

Chemical Kinetics

Measuring Reaction Rates

Name BETH "KEY"

1. A chemist wishes to determine the rate of reaction of zinc with hydrochloric acid. The equation for the reaction is:



A piece of zinc is dropped into 1.00 L of 0.100 M HCl and the following data were obtained:

Time	Mass of Zinc
0 s	0.016 g
4 s	0.014 g
8 s	0.012 g
12 s	0.010 g
16 s	0.008 g
20 s	0.006 g

- a) Calculate the rate of reaction in grams of Zn consumed per second.

$$\text{RATE} = - \frac{(0.006\text{g} - 0.016\text{g})}{(20\text{s} - 0\text{s})} = - \left(\frac{-0.010\text{g}}{20\text{s}} \right) = \boxed{5 \times 10^{-4} \frac{\text{g}}{\text{s}}}$$

- b) Calculate the rate of reaction in moles of Zn consumed per second.

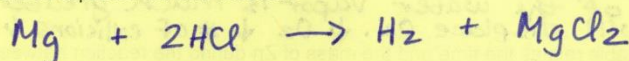
$$\frac{5 \times 10^{-4} \text{ g Zn/s}}{65.39 \text{ g/mol Zn}} = 8 \times 10^{-6} \text{ mol Zn/s}$$

- c) What will happen to the [H⁺] as the reaction proceeds? decrease

- d) What will happen to the [Cl⁻] as the reaction proceeds? stays the same

2. When magnesium is reacted with dilute hydrochloric acid (HCl), a reaction occurs in which hydrogen gas and magnesium chloride is formed.

- a) Write a balanced equation for this reaction.



- b) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the rate of consumption of HCl in moles/s.

$$5.0 \times 10^{-9} \frac{\text{mol Mg}}{\text{s}} \times \frac{2 \text{ mol HCl}}{1 \text{ mol Mg}} = \boxed{1.0 \times 10^{-8} \frac{\text{mol HCl}}{\text{s}}}$$

- c) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the rate of production of H₂ in g/s.

MOLE RATIO Mg : H₂ = 1 to 1

$$\text{RATE OF CONSUMPTION Mg} = \text{RATE OF PRODUCTION H}_2 = 5.0 \times 10^{-9} \frac{\text{mol}}{\text{s}}$$

- d) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the rate of production of H₂ in L/s (at STP).

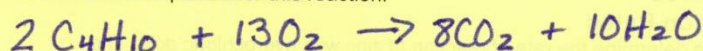
$$5.0 \times 10^{-9} \frac{\text{mol H}_2}{\text{s}} \times \frac{22.4 \text{ L}}{\text{mol H}_2 \text{ at STP}} = \boxed{1.1 \times 10^{-7} \frac{\text{L H}_2}{\text{s}}}$$

$\times 2.02 \text{ g/mol}$
 $\boxed{1.0 \times 10^{-8} \frac{\text{g}}{\text{s}}}$

- e) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the mass of Mg consumed in 5.0 minutes.

$$5.0 \times 10^{-9} \frac{\text{mol Mg}}{\text{s}} \times \frac{24.31 \text{ g Mg}}{1 \text{ mol Mg}} \times \frac{60 \text{ s}}{1 \text{ min}} \times 5.0 \text{ min} = \boxed{3.6 \times 10^{-5} \text{ g}}$$

3. Butane, commonly found in lighters, easily combusts.
a) Write a balanced equation for this reaction.



- b) If butane is consumed at an average rate of 0.116 grams/s, determine the rate of production of CO_2 in g/s.

$$\frac{0.116 \text{ g C}_4\text{H}_{10}}{\text{s}} \times \frac{1 \text{ mol C}_4\text{H}_{10}}{58.14 \text{ g}} \times \frac{8 \text{ mol CO}_2}{2 \text{ mol C}_4\text{H}_{10}} \times \frac{44.01 \text{ g CO}_2}{1 \text{ mol CO}_2} = \boxed{0.351 \frac{\text{g}}{\text{s}}}$$

6. The longer the *time of reaction*, the lower the *rate of reaction*.

7. Give some examples of situations where we might want to **increase** the rate of a particular reaction.

Production of gas in a car airbag.
Cooking food.
Neutralize stomach acid when you have an upset stomach.

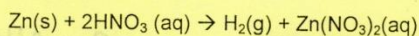
8. Give some examples of situations where we might want to **decrease** the rate of a particular reaction.

Decrease rate of combustion when a building is on fire.
Decrease rate of rusting on a car.
Decrease rate of tarnishing on silver jewelry/etc.
Digestion of food. (Enzymes act as a catalyst)

10. Give **two** reasons why *water* is effective at putting out fires. Use concepts learned in this unit so far.

- H_2O has a high heat capacity (ability to absorb energy) and will lower the rxn temperature decreasing the rate of rxn due to less energetic collisions.
- H_2O sprayed on the fire will vaporize. As it does the volume of the water vapor is much greater than liquid H_2O so it will displace O_2 . $\downarrow \text{O}_2 \downarrow \# \text{ of collisions} \downarrow \text{effective collisions}$ and slows rate of combustion.

11. The following table relates the time and the mass of Zn during the reaction between Zn and 0.5M HNO_3 :



Time	Mass of Zn (g)
0.0 s	36.2 g
60.0 s	29.6 g
120.0 s	25.0 g
180.0 s	22.0 g

- a) Calculate the reaction rate, in g/s, from time 0 to 60 s.

$$\text{RATE} = - \frac{(29.6 \text{ g} - 36.2 \text{ g})}{(60.0 \text{ s} - 0.0 \text{ s})} = - \left(\frac{-6.6 \text{ g}}{60.0 \text{ s}} \right) = \boxed{0.11 \frac{\text{g}}{\text{s}}}$$

- b) Calculate the reaction rate, in g/s, from time 120s to 180 s.

$$\text{RATE} = - \frac{(22.0 \text{ g} - 25.0 \text{ g})}{(180.0 \text{ s} - 120.0 \text{ s})} = - \left(\frac{-3.0 \text{ g}}{60.0 \text{ s}} \right) = \boxed{0.050 \frac{\text{g}}{\text{s}}}$$

- c) Explain why the rate in calculation "b" is less than that of calculation "a".

Concentration impacts reaction rates. As the reaction proceeds, the concentration of HNO_3 will decrease slowing the rate of reaction. Fewer HNO_3 molecules means less collisions which results in fewer effective collisions.