April 19, 2002

- **Exam #3**
  - ✓Solution Key will be online this weekend
  - ✓Graded exams returned next week
- **Kinetics**
  - ✓Assigned problems will be posted by the weekend
  - ✓Solutions to problems will be online next week
- ✓**Labs**

ALL LABS DUE NO LATER THAN:

MIDNIGHT, MAY 1st

1

But what about . . . Aluminum?

- One of the most abundant elements (8% of the Earth's crust)
- Found almost *exclusively* as Al^{3+} in nature
- Can't do electrolysis reduction in aqueous solution:

$$Al^{3+}(aq) + 3e^- \rightarrow Al(s) \qquad E^o = -1.706\ V$$

$$\boxed{2H_2O + 2e^- \rightarrow H_2 + 2OH^- \qquad E^o = -0.83\ V}$$

This is what happens!

2

The Hall-Hêroult Process

- 1885: Charles Martin Hall
  - ✓ 22 year-old student at Oberlin College
  - ✓ Electrolysis in a *molten salt* (Na_3AlF_6 at 1000 °C):

$$Al_2O_3\ (s) + 3C\ (s) \rightarrow 2Al\ (l) + 3CO\ (g)$$

  - ✓ Result: *inexpensive Al metal*
- **LOTS of energy is stored in Al metal**
  - ✓ ~3 billion pounds of Al thrown away each year
  - ✓ ΔG (Hall Process) = 300 - 600 kJ/mol Al
  - ✓ ΔG (Al Recycling) = 25 kJ/mol Al

3

Corrosion

- O_2 is a strong oxidizing agent and can oxidize many metals
- **Rust!** Fe + O_2
  - Solution? Coat Fe with a more easily oxidizable metal: Zn (galvanization)

$$E^o_{Zn} = -0.763 \text{ V versus } E^o_{Fe} = -0.440 \text{ V}$$

- Why doesn't Al oxidize ("rust")? $E^o_{Al} = -1.66$ V
  - It does! All Al metal has a thin coating of Al_2O_3
  - Al_2O_3 adheres to the surface and protects it

4

Chemical Kinetics

Chem 36

Spring 2002

What is it?

- **<u>Thermo:</u>** *Could the reaction happen?*
- **<u>Kinetics:</u>** *How does the reaction happen?*

Two Goals of Kinetics:

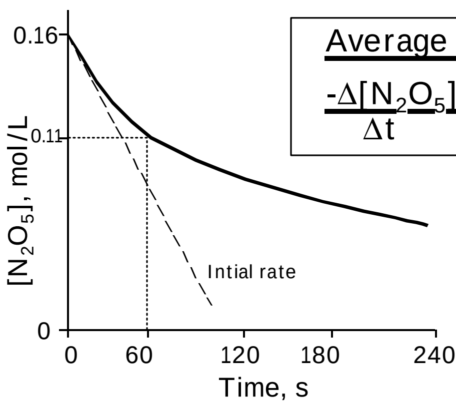
1. Determine the reaction pathway (*Mechanism*)
   - ✓What steps are involved in the reaction?
2. Control the *Rate* of the reaction
   - **Example:** $CO\ (g) + NO\ (g) \rightarrow CO_2\ (g) + \frac{1}{2}N_2\ (g)$
   - ✓Thermodynamically favored, but is *slow*

6

Reaction Rates

- Let's look at this reaction:

$2N_2O_5$ (g) ® $4NO_2$ (g) + O_2 (g)



Average Decomposition Rate =

$$\frac{-\Delta[N_2O_5]}{\Delta t} = \frac{-(0.11 - 0.16)}{60 - 0} = 8.3 \times 10^{-4} \text{ mol/L-s}$$

Instantaneous Rate:

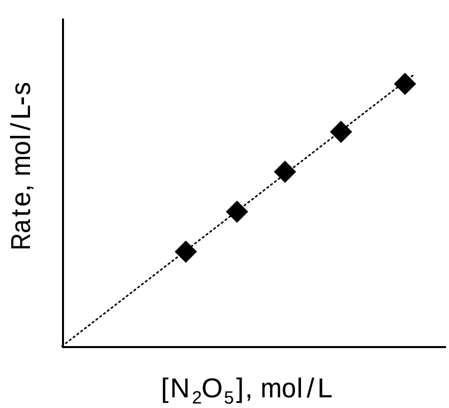
As $\Delta t \to 0$, rate becomes:

$$\frac{-d[N_2O_5]}{dt}$$ Slope at any time ***t***

7

Rate Laws

- Reaction rate varies with $[N_2O_5]$:



Linear relationship:

$\boxed{\textbf{Rate} = k[N_2O_5]}$

Rate constant (slope of line)

$$k = \frac{\text{rate}}{[N_2O_5]} = \frac{0.056 \text{ mol/L-min}}{0.160 \text{ mol/L}}$$

k = ***0.35 min^{-1}***

8

Rate Laws - In General

- For any reaction:

$$aA + bB \rightarrow \text{products}$$

We can write:

$$\boxed{\textbf{Rate = k[A]}^{\mathbf{m}}\textbf{[B]}^{\mathbf{n}}}$$

m = order of A in rxn

✓m + n = *overall* rxn order

✓m and n $\neq$ a and b

✓Products play no role in rate of reaction

9