All things being equal

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Jenison High School

- Jenison, Michigan
- Public High School – 1400 students
- Introductory Chemistry Class
- All students required to take the same chemistry class, no tracking.
- Designed inquiry labs to be accessible to all students

Jenison Public Schools

All things being equal

Description: To study equilibrium and understand what happens to the concentration of reactants and products in an equilibrium system.

Time: 3 days for activity (1 day for each part)

- Can be used in secondary or post secondary level.
  - Grand Valley State University, Allendale, MI
  - University of Cape Town, South Africa

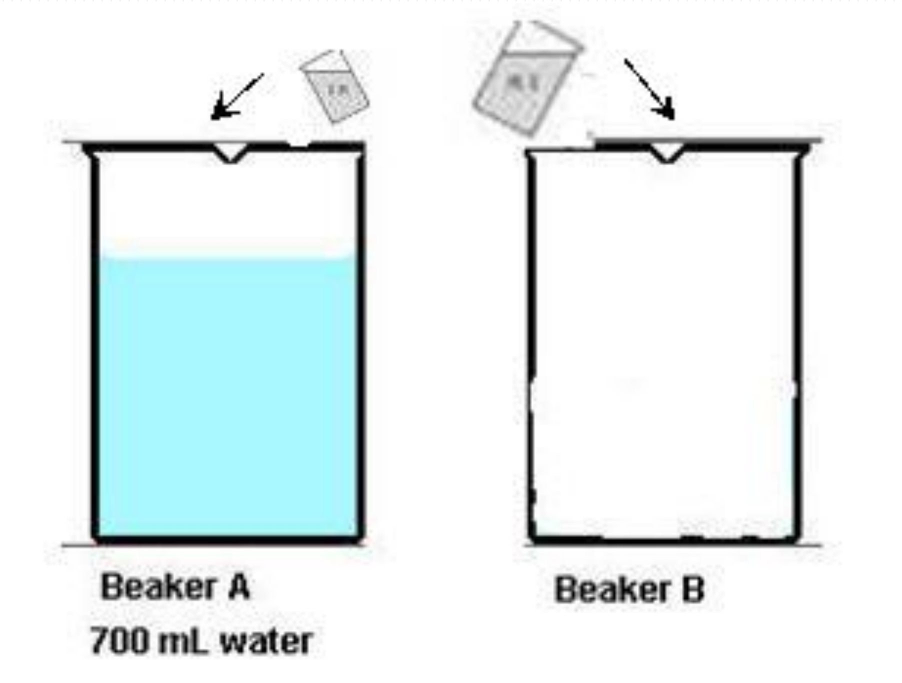
Student misconceptions

1) Many students erroneously assume that the condition of equilibrium means equal concentrations of reactants and products.
2) Students do not easily grasp the notion that one can approach an equilibrium state from either direction.

J. Orvis and J.A. Orvis, (2005). Throwing paper wads in the chemistry classroom, *Journal of College Science Teaching*, 35(3), pages 23-25.

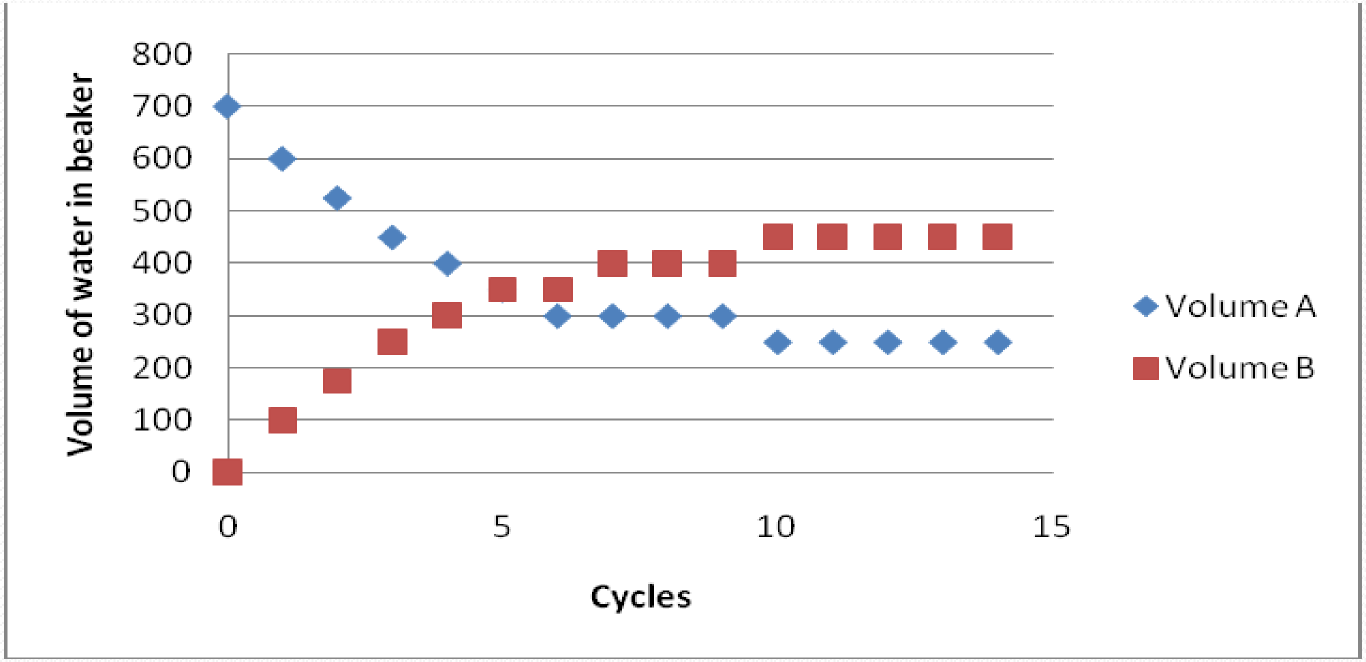
Part I: Investigating a simple physical equilibrium system

Objective: To study equilibrium and understand what happens to the concentration of reactants and products in an equilibrium system.



Sample Graph

Beaker A and B with 700 ml of water



Sample Questions

- On the graph, circle the points where you believe the reaction has reached equilibrium.
- What cycle(s) of the experiment did the reaction reach equilibrium? B) How do you know?
- Are the volume of liquid in Beaker A and Beaker B the same at equilibrium?
- Based on the graph, what must be the same in order for a reaction to be at equilibrium?

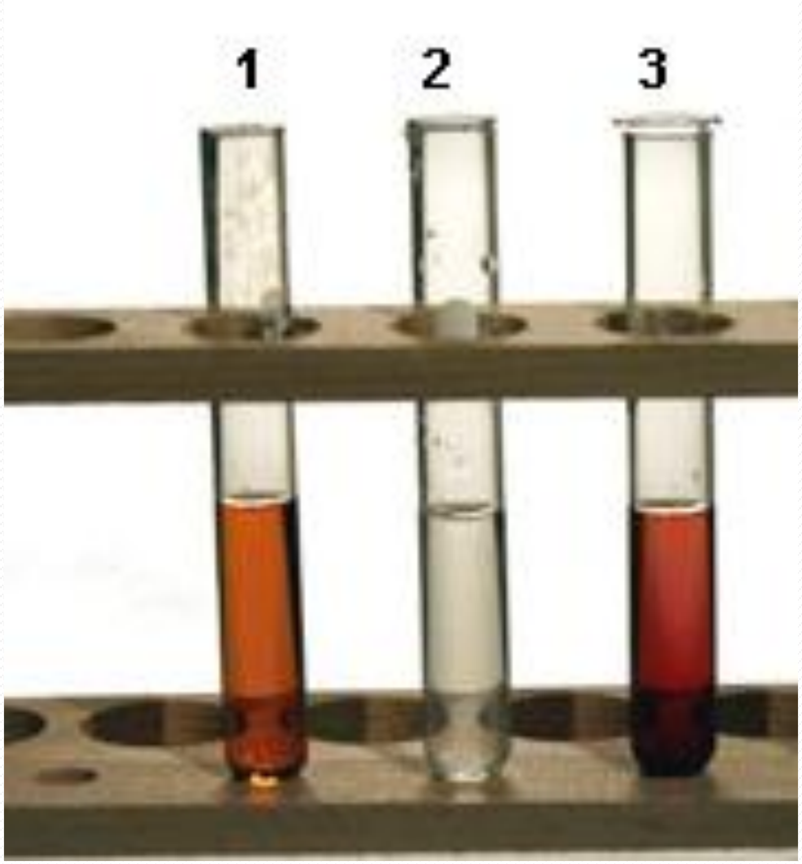
PART II: A macroscopic view of a chemical equilibrium system.

Objectives: Study a macroscopic equilibrium system.

$$Fe^{+3} \quad + \quad SCN^{-} \quad \rightleftharpoons \quad FeSCN^{+2}$$

light orange	Colorless	Red

- Test Tube #1: $Fe(NO_3)_3$
- Test Tube #2: KSCN
- Test Tube #3: $Fe(SCN)^{+2}$



Part III: A Particulate View of a Chemical Equilibrium System

- Be able to write an equilibrium constant and what the value means.
- Explain how a reversible reaction can be different colors and still at equilibrium (LeChatelier's Principle).
- Demonstrate a particulate understanding of LeChatelier's Principle.

Equilibrium constant K

1. Fe^{+3} + SCN^- ⇌ $FeSCN^{+2}$

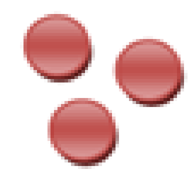
light orange — Colorless — Red

2. $K = \frac{[FeSCN^{+2}]}{[Fe^{+3}] \times [SCN^-]}$

Calculate K for the following

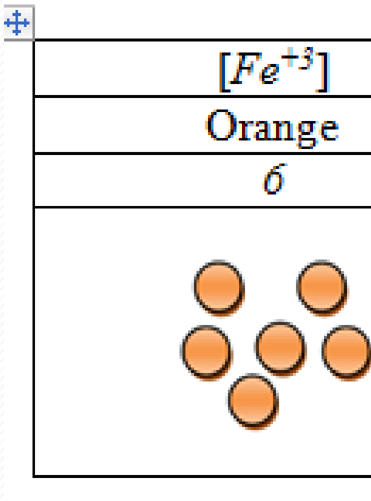
Fe^{+3} + SCN^{-} ⇌ $FeSCN^{+2}$

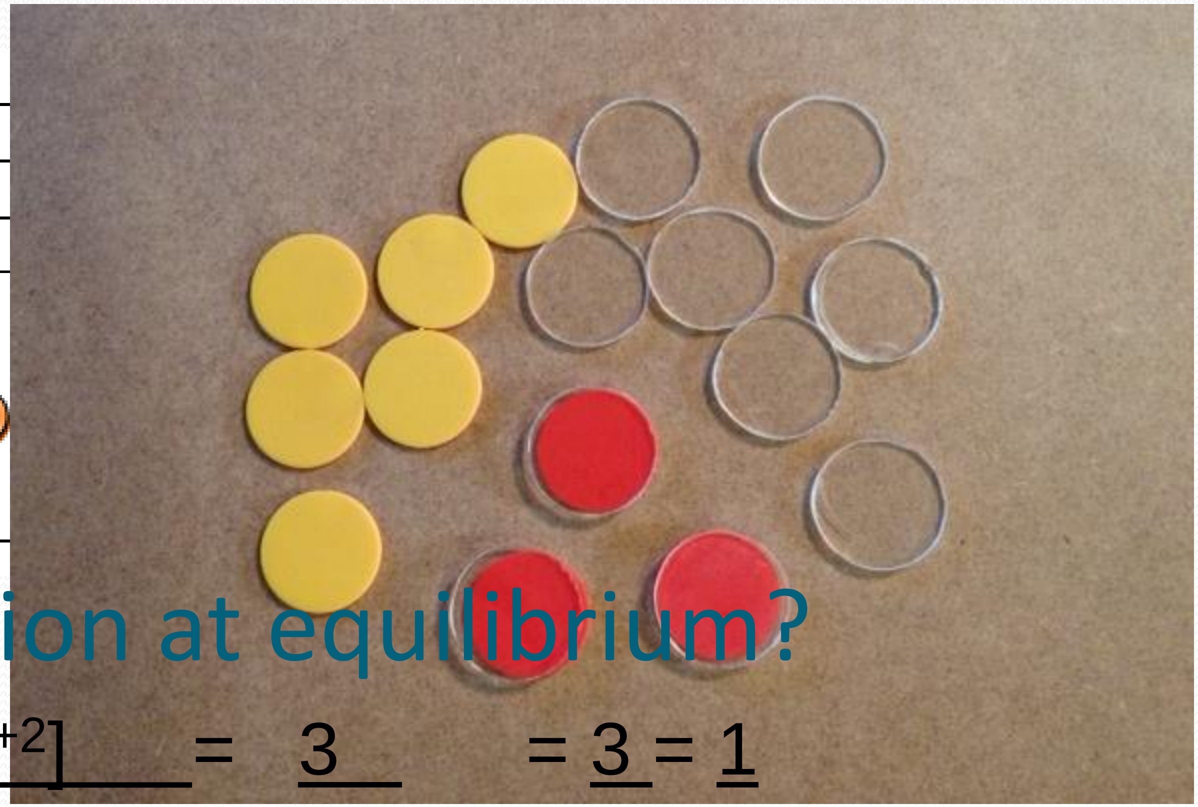
Orange Colorless Red

$[FeSCN^{+2}]$
Red Particles
3


$$= \frac{1}{4}$$

Add 4 orange chips and 1 colorless chips to the system





Is the reaction at equilibrium?

$$K = \frac{[FeSCN^{+2}]}{[Fe^{+3}] \times [SCN^{-}]} = \frac{3}{(6 \times 7)} = \frac{3}{42} = \frac{1}{14}$$

Not at equilibrium, new K value doesn’t equal ¼.

Do you need more reactants or products to reach equilibrium?

- The reaction needs to produce more products.

Covert reactants into products until the reaction is at equilibrium.

[SCN

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5

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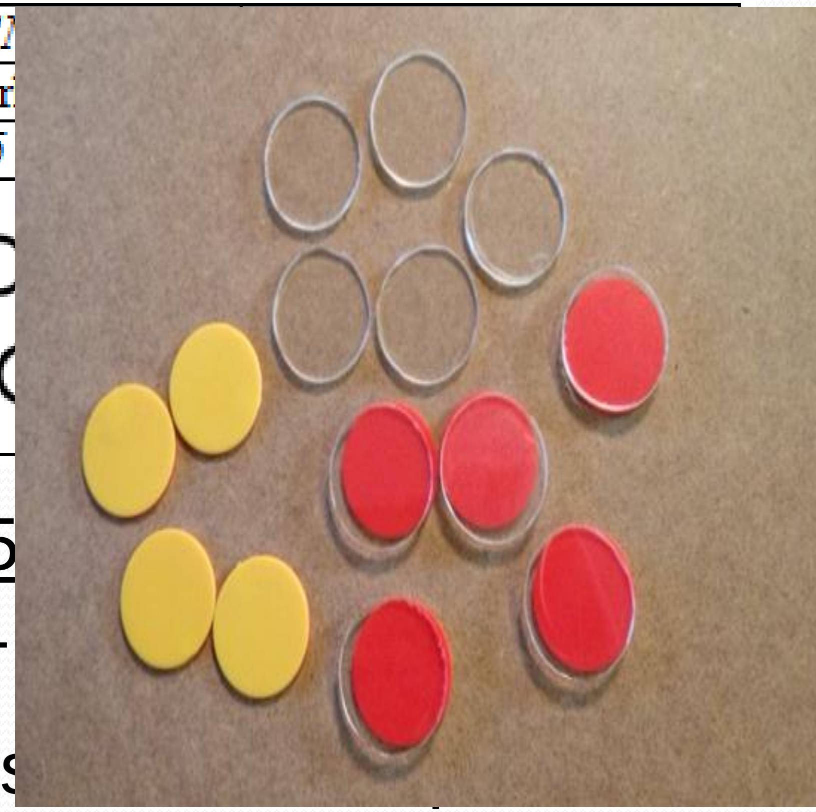
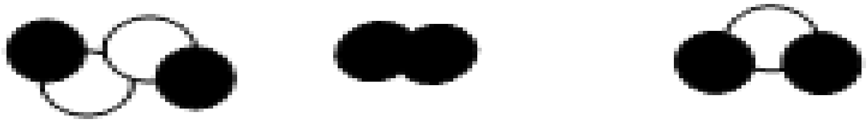


Assessment questions

- $S_2Cl_2(g) + Cl_2(g) \rightleftharpoons 2SCl_2(g)$ $K_{eq} = 4$



A. $K_{eq} = \frac{2[SCl_2]}{[S_2Cl_2][Cl_2]}$

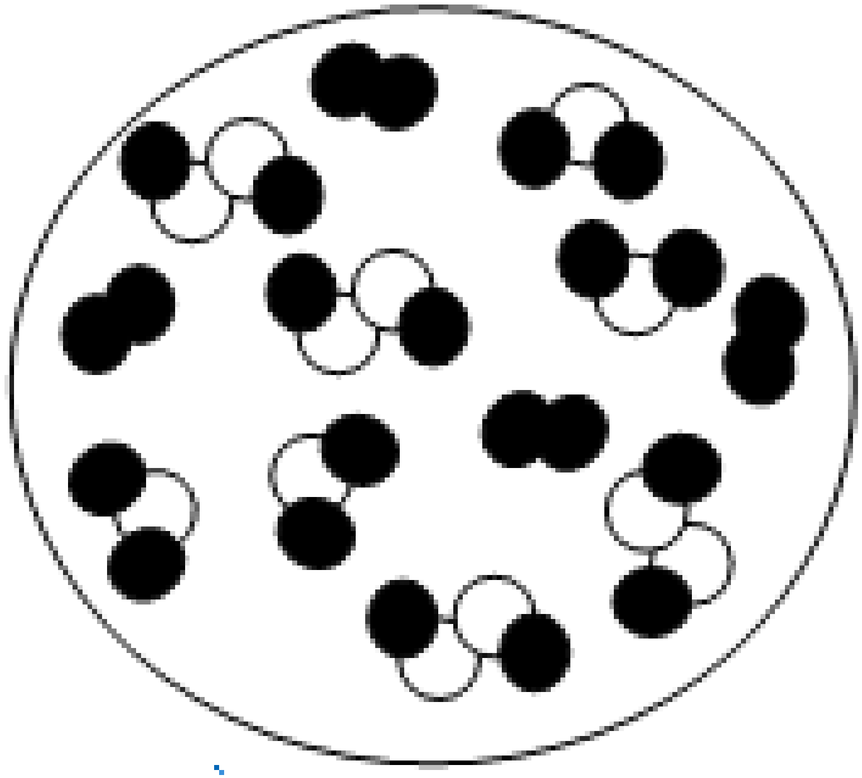
B. $K_{eq} = \frac{[SCl_2]}{[S_2Cl_2]+[Cl_2]}$

C. $K_{eq} = \frac{[S_2Cl_2][Cl_2]}{[SCl_2]^2}$

D. $K_{eq} = \frac{[SCl_2]^2}{[S_2Cl_2][Cl_2]}$

E. $[S_2Cl_2][Cl_2][SCl]^2$

Examine the figure, and determine if the system is at equilibrium. If it is not, in which direction will it proceed to reach equilibrium?



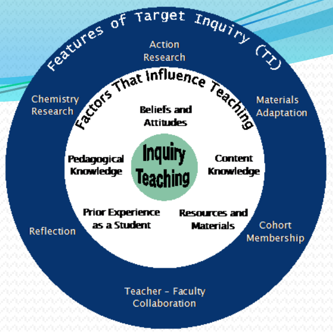
Materials

- Two-color counting chips red and yellow
  - www.educationworkshawaii.com (#LER7566)
  - Amazon
- Colorless chips: Plexiglass, overhead acetates

Student comments

- “I could see the reactions happen, what there was more or less of.”
- “It helped to be able to use the paper with the chips and actually see what we were doing with the reactants and products and how it affected equilibrium.”
- “It was cool to see how the variable used can change the equilibrium.”
- “I was able to understand the changes in the ratio and how concentrations are key.”

Questions?



Acknowledgements

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