Name: _____ Date: _____ Period: _____

SL Topic 6_ Kinetics - Guided Notes

Slide 3: Rate of A Reaction

- Depends on how quickly _____ of reactants or product change over time
- Typically shown through graphs of _____ vs. time
- Δt
- Δt
- **_____ how quickly a reaction proceeds**
- Expressed as:
- Rate of _____ = Δ[P] or -Δ[R]
- **Units are mol dm^{-3} s^{-1}**

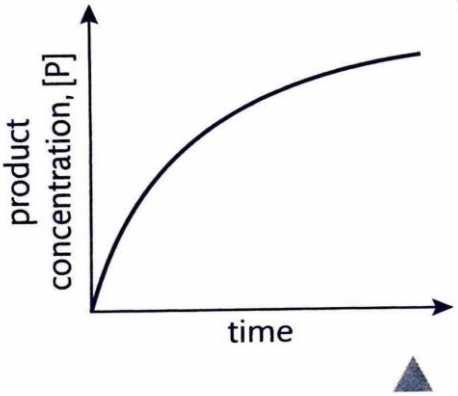


Figure 6.1 Concentration of product against time.

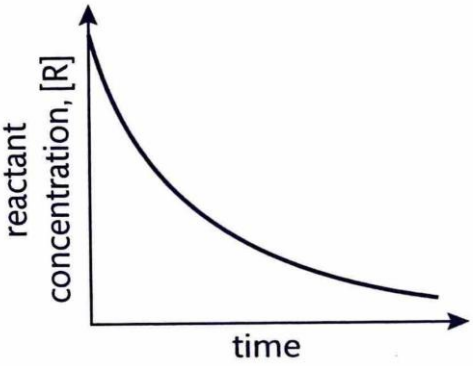
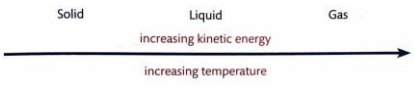


Figure 6.2 Concentration of reactant against time.

Slide 4: Collision theory

- **In order to react, particles must collide with kinetic energy greater than the _____ energy and have the correct collision geometry.**
- Based on the **kinetic-_____ theory of matter**
- Kinetic energy is described by **absolute _____ (K)**, which is the **average** kinetic energy of the particles in a substance.



- **All _____ have random, constant motion due to their kinetic energy**
- **Adding heat to a substance raises its average kinetic energy, so also raises its _____**

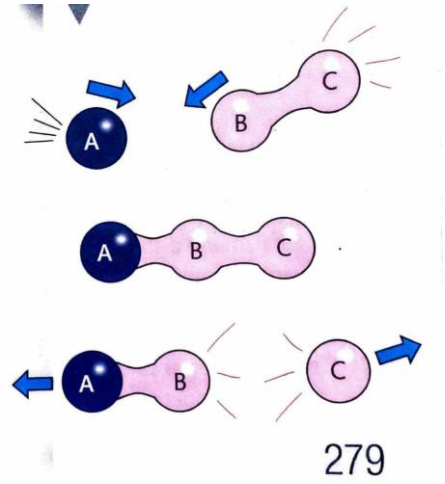
Slide 5: Maxwell-Boltzmann distribution curve

- Shows the particles in a gas have at a particular _____ have a range of kinetic energy values.
- The area under the curve _____ the total number of particles in the sample.

Slide 6: There is more heat contained in an iceberg than in a cup of boiling coffee. Offer an explanation of this phenomenon.

Slide 7: How reactions occur

- Kinetic energy of reactants cause _____, resulting in bonds breaking and forming.
- The rate of a reaction depends on the number of "_____ collisions" that lead to the formation of products.
- ***Not all _____ will be successful.***
- _____ collisions depend on:
- Energy of collision
- Geometry of _____



Slide 8: Energy of A collision

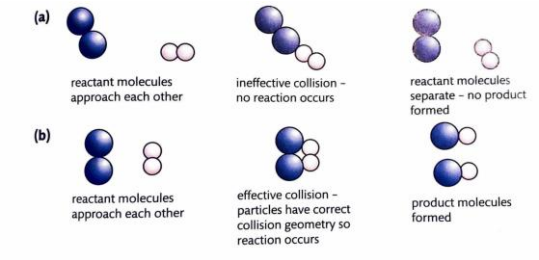
- Particles must have a minimum _____ **energy (Ea)** for a reaction to occur
- _____ energy is required to overcome repulsion between molecules and breaking bonds in reactants that is necessary for the reaction to occur.
- Addition of the _____ energy allows reactants to reach a **transition state** from which products can form.
- Only particles with kinetic energies greater than the _____ energy will have successful collisions.
- Other particles still collide, but will not contribute to the _____ of the reaction.
- **Minimum value of kinetic energy _____ must have in order to react**

Slide 9: Activation Energy

- _____ energies have different values in different reactions.
- The rate of a reaction depends on the _____ of particles that have more kinetic energy than the activation energy
- **Higher _____ energies = slower reactions.**

Slide 10: Geometry of Collisions

- Remember, particle _____ are *random*.
- This means they can collide with many different _____.
- Geometry of the particles crucial to _____ if collisions are successful and the proportion of collisions that lead to a reaction.



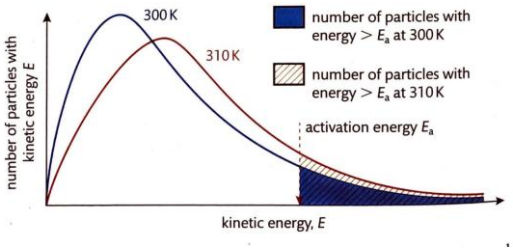
Slide 11: Temperature

Temperature	**↑ Temp = ↑ Rate**
Concentration	**↑ Concentration = ↑ Rate**
Particle Size	**↓ Particle Size = ↑ Rate**
Pressure	**↑ Pressure = ↑ Rate**
Catalyst	**Add catalyst = ↑ Rate**

- Factors That Affect _____ Rates
- **Any factor that increases the number of _____ collisions will increase the rate of a reaction.**

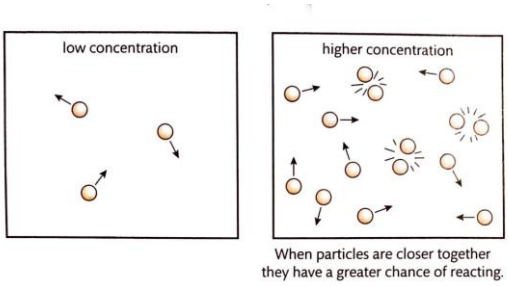
Slide 12: Temperature

- Increasing _____ increases average kinetic energy of particles, which increases proportion of particles that have kinetic energy greater than the activation energy.



Slide 13: Concentration

- Increasing _____ increases frequency of successful collisions between reactants.



When particles are closer together they have a greater chance of reacting.

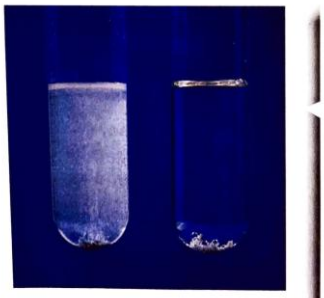


Figure 6.18 Effect of concentration on collision frequency.

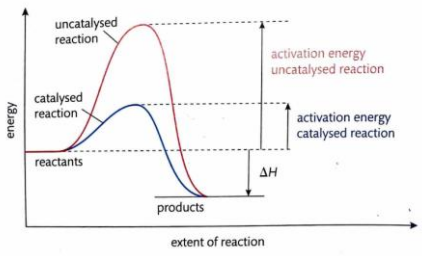
The effect of concentration on the rate of reaction between zinc and sulfuric acid. The tube on the left has a more concentrated solution of the acid, the one on the right a more dilute solution. The product, hydrogen gas, is seen collecting much more quickly in the presence of the more concentrated acid.

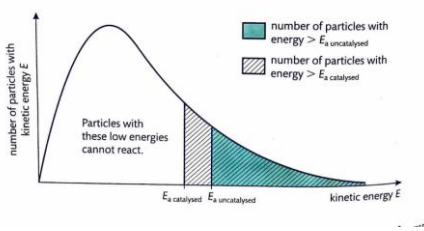
Slide 14: Particle Size

- _____ particle size increases the rate of reaction by increasing the surface area available for collisions.
- Pressure
- For gases, _____ pressure increases the rate of the reaction because it increases the frequency of collisions.

Slide 15: Catalyst

- Increases the rate of a reaction by providing an alternate route that has a lower _____ energy.
- Causes a larger number of particles to have kinetic energy greater than the _____ energy.
- **Remember, _____ do not undergo permanent changes in reactions.**
- **Catalysts decrease _____ energy of both forward and reverse rxns.**





Slide 17: Let's Practice!

Exercises

8 Which of the following statements is correct?

A A catalyst increases the rate of the forward reaction only.
B A catalyst increases the rate of the forward and backward reactions.
C A catalyst increases the yield of product formed.
D A catalyst increases the activation energy of a reaction.

9 Which statements are correct for the effects of catalyst and temperature on the rate of reaction?

	Adding a catalyst	Increasing the temperature
A	collision frequency increases	collision frequency increases
B	activation energy decreases	collision frequency increases
C	collision frequency increases	activation energy increases
D	activation energy increases	activation energy decreases

10 In the reaction between marble (calcium carbonate) and hydrochloric acid, which set of conditions would give the highest rate of reaction?

$$CaCO_3(s) + 2HCl \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

A marble chips and 1.0 mol dm^{-3} HCl
B marble powder and 1.0 mol dm^{-3} HCl
C marble chips and 0.1 mol dm^{-3} HCl
D marble powder and 0.1 mol dm^{-3} HCl

11 A sugar cube cannot be ignited with a match, but a sugar cube coated in ashes will ignite. Suggest a reason for this observation.

Slide 18: Kinetics Simulator Activity

- Go to PhET Simulator.
- Click to open the simulator.
- Click the "many collisions" tab.
- Note the reaction you are observing (located on the bottom of the screen).
- Look at the graph representing the reaction on the side of the screen. Is the reaction exothermic or endothermic?
- In the box labeled "current amounts", enter 10 for A and 10 for BC. Watch for 30 seconds and observe the amount of products formed.
- Increase the temperature of the reaction so that the total average energy is above the energy level of the products but below the activation energy.
- Repeat step 5.
- Raise the temperature above the activation energy.
- Repeat step 5.
- What did you notice about the rate of formation of products between the three temperature?

Slide 19: Common Misconceptions

- The overall rate of a reaction is not the same as the individual rate of _____ of individual products/formation of individual reactants
- _____ rates can be different
- Overall rate _____ the entirety of the chemical reaction
- Average rates ≠ _____ rates
- The rate of a _____ is not constant
- Higher at the _____
- When the rate curve levels out, this means the reaction has stopped (no change in _____ of reactants/products)
- When a reaction is in _____, it means the rates of forward and reverse reactions are equal, not that the reaction has stopped

Slide 20: Measuring Rates of Reaction

- Can be determined _____ by measuring the change in concentration of reactants OR products
- Most changes in _____ are not directly measured, but instead are indicated by changes in other parameters
- Change in volume of gas _____
- Change in mass lost
- Change in color
- This means raw data can be in a _____ of units other than mol dm^{-3}
- Data-_____ devices can be used

Slide 21: Methods for Measuring Reaction Rates

- Change in volume of gas _____
- Change in mass
- Change in transmission of light (colorimetry/_____)
- Change in _____ measured using titration
- Change in _____ measured using conductivity
- Clock-reactions

Slide 22: Change in Volume of Gas

- _____ if one of the products is a gas
- A gas syringe is often used to collect gas _____ in a reaction
- Gas can also be collected by water _____ method

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

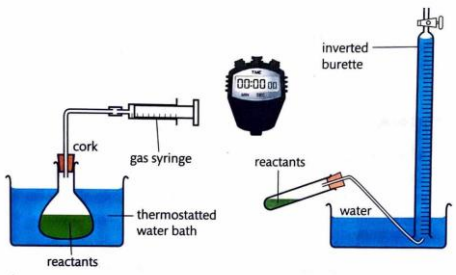


Figure 6.6 Experiments to measure rate of reaction by following change in volume against time.

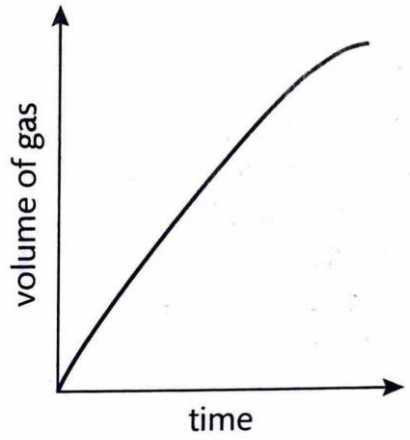


Figure 6.7 Volume of gas against time.

Slide 23: Change In Mass

- If _____ gives off a gas, a decrease in mass can be measured by putting the reaction mixture on a balance
- Useful if small molar-mass gases are given off (e.g. H_2, CO_2)

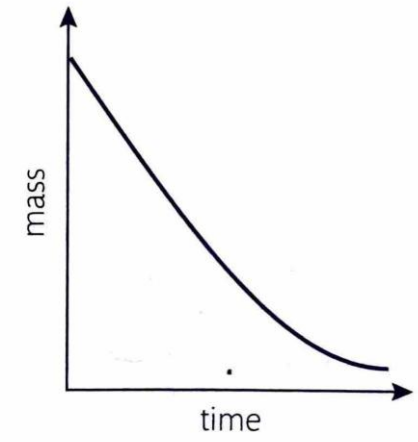
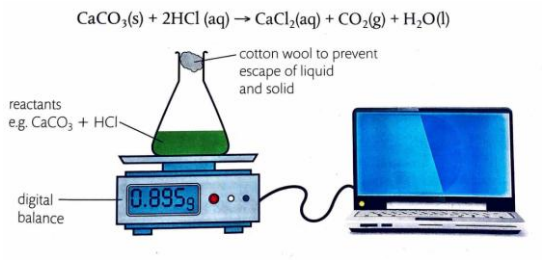


Figure 6.9 Mass against time.



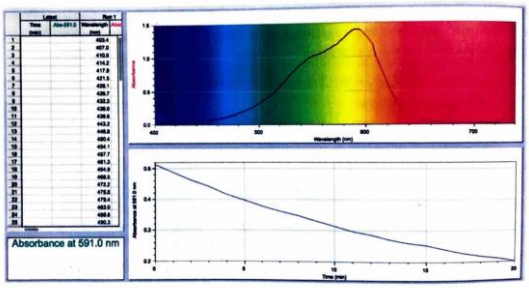
Slide 24: Find another example of a reaction whose rate can be measured through changes in volume of gas or change in mass.
What are some variables that would need to be controlled in the experimental setup you chose? How would you accomplish this?

Slide 25: Change in Light Transmission

- Can be used if one of _____ or products is colored
- Or if a color _____ can be used
- This produces absorption in visible region of _____ spectrum
- Colorimeter or _____ works by passing certain wavelengths of light through a solution and measuring amount of transmitted light
- As concentration of colored compounds increases, light absorbance _____ increases, so transmitted light decreases.
- Continuous readings can be made, so graph of absorbance (or _____) vs. time can be made

Slide 26: Change in Light Transmission Example

- Reaction between crystal violet and sodium hydroxide
- $CV^+ + OH^-$ CVOH
- Crystal violet is coloured
- Product is colorless
- Rate measured through a decrease in absorbance (increase in transmission)



Slide 27: Change in Concentration - Titration

- Measures the _____ of one of reactants or products by titrating against a known standard
- Samples are removed from the reaction at time _____, then analyzed by titration
- Quenching is often used (substance added to stop the reaction) to prevent the reaction from _____ after samples are drawn
- The _____ of iodine can be calculated by titration with sodium thiosulfate. At regular time intervals, samples are removed and quenched with sodium carbonate.

$$H_2O_2\,(aq) + 2\,H^+(aq) + 2\,I^-(aq) \rightarrow I_2\,(l) + 2\,H_2O(l)$$

Slide 28: Change In Concentration- Conductivity

- Total electrical conductivity depends on total _____ of ions and their charges.
- _____ can be measured using a conductivity meter to record changes as reactants are converted to products
- Calibration can be done to determine _____ of solutions from their conductivities
- _____ of solutions of known concentration can be measured and graphed to determine the concentration of unknown solutions from their conductivities
- A decrease in ions would cause a decrease in _____.

$$BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$$

Slide 29: Non-Continuous Method-Clock Reactions

- Measures the time it takes for a reaction to reach a fixed point ("end point")
- Time taken to reach this point for the same reaction under different conditions can be compared to determine how rates change
- This method only gives average rates of reaction over the time interval.
- What are the end points for these reactions?

$$Mg(s) + 2HCl \longrightarrow MgCl_2 + H_{2(g)}$$

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + H_2O(l) + S(s) + SO_2(g)$$

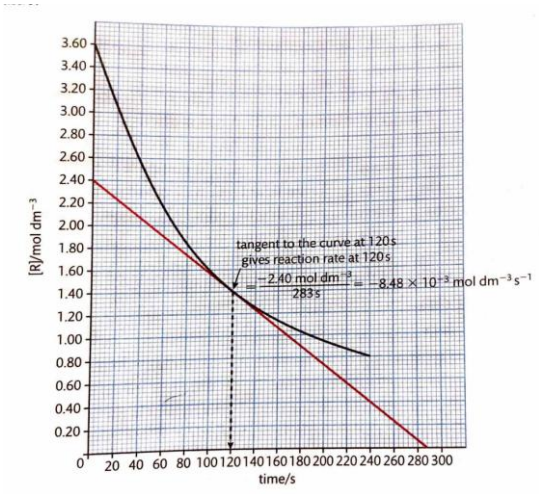
Slide 30: The steepness/gradient of a curve is a measure of the change in concentration per unit time (aka rate)

Since the gradient isn't constant, it can only be given for a specific time point or time frame.

Measured by drawing a tangent to the curve.

Extending the tangent to be as long as possible gives a more accurate value for the rate.

- Calculating _____ Rates
- **Although [R] is _____, by convention, rates are expressed as positive values**

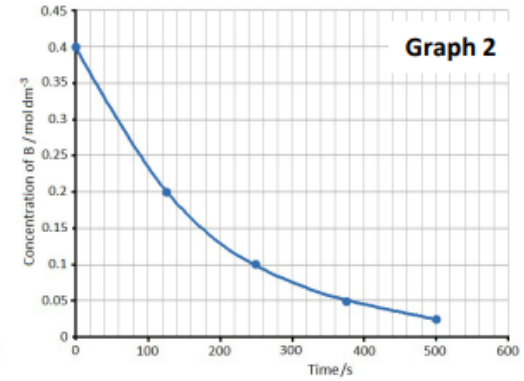


Slide 31: Calculating Average Rates

- Average change in _____ over a period of time.
- Average rate of _____ = Δ[P] or -Δ[R]
- Δ*t*
- Δ*t*
- This can be estimated from a given graph or _____ more precisely if given data in table format.

Slide 32: Example-Finding Instantaneous and Average Rates

- Find the average rate of the disappearance of B between 120 s and 380 s
- Find the rate of the disappearance of B at 245 s



Slide 33: Example-Calculating Rates from Experimental Data

- Draw a graph of concentration against time and determine the reaction rate
- After 60s
- After 120s
- Between 60s and 120s