Hebden I1 - I4 (pg 1 - 11)

Chemistry 12

Reaction Kinetics I

Name:
Date:
Block:

1. **Monitoring and Calculating Rates**
2. **Measuring Rates**
3. **Factors Affecting Rates**

Monitoring and Calculating Reaction Rates

Example 1. Terry walked 19 km and Kevin walked 12 km. Who walked faster?

Cannot answer
↳ need time or speed

Example 2. Bobby drove 55 km/h and Dan drove 55 mph. Who drove faster? (1 mile = 1.6 km)

must be the same

What do we know?

Distance ✓

Time ✓

$\frac{55 \text{ miles}}{1 \text{ hour}} \times \frac{1.6 \text{ km}}{1 \text{ mile}} = 88 \text{ km/hr}$

∴ Dan drove faster

Example 3. In reaction A, 62.0 mL of H_2 gas was produced. In reaction B, 62.0 g of H_2 gas was produced. Both took place over exactly 60 seconds and were at STP conditions. Which reaction produced hydrogen gas at a slower rate?

What do we know?

Mass / volume (amount) ✓

Time ✓

Rxn A $\frac{62.0 \text{ mL}}{60 \text{ sec}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{2.0 \text{ g}_{H_2}}{1 \text{ mol}_{H_2}}$

$= 9 \times 10^{-5} \text{ g/s}$

Rxn B $\frac{62.0 \text{ g}}{60 \text{ sec}} = 1.03 \text{ g/s}$

∴ Rxn A is slower

Reaction Rate = $\frac{\text{change in a measurable quantity}}{\text{change in time}}$ ex. $\frac{\Delta \text{ mass}}{\Delta \text{ time}}$

Measurable quantity:
- distance
- mass
- concentration
- volume
- heat

Time:
- sec
- min
- hours

Given the following equation and data:

$$2\ HNO_{3\,(aq)} + Cu_{\,(s)} \rightarrow NO_{2\,(g)} + H_2O_{\,(l)} + CuNO_{3\,(aq)}$$

Mass of copper (g)	3.26	2.93	2.60
Time (min)	5.00	7.00	9.00

a) Does the reaction above have a constant rate? Explain why or why not.

$\frac{\Delta \text{ mass}}{\Delta \text{ time}} = \frac{2.93\text{g} - 3.26\text{g}}{7.00\text{min} - 5.00\text{min}} = \frac{-0.33\text{g}}{2.00\text{min}}$ ① → ②

$\frac{2.60\text{g} - 2.93\text{g}}{9.00 - 7.00\text{min}} = \frac{-0.33\text{g}}{2.00\text{min}}$ ② → ③

Yes, the rxn has a constant rate

b) Calculate the rate in units of grams of Cu consumed per minute.

$\frac{-0.33\text{g}}{2.00\text{min}} = \frac{-0.17\text{g}}{1.00\text{min}}$

0.17g/min consumed

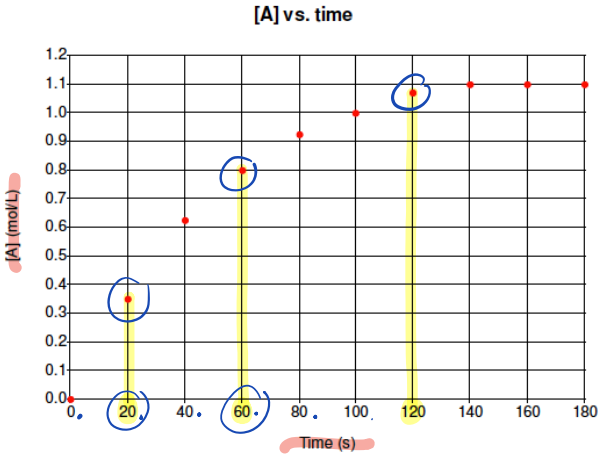
c) Calculate the rate in units of liters of NO_2 gas produced per minute at STP.

$\frac{0.17\text{g Cu}}{1\text{ min}} \times \frac{1\text{ mol Cu}}{63.5\text{ g Cu}} \times \frac{1\text{ mol } NO_2}{1\text{ mol Cu}} \times \frac{22.4\text{ L } NO_2}{1\text{ mol } NO_2} = 0.060\text{ L/min } NO_2$

d) How many liters of NO_2 gas would be produced in 22 seconds?

$\frac{0.060\text{ L } NO_2}{1\text{ min}} \times \frac{1\text{ min}}{60\text{ sec}} \times 22\text{sec} = 0.022\text{ L/22 sec } NO_2$

Consider the following graph:



1. Calculate the rate of reaction of the production of A in M/s for the time interval 20 – 60 s.

$\frac{\Delta [A]}{\Delta \text{ time}} = \frac{0.8 - 0.35\text{M}}{60 - 20\text{s}} = \frac{0.45\text{M}}{40\text{s}} =$

0.011M/s

2. Calculate the rate of reaction of the production of A in M/s for the time interval 60 – 120 s.

$\frac{\Delta [A]}{\Delta \text{ time}} = \frac{1.08 - 0.8\text{M}}{120 - 60\text{s}} = \frac{0.28\text{M}}{60\text{s}} =$

0.0047M/s

Measuring Reaction Rates

Changing rates of reactions can be found by **measuring a change** in one of the following properties:

1. Colour
2. Temperature
3. Pressure (gas)
4. Volume (gas)
5. Mass (solid)
6. Concentration (aqueous)
7. pH
8. Heat produced or consumed

(s) = solid
(aq) = aqueous
(l) = liquid
(g) = gas

State **two** different methods for measuring the rate of the reaction for the following reactions:

Example 1.

An iron nail in concentrated hydrochloric acid:

a. What is the balanced chemical equation? (HCl is colourless; $FeCl_2$ is yellow-orange)

$$Fe_{(s)} + HCl_{(aq)} \rightarrow FeCl_{2\,(aq)} + H_{2\,(g)}$$

Colourless — yellow-orange

b. What properties would/could you monitor?

- Colour - as the reaction progresses, the colourless solution will turn yellow-orange
- Pressure - as the reaction progresses, the pressure of H_2 will ↑

Example 2.

$$CH_3COOH_{(aq)} + NaHCO_{3\,(s)} \rightarrow NaCH_3COO_{(aq)} + CO_{2\,(g)} + H_2O_{(l)}$$

- Mass - as the rxn progresses, mass of $NaHCO_{3(s)}$ ↓
- Concentration - as the rxn progresses, $[CH_3COOH_{(aq)}]$ ↓

Consider the following reactions in open systems:

I. $2\,H_{2(g)} + O_{2(g)} \rightarrow 2\,H_2O_{(g)}$

II. $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

III. $CaO_{(s)} + SiO_{2(s)} \rightarrow CaSiO_{3(s)}$

IV. $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$

In which of the above could reaction rate be determined by a change in mass?

A. I ✗ B. II ✓ C. III ✓ D. IV ✓

Complete Reaction Rates Worksheet #1-5

moving ↑ molecules/particles ↗

KMT - Kinetic molecular theory

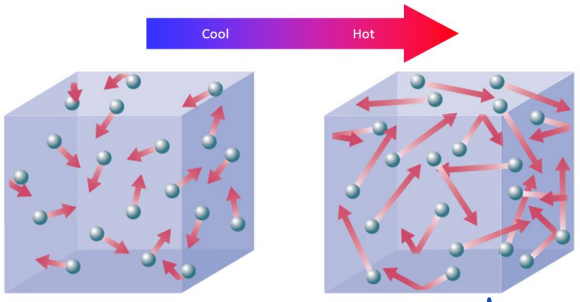
Factors Affecting Reaction Rates

It is one thing to **monitor/measure** the reaction rate. If the goal is to **change** the rate, the reactants must be manipulated.

$$A_{(s)} + B_{(l)} + C_{(aq)} + D_{(g)} \rightarrow E_{(?)}$$

In order to INCREASE/DECREASE the reaction rate, the following factors must be manipulated:

1. **Temperature**
   - When the temperature is increased, the particles have increased energy.
   - Will result in more frequent and more forceful collisions.
   - The time for the reaction to take place will reduce therefore the reaction rate will increase.

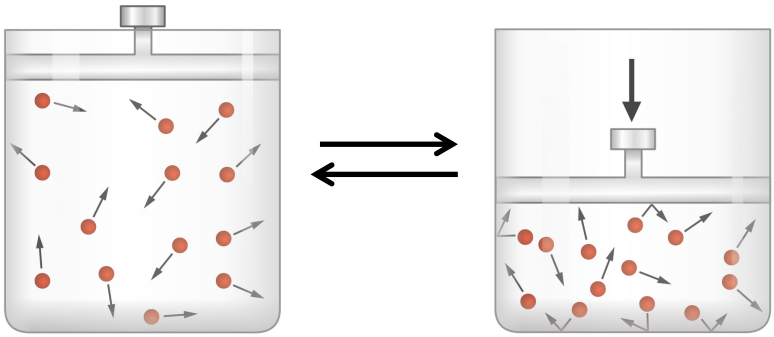


   - When temperature is decreased, the reaction rate will decrease.
   - A change in temperature affects solids, liquids and gases.

2. **Concentration**
   - To change the concentration of a reactant, particles are either added or removed.
   - As the reactant concentration increases, there are more particles to collide with each other.
   - The reaction rate will increase.

   - When the concentration decreases, the reaction rate will decrease.

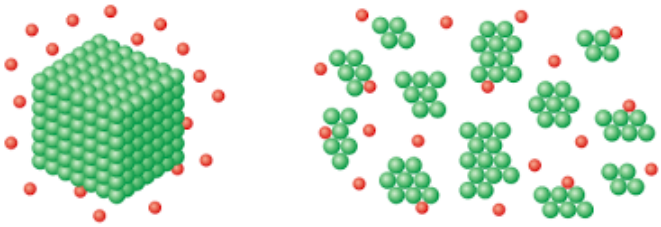
3. **Pressure/Volume**
   - An increase in pressure or a decrease in volume causes the gas particles to be closer together.
   - Increase in pressure or a decrease in volume causes the reaction rate to increase



   - Decrease in pressure or an increase in volume causes the reaction rate to decrease.

Complete Gas Properties Simulation Lab

4. **Surface Area**
   - With a greater the surface area exposed, there is an **increase in locations** where the reaction can take place.
   - Allows for increase in reaction rate.
   - Most relevant for reactants in the solid phase.



5. **Nature of the reactants**
   - Factors such as ionization energy, electronegativity, ionic and molecular polarity, size, complexity of structure, etc.
   - In general, at room temperature the rate of **aqueous > gas > liquid > solid**.

6. **Presence of a catalyst**
   - Substances that increase the rates of chemical reactions without being used up.
   - *(An inhibitor is a species that reduces the rate of a chemical reaction by combining with a reactant to stop it from reacting in its usual way.)*

The following reaction is taking place in a **closed** container at room temperature:

$$S_{(s)} + O_{2\,(g)} \rightarrow SO_{2\,(g)}$$

State what effect each of the following procedures will have on the rate of this reaction, and explain why the procedure has the stated effect.

a) The temperature is decreased.

↓ rate ; particles have less energy, resulting in less frequent collisions

b) More $O_{2\,(g)}$ is added in the same volume.

↑ rate ; more O_2 particles to react resulting in more collisions

c) The sulphur is ground up into a powder.

↑ rate ; more surface area (SA) where rxns can occur

d) The volume of the container is increased.

↓ rate ; less frequent collisions b/c O_2 is more spread out

Be careful when discussing MEASURING reaction rates and AFFECTING reaction rates.

Reaction 1: $A_{(s)} + B_{(aq)} \rightarrow C_{(aq)} + D_{(g)}$

- List two ways the reaction rate could be measured: ← measuring
  - Measure amount of $D_{(g)}$ being produced
  - Measure mass of $A_{(s)}$
- List two ways the reaction rate above could be increased: ← affecting
  - ↑ $[B_{(aq)}]$; more frequent collisions ; ↑ rate
  - heat it up
  - crush up $A_{(s)}$
  - Add catalyst

Reaction 2: $E_{(aq)} + F_{(aq)} \rightarrow G_{(aq)} + H_{(s)}$

- List two ways the reaction rate could be measured:
  - Weigh $H_{(s)}$ (should go up as rxn progresses)
  - Measure amount of $G_{(aq)}$ being produced
- List two ways the reaction rate above could be decreased:
  - Cool it down
  - dilute E and/or F
  - add an inhibitor

Complete Reaction Rates Worksheet #6-10