Continuation of Chapter 6

Thursday, Feb 28, 2013

Problem #2, page 272

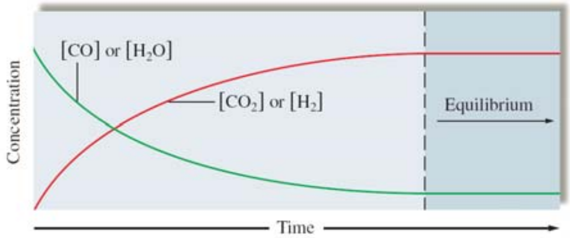
$N_2(g) + 3H_2(g) = 2NH_3(g)$ + energy

- This reaction is exothermic: gives off heat
- Number of moles of gas decreases during forward reaction
- Discuss with partner: How will changes in pressure and temperature affect the amount of ammonia produced

Problem 2, p. 272
To obtain the highest yield of ammonia:

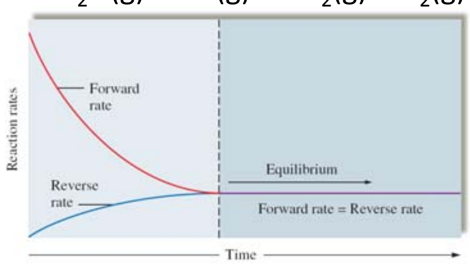
25%	1. Use high T and P
25%	2. Use low T and P
25%	3. Use high T and low P
25%	4. Use low T and high P

Rates of change:
$H_2O(g) + CO(g) = CO_2(g) + H_2(g)$



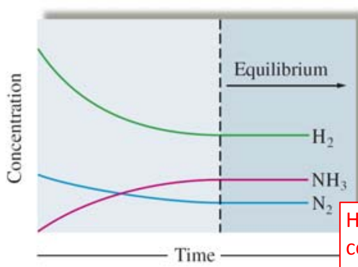
How do the rates change with time?
How are the rates for change in products and reactants related?

Forward vs Reverse rate:
$H_2O(g) + CO(g) = CO_2(g) + H_2(g)$



How do the relative forward and reverse rates change with time?

Another example:
$N_2(g) + 3H_2(g) = 2NH_3(g)$



How are the rates consistent with the reaction coefficients?

The Equilibrium Constant

$N_2(g) + 3\ H_2(g)\ =\ 2NH_3(g)$

Concentrations of gases can be measured either in mol/L or in atm. In mol/L:

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Products in numerator

Reactants in denominator

The Equilibrium Constant

$N_2(g) + 3\ H_2(g)\ =\ 2NH_3(g)$

Exponents come from reaction coefficients

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Multiply by a constant

$2N_2(g) + 6\ H_2(g)\ =\ 4NH_3(g)$

$$K = \frac{[NH_3]^4}{[N_2]^2[H_2]^6}$$

If we multiply the reaction by a constant α

$$K \Rightarrow K^{\alpha}$$

If we reverse the reaction

$$K \Rightarrow \frac{1}{K}$$

Are K and K_p numerically equal?

$N_2(g) + 3\ H_2(g) = 2NH_3(g)$

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} \qquad K_p = \frac{P_{NH_3}^2}{P_{N_2} P_{H_2}^3}$$

Related to the change in gas moles in the reaction.

In general $P_i = \frac{n_i RT}{V} = \left(\frac{n_i}{V}\right) RT = C_i RT = [i] RT$

$$K_p = \frac{P_{NH_3}^2}{P_{N_2} P_{H_2}^3} =$$

For the reaction
$N_2(g) + O_2(g) = 2\ NO(g)$
Does $K_p = K$?

1. Yes
2. No

Hanson Activity 15-2

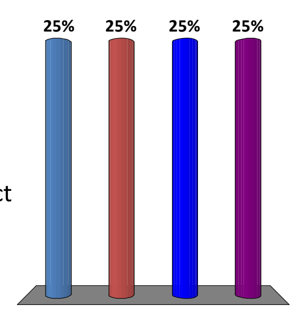
- Discuss Key Questions 1-7 of Activity 15-2, page 274, with your partner for five minutes.
- The clicker quiz will commence in 5 minutes

Clicker quiz

- You may refer to your Hanson workbook
- Answer the questions individually
- In each case indicate the best answer
- No paper responses will be accepted

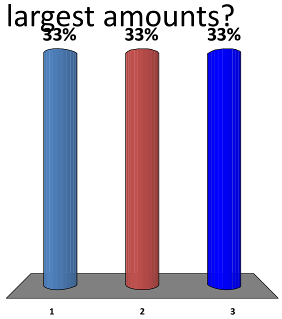
In forming a reaction quotient Q, what items go into the denominator?

1. Reactant concentrations
2. Product concentrations
3. Combination of reactant and product concentrations
4. The equilibrium constant



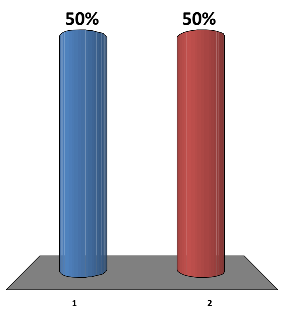
When the equilibrium constant is large, what will be present at equilibrium in the largest amounts?

1. Reactants
2. Products
3. Depends on the temperature



If Q is larger than K, the reaction will:

1. Proceed in the forward direction as written
2. Proceed in the reverse direction as written



Questions about the Key Questions?

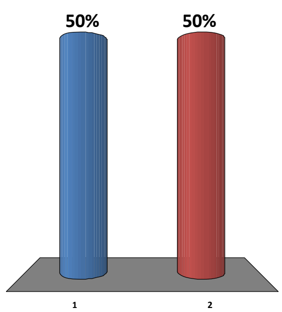
- In the model, page 274, where did the units go in K?
- Discuss activities, Section 6.4
- Reference states: P_{ref}= 1 atm and $[i]_{ref}$ = 1M
- Substituion of P_i /P_{ref} and $[i]/[i]_{ref}$ into the equilibrium constant makes it appear unitless, but with the same numeric value.

Exercises at Projector

- Exercise 1
- Exercise 2: with your parnter: what about the solid?
- With your partner, do Exercise 3

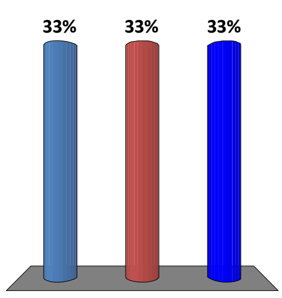
Which one is K_P for $2NO(g) + Cl_2(g) = 2\ NOCl(g)$?

1. $P^2_{NOCl}/P_{NO}{}^2P_{Cl2}$
2. $P_{NO}{}^2P_{Cl2}/P^2_{NOCl}$



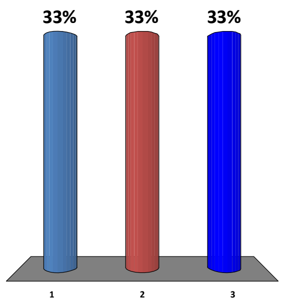
What is the value of K_P?

1. $1.6 – 1.8 \times 10^3$
2. $1.8 – 2.0 \times 10^3$
3. $2.0 – 2.3 \times 10^3$



GotIt: In the flask at equilibrium, there is:

1. Mostly HI
2. Mostly H_2 and I_2
3. Approx equal concentrations of all three species



Activity 15-4 (RICE Table) at the projector

- What is the reaction:

$3\ H_2(g) + N_2(g) = 2\ NH_3(g)$ (R)

- What are the initial amounts or concentrations?
- **3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)**

Activity 15-4 (RICE Table) at the projector

- What is the reaction:

$3\ H_2(g) + N_2(g) = 2\ NH_3(g)$ (R)

- **3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)**
- What are the changes?
- -3x -x +2x (C)

Activity 15-4 (RICE Table) at the projector

- What is the reaction:

$3\ H_2(g)$ + $N_2(g)$ = $2\ NH_3(g)$ (R)

- **3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)**
- -3x -x +2x (C)
- What are the amounts at equilibrium or completion of the reaction?
- **3.5 – 3x mol 1.5 – x 2x (E)**

Activity 15-4 (RICE Table) at the projector

$3\ H_2(g)$ + $N_2(g)$ = $2\ NH_3(g)$ (R)

3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)

-3x -x +2x (C)

3.5 – 3x mol 1.5 – x 2x (E)

- Volume = 1.00 L, T = 700°C
- At equilibrium: $[NH_3]$ = 0.540 M
- What are the changes in terms of x? (C)

Activity 15-4 (RICE Table) at the projector

$3\ H_2(g)$ + $N_2(g)$ = $2\ NH_3(g)$ (R)

3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)

-3x -x +2x (C)

3.5 – 3x mol 1.5 – x 2x (E)

- Volume = 1.00 L, T = 700°C
- At equilibrium: $[NH_3]$ = 0.540 M
- What are the changes in terms of x? (C)
- Solve for x, given that $[NH_3]$ = 0.540 *M*
- X = 0.270 *M*

Activity 15-4 (RICE Table) at the projector

$3\ H_2(g)$ + $N_2(g)$ = $2\ NH_3(g)$ (R)

3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)

-3x -x +2x (C)

3.5 – 3x mol 1.5 – x 2x (E)

- Volume = 1.00 L, T = 700ºC
- At equilibrium: $[NH_3]$ = 0.540 M
- X = 0.270 *M*
- *What are the three equilibrium concentrations?*
- ***2.69 M, 1.23 M, and 0.540 M.***

Activity 15-4 (RICE Table) at the projector

$3\ H_2(g)$ + $N_2(g)$ = $2\ NH_3(g)$ (R)

3.50 moles H_2, 1.5 moles N_2, 0 moles NH_3 (I)

-3x -x +2x (C)

3.5 – 3x mol 1.5 – x 2x (E)

- Volume = 1.00 L, T = 700ºC
- At equilibrium: $[NH_3]$ = 0.540 M
- X = 0.270 *M*
- *2.69 M, 1.23 M, and 0.540 M.*
- *What is the value of the equilibrium constant K?*
- *K = 0.0122*

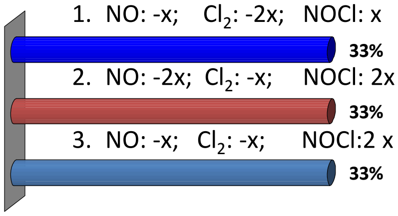
Key Questions, page 282-3

Exercise 1 at projector

$2NO + Cl_2 = 2\ NOCl$

What are the changes in terms of x?

1. NO: -x; Cl_2: -2x; NOCl: x
2. NO: -2x; Cl_2: -x; NOCl: 2x
3. NO: -x; Cl_2: -x; NOCl:2 x

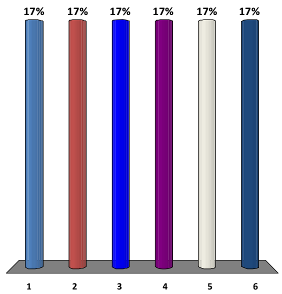


Exercise, page 283

- What are the equilibrium amounts?
- What is the value of x?
- 0.48 mol

What is the value of K_c

1. < 100
2. 100-500
3. 500-1000
4. 1000-1500
5. 1500-2000
6. >2000

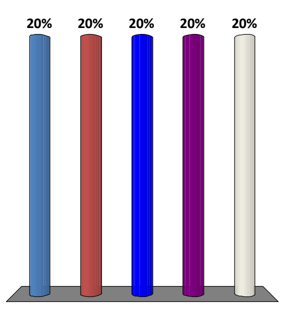


Problem #1, page 284

- With partner, set up the RICE process and get an expression for the equilibrium constant in terms of the change *x*.
- How can we solve this for x? –

What is the value of *x*?

1. 0.01 – 0.02 M
2. 0.02 – 0.03 M
3. 0.03 – 0.04 M
4. 0.04 – 0.05 M
5. None of the above



Problem 2, page 285

- Write the RICE table
- With your partner, find an expression for the equilibrium constant in terms of x.
- What is the expression for x?

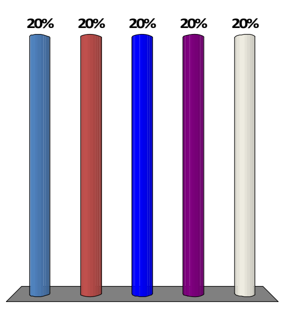
$$K_p = \frac{x}{(1.00 - 2x)^2} = 3.33$$

$$K_p = \frac{x}{(1.00 - 2x)^2} = 3.33$$

- How to solve for x?
- X = 0.34 atm

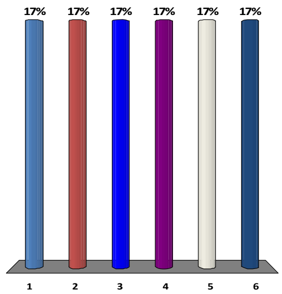
What is the partial pressure of NO_2

1. 0.16 atm
2. 0.17 atm
3. 0.32 atm
4. 0.34 atm
5. 0.68 atm



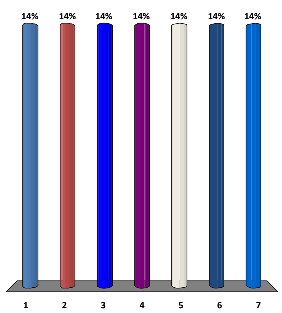
What is the partial pressure of N_2O_4 ?

1. 0.16 atm
2. 0.17 atm
3. 0.32 atm
4. 0.34 atm
5. 0.64 atm
6. 0.68 atm



What is the total pressure in the flask at equilibrium?

1. 0.32 atm
2. 0.34 atm
3. 0.66 atm
4. 1.00 atm
5. 1.32 atm
6. 1.34 atm
7. 1.66 atm

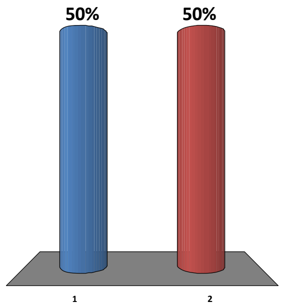


Problem #3, page 286

- Set up the RICE procedure
- 2.1% of the CO_2 decomposes
- What is the final pressure of carbon dioxide?
- What is the value of x?

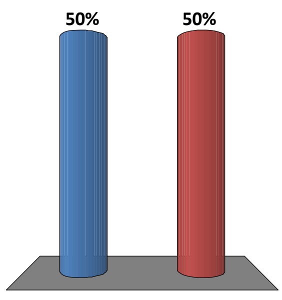
The equilibrium pressure of CO is 0.021 atm?

1. True
2. False



The equilibrium pressure of O_2 is 0.021 atm?

1. True
2. False

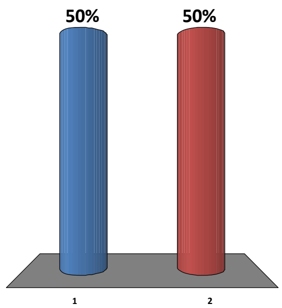


Problem 3

- Calculate the value of K_P
- 4.8×10^{-6}

Problem 4, p. 286. The expression for K is:

1. $P_{N2O} (P_{H2O})^2 / P_{NH4NO3}$
2. $P_{N2O} (P_{H2O})^2$



Hanson, Problem 4, page 286

- Work at the projector
- Reaction
  $NH_4NO_3(s) = N_2O(g) + 2\ H_2O\ (g)$ (R)
- At equilibrium P_{tot} = 4.30 atm
- Calculate K_P
- What are the Initial Partial Pressures? (I)
- What are the Changes (set up the x's) (C)
- Equilibrium Partial Pressures in terms of x ? (E)

Hanson, Problem 4, page 286

- How do we solve for x here? With partner
- X = 1.43 atm
- What is the value of K_P? With partner
- 11.8