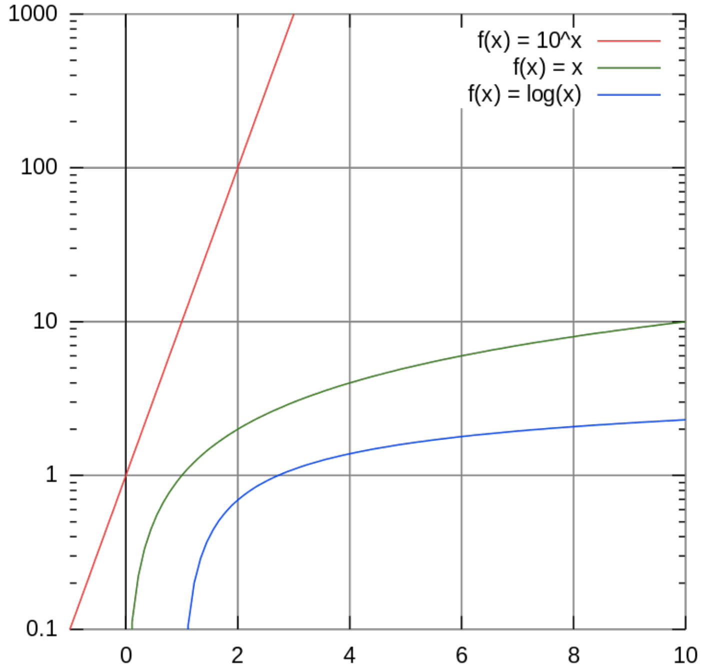
$$log_{10}(number\ in\ log\ scale) = respective\ number\ in\ linear\ scale$$

Example:

$$log_{10}(1000) = 3$$

So, the log scale is linear in the sense that, after you log the value of the log scale, you get the linear scale:

$$1,\ 2,\ 3,... = log(10),\ log(100),\ log(1000), \ldots$$



Good? The semi-log graph is just a part-log, part-linear graph:

The vertical axis is in log scale, whereas the horizontal axis is in linear scale. Pharmacokinetically saying, the vertical axis shows concentration, and the horizontal axis shows time.

What you should be careful with semi-log scale

Since the vertical axis is already in log scale, when you draw data from the graph, the number you collect reflect the **TRUE** concentration of the drug. In linear scale, the data you collect from the graph will be lnC. Make sure you know the difference.

A tip is that if the question gives you the graph, look at the annotation of the vertical axis. The number you collect from the graph will be that function.

So in conclusion, although the concentration-time plot is a straight line, but if it's drawn on a semi-log graph, then it's first order, NOT zeroth order!

Below are 3 examples so you can have a closer and more intuitive look:

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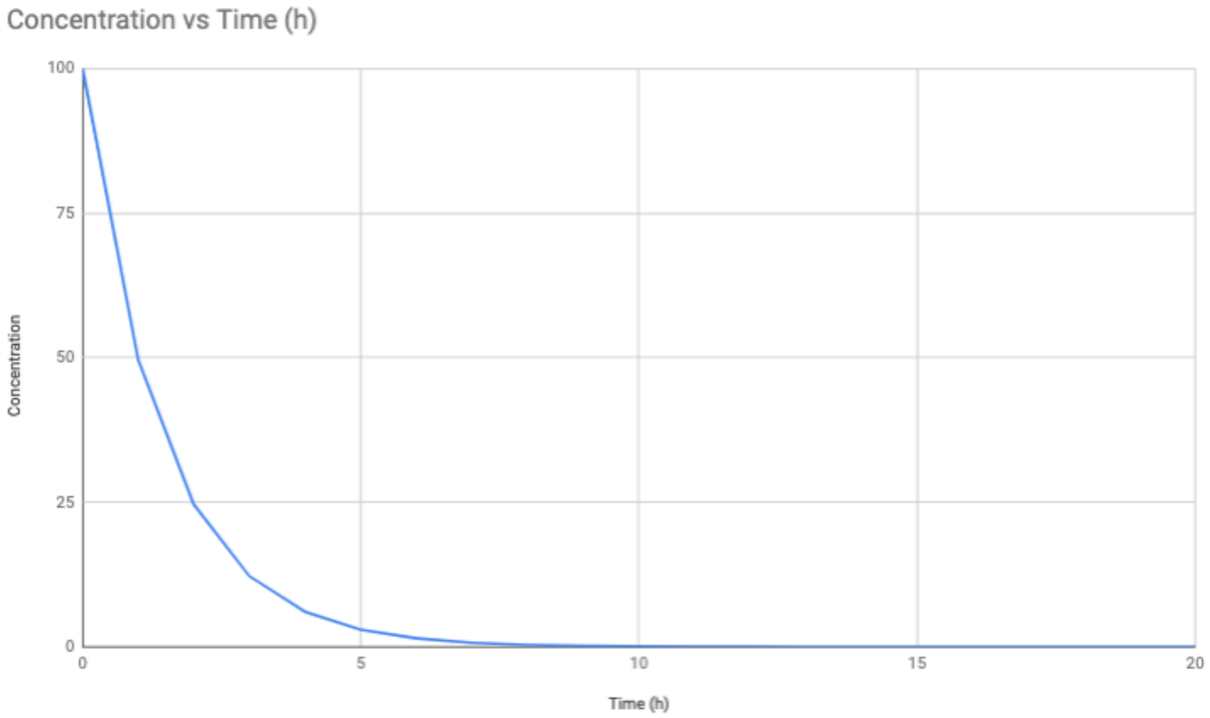
Example 1

This is a linear graph, showing first order kinetics. Look at the vertical axis, nothing weird. Concentration-time plot is a curve. Example 2 on the next page.



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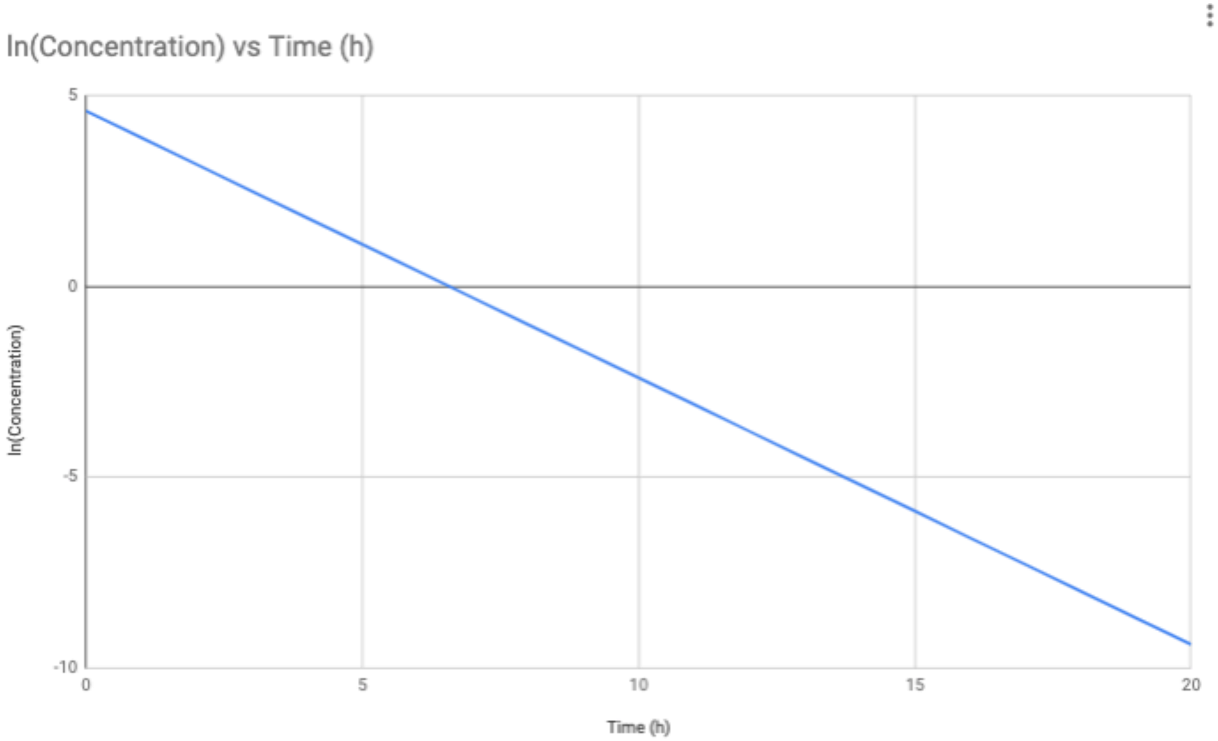
Example 2

This is a linear graph, showing first order kinetics. Look at the vertical axis, it's lnC. So the plot of lnC-time is a line, which is correct with first order kinetics. the value that you get from the graph will be lnC, NOT the TRUE concentration. You can use that value directly to the formula of first order reaction.



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Example 3

This is a semi-log graph, showing first order kinetics. Look closely at the vertical axis, it's in log scale. The annotation on the vertical axis says "concentration", meaning the value you draw from the graph will be the TRUE concentration. You have to put that concentration in natural log in the formula to be able to calculate.