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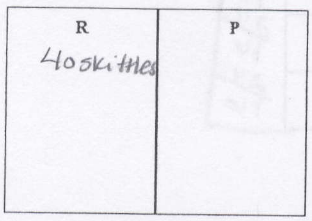
Skittles Equilibrium Lab

Materials:

- 40 skittles candies for each group
- 1 blank sheet of paper

Introduction:

For this lab, we will be using skittles candies to represent chemical compounds undergoing a reaction. In groups of two, draw a line down the middle of a sheet of paper. Label the left side of the paper "R" for reactants and the right side "P" for products.



You will be performing all of your reactions on this paper according to the following equation:

½ → 20 skittles
← 10 skittles

$$R \rightleftharpoons P$$

To represent molecules that are reactants, you will put skittles on the reactant side of the paper; products will be skittles on the product side of the paper. Reactions will be represented by moving a skittle from one side of the paper to the other.

This activity will help you to model the following three key concepts:
(Please keep these in mind as you work and fill in the blanks as you determine the answers)

Q1. At equilibrium, the rate of the forward reaction ___equal___ the rate of the reverse reaction.

Q2. Under the same conditions, at equilibrium the concentrations of both reactants and products remain ___the same___.

Q3. Equilibrium may be approached from different starting points, but at equilibrium the ratio of products to reactants will be ___constant___.

Part I

For this part, one person should take care of moving skittles from the reactant side and the other should take care of the product side of the paper.

1. Start with 40 skittles on the reactant side of the paper.
2. Each round, you will be exchanging skittles between R and P.
3. For each round, R should move half of his/her skittles to the P side. P should move one fourth of theirs to the R side. (If you end up with a decimal for the number to exchange, you should round up.)
4. At the end of each round, count the skittles on each side of the paper and keep track of the numbers in a table.

Round	R	P	P/R
0	40	0	0/40
1	25	15	15/25
2	19	21	21/19
3	16	24	24/16
4	16	24	24/16
5	16	24	24/16
6	16	24	24/16
7	16	24	24/16
8	16	24	24/16
9	16	24	24/16
10	16	24	24/16

\# 1 → 1/2 ← 1/4

\# 2 → ← 1/4

5. Keep going for 10 rounds.
6. At the end of 10 rounds, calculate the ratio of products to reactants.

1.5

ratio = P/R

Part II

1. Part two is the exact same as part one except for the starting amounts of reactants and products. Choose a number of skittles to put in the reactant side and put the rest in the products side.
2. Start exchanging the skittles by following the same rules from step 3 in part one. Keep track of the number of candies on each side after each transaction in another table.
3. Keep going for 10 rounds.
4. At the end of 10 rounds, calculate the ratio of products to reactants.

Part III

1. Part three follows the same rules as parts one and two. Except you will need to join up with another group for this part because it requires more total skittles.
2. Start again with 40 Products and no reactants
3. One of the two groups exchange for five rounds and calculate the ratio of products to reactants.
4. After the fifth round, add another group's candies to the reactant side of the equation and continue to exchange for another 5 rounds.
5. At the end of the last round, calculate the ratio of products to reactants.

Q4. What happened after several rounds of reaction in each of the three parts?
Q5. Why do you think this phenomenon is often described as "dynamic" equilibrium?
Q6. Do you think that temperature would affect these systems in any way? If yes, how? If no, why not?

Name ____________________ Date ____________ Class ____________

16–2 Practice Problems

1. Write the equilibrium expression for the oxidation of hydrogen to form water vapor.
$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$

2. Write the equilibrium expression for the formation of nitrosyl bromide.
$2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g)$

3. Write the equilibrium expression for the following reaction.
$NO(g) + O_3(g) \rightleftharpoons O_2(g) + NO_2(g)$

4. Write the equilibrium expression for the following reaction.
$CH_4(g) + Cl_2(g) \rightleftharpoons CH_3Cl(g) + HCl(g)$

5. Write the equilibrium expression for the following reaction.
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

6. Write the equilibrium expression for the following reaction.
$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

7. Write the equilibrium expression for the combustion of ethane at high temperature.
$2C_2H_6(g) + 7O_2(g) \rightleftharpoons 4CO_2(g) + 6H_2O(g)$

8. Write the equilibrium expression for the decomposition of ethane.
$C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$

9. Write the equilibrium expression for the following reaction.
$Hg(g) + I_2(g) \rightleftharpoons HgI_2(g)$

10. Write the equilibrium expression for the following reaction.
$SnO_2(s) + 2CO(g) \rightleftharpoons Sn(s) + 2CO_2(g)$

11. Write the equilibrium expression for the following reaction.
$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

12. Write the equilibrium expression for the following reaction.
$FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$

13. Write the equilibrium expression for the following reaction.
$KCl(l) + Na(l) \rightleftharpoons NaCl(l) + K(g)$

14. Write the equilibrium expression for the following reaction.
$NaCl(s) + H_2SO_4(l) \rightleftharpoons HCl(g) + NaHSO_4(s)$

15. Write the equilibrium expression for the following reaction.
$P_4(s) + 6NO(g) \rightleftharpoons P_4O_6(s) + 3N_2(g)$

16. Write the equilibrium expression for the following reaction.
$2NO(g) + 2H_2(g) \rightleftharpoons N_2(g) + 2H_2O(l)$

16–2 Practice Problems (continued)

17. Write the equilibrium expression for the following reaction.
$H_2CO_3(s) \rightleftharpoons H_2O(l) + CO_2(g)$

18. Write the equilibrium expression for the following reaction.
$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(l)$

19. At 740°C, $K_{eq} = 0.0060$ for the decomposition of calcium carbonate ($CaCO_3$), which is described by the equation
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
Find Q and predict how the reaction will proceed if $[CO_2] = 0.0004\ M$.

20. For the reaction
$CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$
$K_{eq} = 5.10$ at 527°C. If $[CO] = 0.15\ M$, $[H_2O] = 0.25\ M$, $[H_2] = 0.42\ M$, and $[CO_2] = 0.37\ M$, calculate Q and determine how the reaction will proceed.

21. At 340°C, $K_{eq} = 0.064$ for the reaction $Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$
Given that $[H_2] = 0.45\ M$ and $[H_2O] = 0.37\ M$, find Q and predict how the reaction will proceed.

22. At 2130°C, $K_{eq} = 0.0025$ for the reaction
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
If $[N_2] = 0.81\ M$, $[O_2] = 0.75\ M$, and $[NO] = 0.030\ M$, find Q and determine the direction in which the reaction will proceed.

23. Ammonia is synthesized from nitrogen and hydrogen in the reaction
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
At 500°C, the equilibrium constant for this reaction is 0.080. Given that $[NH_3] = 0.0596\ M$, $[N_2] = 0.600\ M$, and $[H_2] = 0.420\ M$, find Q and predict how the reaction will proceed.

24. The decomposition of antimony pentachloride ($SbCl_5$) is described by the equation
$SbCl_5(g) \rightleftharpoons SbCl_3(g) + Cl_2(g)$
At 448°C, the equilibrium constant for this reaction is 0.0251. What is the value of Q if $[SbCl_5] = 0.095\ M$, $[SbCl_3] = 0.020\ M$, and $[Cl_2] = 0.050\ M$? How will this reaction proceed?

25. At 1000°C, $K_{eq} = 1.0 \times 10^{-13}$ for the decomposition of hydrofluoric acid (HF), as described in the reaction
$2HF(g) \rightleftharpoons H_2(g) + F_2(g)$
If $[HF] = 23.0\ M$, $[H_2] = 0.540\ M$, and $[F_2] = 0.380\ M$, determine the value of Q and predict how the reaction will proceed.

26. At 1227°C, K_{eq} for the following reaction is 0.15.
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$
If $[SO_2] = 0.344\ M$, $[O_2] = 0.172\ M$, and $[SO_3] = 0.056\ M$, find Q and determine how the reaction will proceed.

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quiz Friday

Keq

(1) Cross out solids + liquids

(2) moles from balanced equation become exponent

16-2 PP

(1) $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$

$$K_{eq} = \frac{[H_2O]^2}{[H_2]^2[O_2]}$$

(2) $2NO_{(g)} + Br_{2(g)} \rightleftharpoons 2NOBr_{(g)}$

$$K_{eq} = \frac{[NOBr]^2}{[NO]^2[Br_2]}$$

heterogeneous equilibria

(10) The concentration of a pure solid or liq. does not Δ during reaction

~~$SnO_2(s)$~~ $+ 2CO_{(g)} \rightleftharpoons$ ~~$Sn_{(s)}$~~ $+ 2CO_{2(g)}$

$$K_{eq} = \frac{[CO_2]^2}{[CO]^2}$$

(12) ~~$FeO_{(s)}$~~ $+ CO_{(g)} \rightleftharpoons$ ~~$Fe_{(s)}$~~ $+ CO_{2(g)}$

$$K_{eq} = \frac{[CO_2]}{[CO]}$$

Equilibrium Expression

$$K_{eq} = \frac{[P]}{[R]}$$

Ratio of products to reactants is constant @ equilibrium

Keep gases and aqueous

$K_{eq} > 1$ more products than reactants @ equilibrium

$K_{eq} < 1$ more reactants than products

$K_{eq} = 1$ R=P

(13) $KCl_{(l)} + Na_{(l)} \rightleftharpoons NaCl_{(l)} + K_{(g)}$

$$K_{eq} = \frac{[K]}{1}$$

(14) ~~$NaCl_{(s)}$~~ + ~~$H_2SO_{4(l)}$~~ $\rightleftharpoons HCl_{(g)}$ + ~~$NaHSO_{4(s)}$~~

$$K_{eq} = [HCl]$$

(15) ~~$P_{4(s)}$~~ $+ 6NO_{(g)} \rightleftharpoons$ ~~$P_4O_{6(s)}$~~ $+ 3N_{2(g)}$

$N_2 = 0.3M$
$NO = 1.2M$

$$K_{eq} = \frac{[N_2]^3}{[NO]^6} = \frac{0.027}{2.98} = 9.04 \times 10^{-3}$$

$[R] > [\text{products}]$

(16) $2NO_{(g)} + 2H_{2(g)} \rightleftharpoons N_{2(g)}$ + ~~$2H_2O_{(l)}$~~

$$K_{eq} = \frac{[N_2]}{[NO]^2[H_2]^2}$$

(17) ~~$H_2CO_{3(s)}$~~ $\rightleftharpoons$ ~~$H_2O_{(l)}$~~ $+ CO_{2(g)}$

$$K_{eq} = [CO_2]$$

(18) $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)}$ + ~~$H_2O_{(l)}$~~

$$K_{eq} = \frac{[CO]}{[CO_2][H_2]}$$

(19)

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$K_{eq} = \frac{[P]}{[R]}$ @ equilibrium

Disrupt eq

add more reactants or products

↑ temp ↓

↑ pressure, ↓

open container if closed

the value of K_{eq} is affected

When rxn not @ equilibrium ⇒ new value $\frac{[P]}{[R]} \Rightarrow Q$

RXN NOT @ EQ