KINETICS

The art of moving

What is the rate (or velocity) of the car if the…

- Distance from the car to Las Vegas is 200km
- Takes him 2 hours to get there

200km

$$\text{Rate} = \frac{200\text{km}}{2\text{ hours}} \longrightarrow 100\text{km/hr}$$

What is the **rate** of Kobayashi's consumption of hot dogs if he eats 50 hot dogs in 12 minutes?

$$\text{Rate} = \frac{50 \text{ hotdogs}}{12 \text{ minutes}} \longrightarrow 4.1667 \text{ hotdogs/min}$$

What is the **rate** if the apples "brown" $2cm^2$ in 10 minutes?

$$\text{Rate} = \frac{2cm^2}{10 \text{ minutes}} \longrightarrow 0.5 \text{ cm}^2/\text{min}$$

Kinetics

- is the study of the movement of matter; specifically during chemical reactions

-measure the movement of particles over time or the **rate** of the reaction.

$$\text{average rate} = \frac{\Delta[A]}{\Delta \text{time}}$$

- Rate is the change of an observable property over time

The Δ or the Greek letter delta means “change in”.

Expressing Rates

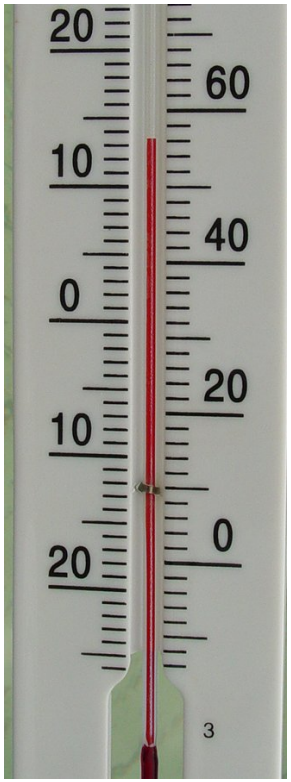
$$\textbf{rate} = \frac{\text{quantity of a } \textbf{product} \text{ formed}}{\text{unit } \textbf{time}}$$

$$\text{or } \textbf{rate} = \frac{\text{quantity of a } \textbf{reactant} \text{ consumed}}{\text{unit } \textbf{time}}$$

$$\text{in general: } \textbf{rate} = \frac{\Delta\ \textbf{amount} \text{ (a reactant or product)}}{\Delta\ \textbf{time}}$$

Variables used to monitor reaction rates

These are not factors that *affect* reaction rates but variables to *record* the reaction rate change



- Temperature (How fast was the exothermic reaction?
- Concentration (Acidity/pH/Colour changes)
- Pressure
- Mass over time
- Conductivity (# of ions produced)

Reaction rate calculations

Example: If 16g of HCl are used up after 12 min in a certain reaction, then the average reaction rate is:

$$\text{Rate of using HCl} = \frac{16\text{g}}{12\text{min}} = 1.3\text{g/min}$$

Example: If a reaction between $CaCO_3$ and HCl produces 245ml of CO_2(g) in 17s, the average reaction rate is:

$$\text{Rate of using producing } CO_2 = \frac{245\text{ml}}{17\text{s}} = 14\text{ml/s}$$

Example 2

According to the reaction A → B, the following data was collected

a) What is the average rate over the entire 50 seconds?
b) What is the average rate for the interval 20 s to 40 s?

Time (s)	Concentration of B (mol/ L)
0.0	0.0
10.0	0.30
20.0	0.50
30.0	0.60
40.0	0.65
50.0	0.67

Example 3

The decomposition of nitrogen dioxide produces nitrogen monoxide and oxygen according to the reaction:

$$2\ NO2(g) \rightarrow 2\ NO(g) + O2(g)$$

the following data has been collected:

Time (s)	**[NO_2] (mol/L**	**[NO] (mol/L)**	**[O2] (mol/L)**
0.0	0.100	0.00	0.00
100	0.066	0.034	0.017
200	0.048	0.052	0.026
300	0.038	0.062	0.031
400	0.030	0.070	0.035

Calculate the average rate of decomposition of NO_2 over 400 s.

For example 3

- Since the answer is -1.75 x 10^{-4} mol/L
- Rate is always expressed as positive for ***products*** forming so the actual value is
- 1.75 x 10^{-4} mol/L

$$\text{rate} = -\frac{\Delta[NO_2]}{\Delta t}$$

Instantaneous Rate

- Back with the driving to Las Vegas example…

What is the rate (or velocity) of the car if the…

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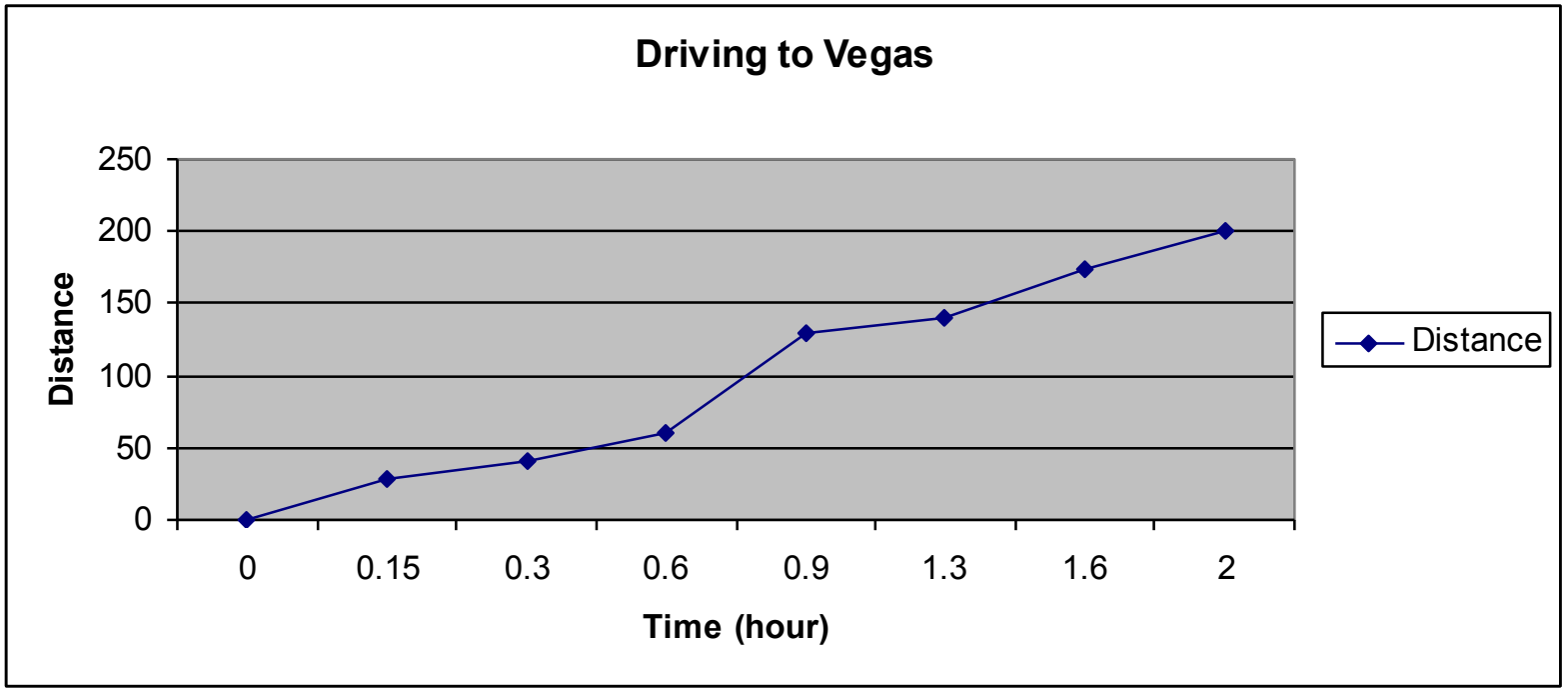
200km

$$\text{Rate} = \frac{200\text{km}}{2\text{ hours}} \longrightarrow 100\text{km/hr}$$

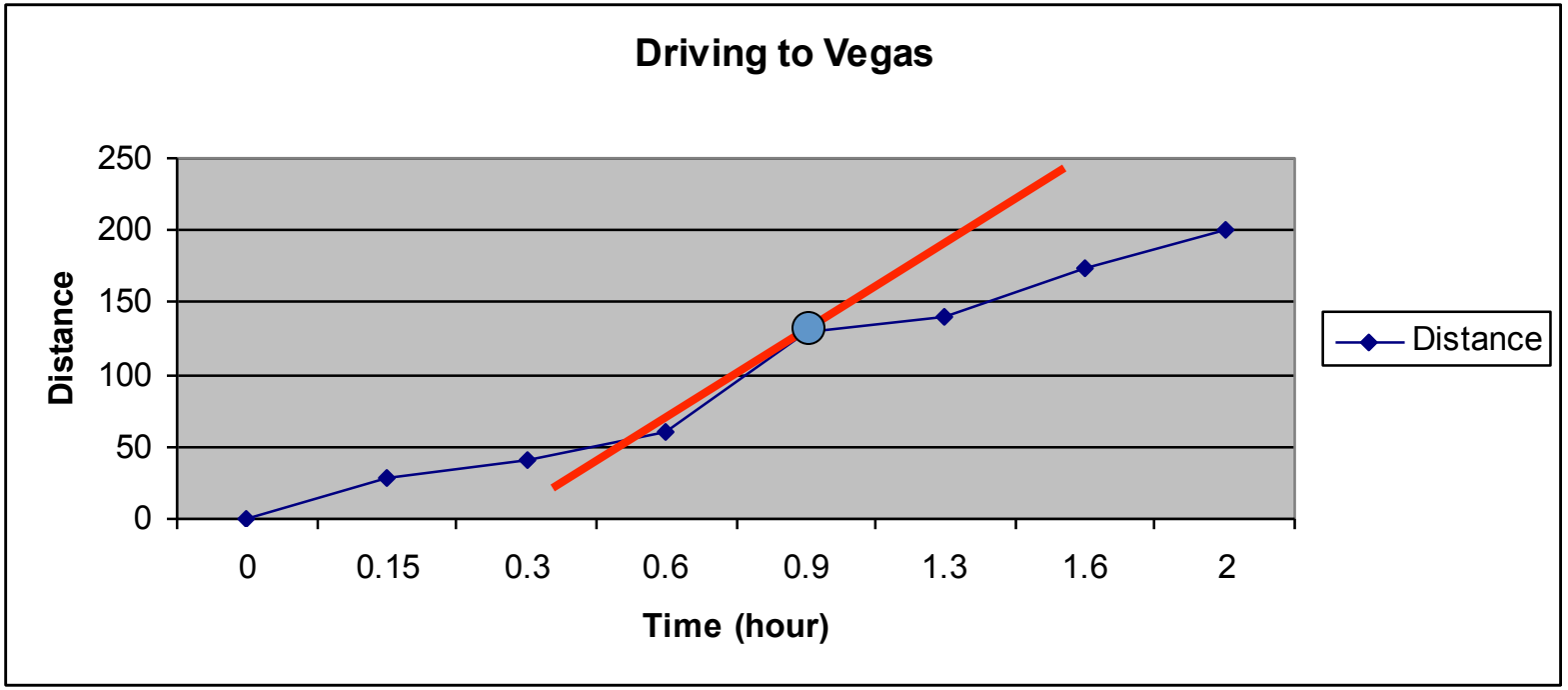
Instantaneous rate

- Is the person driving 100km/hr for every minute of his trip? Or can his velocity fluctuate?
- What if he started off very slowly in the beginning and speed up near the end?



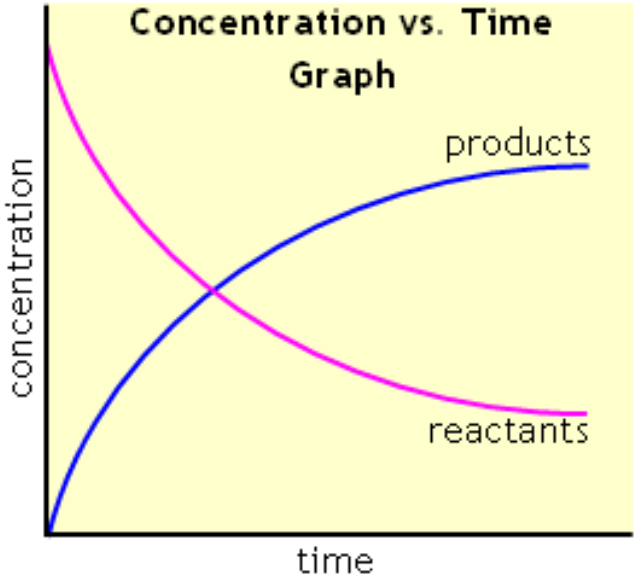
•To figure out the INSTANTANEOUS VELOCITY or the velocity at one specific moment, you draw a tangent to the curve on the graph.

•INSTANTANEOUS rate is the rate at a specific time



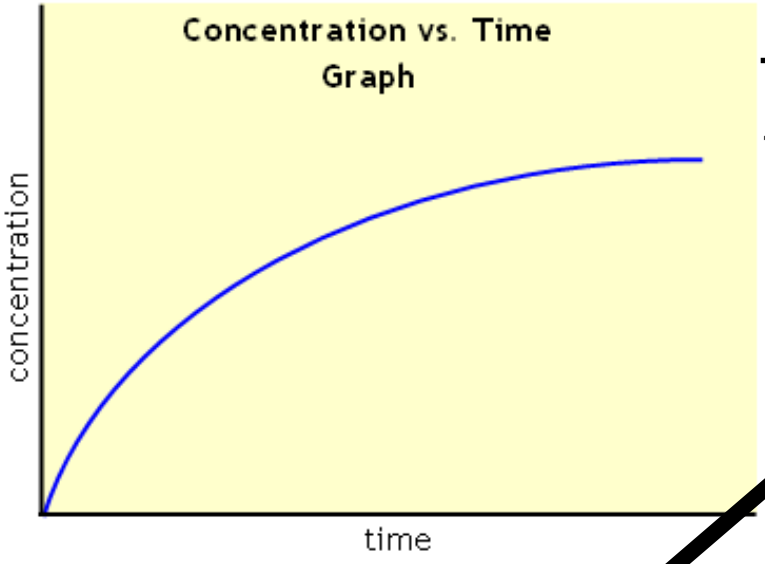
Calculating instantaneous rates for chemical reactions

If we graph the change in concentration of reactants and products the graphs are not linear.



Likewise with the velocity driving to Vegas, chemical reactions do not occur in a constant rate

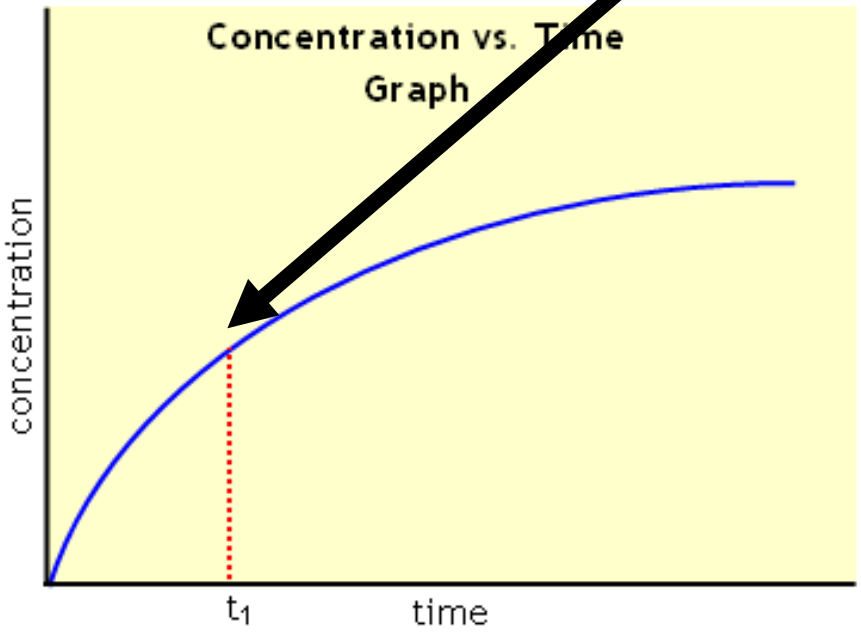
Instantaneous rate is the rate at one specific time



To calculate the rate at a specific time

1st – Pick a time

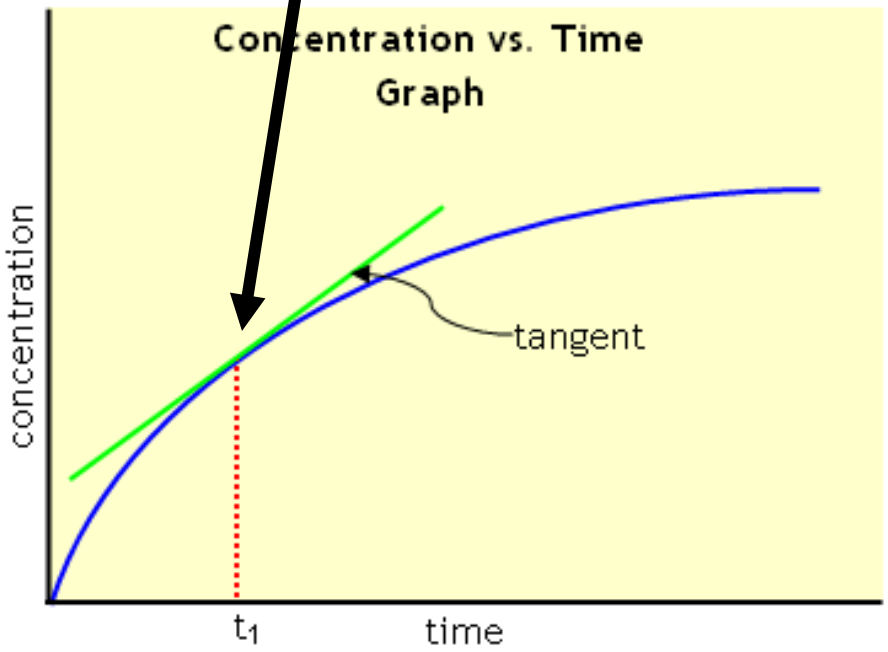
Draw a tangent line to the curve at t_1



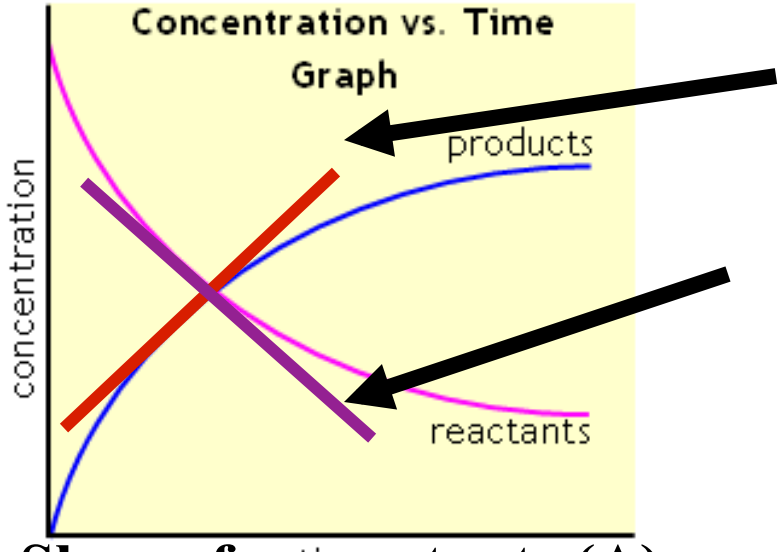
Calculate the slope of the tangent line:

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}}$$

Or $\frac{y_2 - y_1}{x_2 - x_1}$



When do we use (+) and (-) signs for rate?



B

A

Slopes for reactants (A) are *always* negative (-) because you are using up the reactants

Slopes for products (B) are *always* positive (+) because you are gaining products

x

But, *your final rate is always positive – We say the consumption of reactants and formation of products both have (+) rates*