IV) Factors Affecting Reaction Rates

Monday, September 11, 2017 2:21 PM

Think back to when we reacted a metal strip of magnesium with 2.0M HCl. What alterations could we make to increase the rate of the reaction?

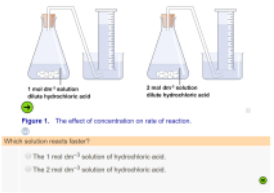
$Mg_{(s)} + 2HCl_{(aq)} \Rightarrow MgCl_{2(aq)} + H_{2(g)}$

- increase temperature
- increase the surface area (smaller pieces or powdered)
- increase [conc.]
- add a catalyst
- use a more reactive metal.

1. **The 'nature' of reactants influences reaction rate**:

- Some substances are simply more reactive than others; usually because their bonds will break at lower energy and/or it is easy to obtain correct collision geometry
- the number of **effective collisions**, and therefore the reaction rate, depend on the reactivity (the nature) of the reactants
- for example, magnesium is a more reactive metal than zinc "activity series" of metals

https://www.absorblearning.com/chemistry/demo/units/LR1503.html

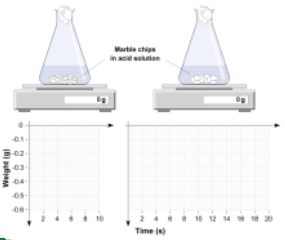


2. **Concentration influences reaction rate**:

- the greater the concentration of an aqueous or gaseous reactant, the more reactant particles per unit space, the more collisions there are between reactant particles, therefore the more **effective collisions** there will be, and hence an increased reaction rate
- for solutions, concentration refers to molarity.
- for gases, concentration refers to pressure.

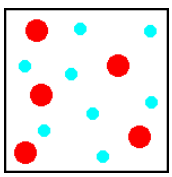
↳ different

https://www.absorblearning.com/chemistry/demo/units/LR1502.html#Increasingsurfacearea

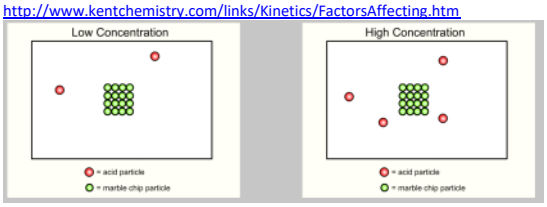


3. **When reactants are heterogeneous, surface area influences reaction rate**:

- heterogeneous reactions have reactants that are in different phases, meaning there is an interface between reactants
- if you can expand the size of the interface (increase the surface area), then there are more particles available to collide, resulting in more successful collisions, therefore effective collisions, therefore an increased reaction rate.
- a homogeneous reaction is one in which there is only one phase meaning the reactants are already as mixed as can be, meaning surface area has been maximized. ex. 2 (aq) solutions.
- for example, *solutions* are homogeneous mixtures that display maximum surface area (already mixed as much as possible – down to the particle)



http://www.kentchemistry.com/links/Kinetics/FactorsAffecting.htm



4. **Phase of reactants influences reaction rate**:

- reactions involving aqueous reactants are instantaneous and are the fastest reactions. What are the possible reasons that this is the case?

1) particles have ↑ KE due to free movement

2) surface area is maximized.

So, in general, aqueous state reactants give the highest reaction rates, followed by gases, because of large KE + no bonds then liquids, and the slowest are generally solids due to low KE (strong bonds) and low surface area.

5. **Catalysts and Inhibitors influence reaction rate**:

- catalysts increase reaction rate, not by producing more collisions, but by increasing the **probability** of an **effective collision**. Catalysts remain unchanged at the end of a reaction. ↳ lower threshold energy.
- inhibitors decrease reaction rate by inhibiting correct geometry and may or may not remain unchanged upon completion of the reaction. Where are inhibitors useful?

6. **Temperature influences reaction rate**: ↳ inc. KE

- an increase in temperature increases reaction rate
- suppose a reaction between two reactants has 100 collisions per second, and 10 are effective. What is the % of effective collisions? 10%
- if temperature is increased, the particles move faster, so there will be more collisions per second. Also, the collisions are harder due to the particles moving faster, so there will be a higher % of effective collisions. (↑ temp)

https://www.absorblearning.com/chemistry/demo/units/LR1504.html#Changingtemperature

effective. What is the % of effective collisions? 10 %

- if temperature is increased, the particles move faster, so there will be more collisions per second. Also, the collisions are harder due to the particles moving faster, so there will be a higher % of effective collisions. (↑ temp)

- thus, by increasing temperature, maybe there will now be 150 collisions per second, and now maybe 30 are effective. What is the new % of effective collisions?

20 %.

* ↑ temp ~10°C = double the rxn. rate

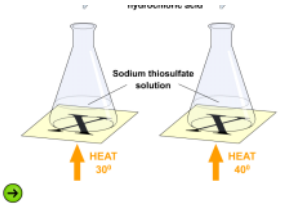


Figure 1. The effect of temperature on rate of reaction.

An increase in temperature increases reaction rate due to two factors. Explain each:

1) The particles are moving faster, more KE, more overall collisions, ∴ more effective collisions ∴ increased rxn rate. eg. 100 → 150

2) particles moving faster ∴ ↑KE ∴ they will collide with more force, which leads to more effective collisions ∴ ↑ rxn rate.

* more frequent + more forceful collisions

- a general rule for temperature change is that every 10 degree increase causes the reaction rate to double

Threshold Energy:

Remember, the threshold energy (TE) is the minimum amount of KE needed to cause reactant bonds to break + products to form.

What types of bonds would have smaller threshold energies? single bonds

What types of bonds would have larger TE? triple bonds (strongest i.e. hard to break)

An increase in concentration of a reactant causes an increase in reaction rate. Does an increase in concentration decrease the TE (cause the reactant bond energy to change)?

No. what ↑[conc.] does is allows for more collisions (and more effective) in order to reach the T.E.

Does an increase in surface are decrease the TE?

Does an increase in temperature decrease the TE?

No (same as above)

Factors that can change the TE:

∴ TE will be different ↑ or ↓

'Nature' of reactants is an actual change in reactant, so the bond energy of the reactants will be different, changing the TE.

Adding a catalyst will lower the TE as well, as a catalyst helps particles collide and bonds to break at a lower energy than usual, either due to a reactant collision with the catalyst, or excellent collision geometry. ↓TE.

Assignment 3: Factors Affecting Rate Exercises

*Note: When you are asked to explain something using '**collision theory**' you must comment on how overall collisions, effective collisions, and reaction rate are affected.*

1. When a 1.0g cube of Zn reacts with 1.0M HCl, the reaction rate is slower than when a 1.0g cube of Mg reacts with 1.0M HCl. What would be the reason for this?
2. If 1.0g pieces of copper are placed into beakers of 0.50M, 1.0M, and 1.5M nitric acid, explain using collision theory which reaction will proceed at the highest rate and why.
3. If 1.0g pieces of copper are placed into beakers of 0.50M and 1.0M nitric acid, and 1.0g of powdered copper samples are placed into beakers of 0.50M and 1.0M nitric acid, which reaction will be fastest, and why? Which will be slowest, and why?
4. Rank each reaction from fastest (1) to slowest (4).

a) $2NH_{3(l)} + 3F_{2(g)} \Rightarrow 2NF_{3(l)} + 3H_{2(g)}$

b) $2Ag^{+}_{(aq)} + SO_4^{2-}{}_{(aq)} \Rightarrow Ag_2SO_{4(s)}$

c) $Fe_{(s)} + H_2S_{(l)} \Rightarrow FeS_{(s)} + H_{2(g)}$

d) $HNO_{3(aq)} + H_2O_{(l)} \Rightarrow NO_3^{-}{}_{(aq)} + H_3O^{+}_{(l)}$

5. Hebden p.8 #13
6. If the rate of a slow reaction at 20°C is 0.040 mol/s, what is the rate at (a) 40°C? (b) 10° C?
7. Suppose a reactant has a triple bond. How will its threshold energy compare with a reactant that has a single bond? How will this affect reaction rate?
8. Hebden p.12 #21