Good comments from the discussion

I think when the temperature achieves the absolute zero, which is 0K, the reaction might stop because the molecule cannot move anymore.

All human activities which will lead to global warming, can increase the rate of reaction. As the temperature is increasing, molecules are likely to have more successful collisions.

- if reactants only collide for a small number of times, will the reaction achieve equilibrium?
- The whole universe should be at a equilibrium. So the helium released back to the atmosphere can be considered a type of equilibrium.
- The universe is now still expanding in size, it's not easy to believe universe is at equilibrium. There is no difference between recent expanding and the big bang.
- the helium particles will be spread throughout the air, and the process will never stop, thus there is no equilibrium.

Questions you did not answer: (well enough)

If a salt is considered insoluble in water, can it react with another salt that is soluble?

Does concentration of the reactants tell you when the reaction will stop?

What is the Delta G of boiling liquid water at 100 C? Will this reaction go forward or backward?

Does the number of steps that it takes for a reaction to occur in the forward direction always equal the number of steps that it takes for a reaction to occur in the reverse direction?

Does the number of steps that it takes for a reaction to occur in the forward direction always equal the number of steps that it takes for a reaction to occur in the reverse direction?

An onion scented candle is burning in Mr. Lawlor's office. You see the fire and know that a chemical reaction is happening, but you don't observe any change in the flame after 30 seconds of observation. Why is this?

The famous writer Dante wrote about the nine circle. . .

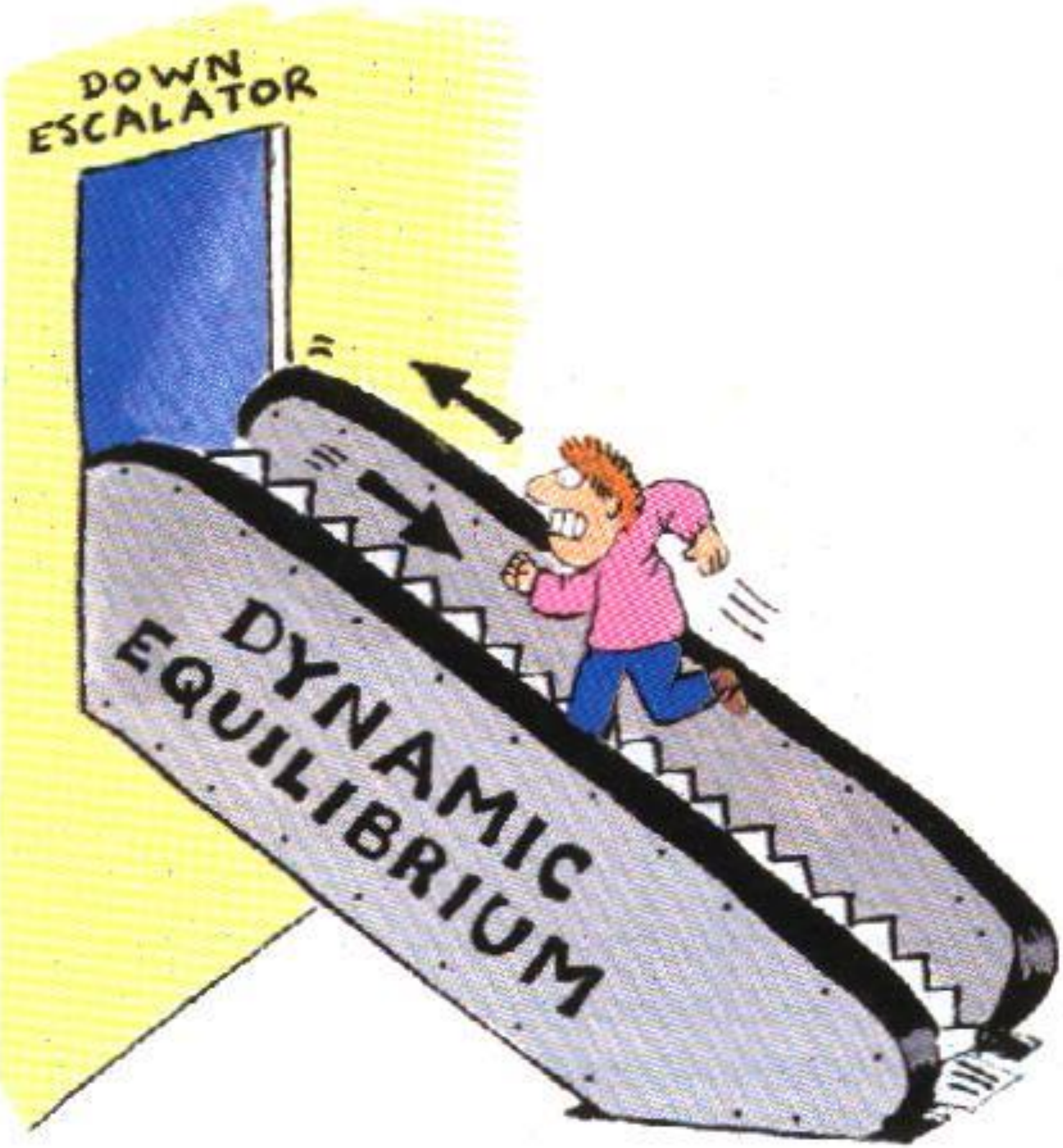
Study these before the midterm

Equilibrium

- The reactions considered until now have had reactants react completely to form products. These reactions “went” only in one direction. “**Steady state”**
- Some reactions can react in either direction. They are “reversible”. When this occurs some amount of reactant(s) will always remain in the final reaction mixture.

- A chemical system where the concentrations of reactants and products remain constant over time.
- On the molecular level, the system is dynamic: The rate of change is the same in either the forward or reverse directions.

DYNAMIC EQUILIBRIA


DOWN ESCALATOR
DYNAMIC EQUILIBRIUM

DYNAMIC EQUILIBRIUM

DYNAMIC

- The forward and reverse reactions are both taking place.

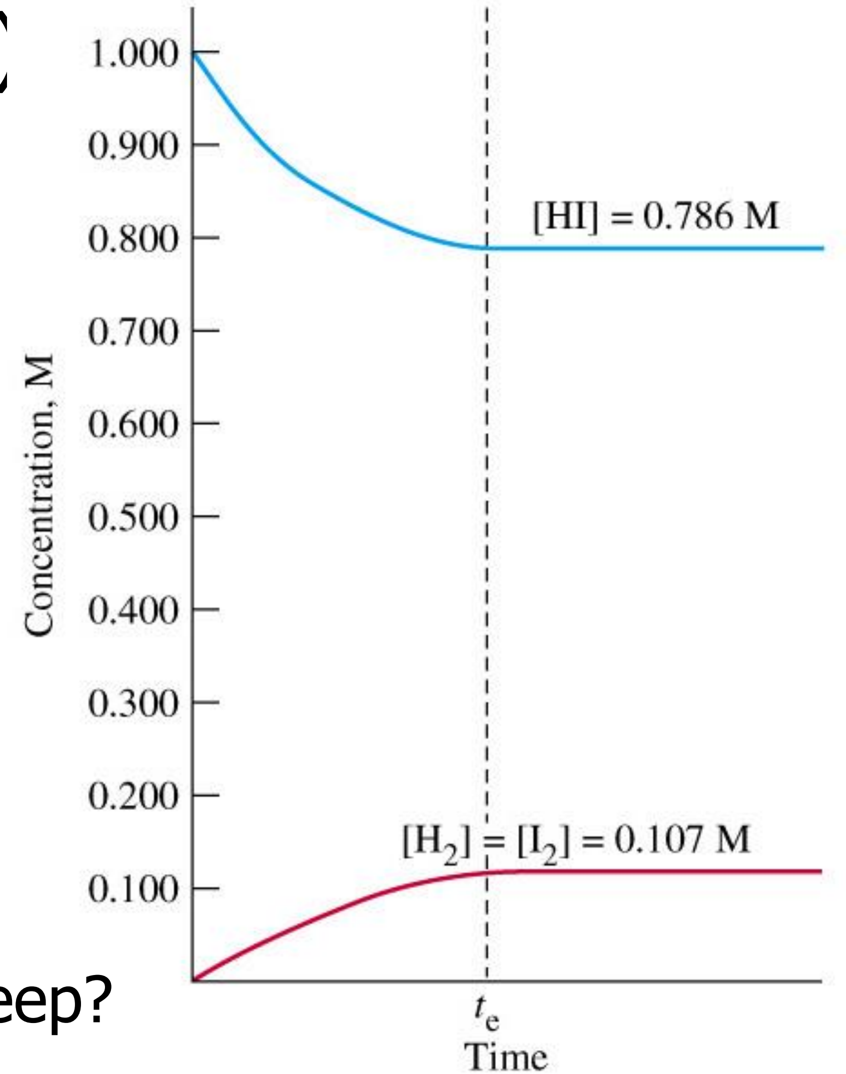
EQUILIBRIUM

- The reactions take place at the same speed.
- All reactants and products are present.
- The concentration of all reactants and products remain constant.

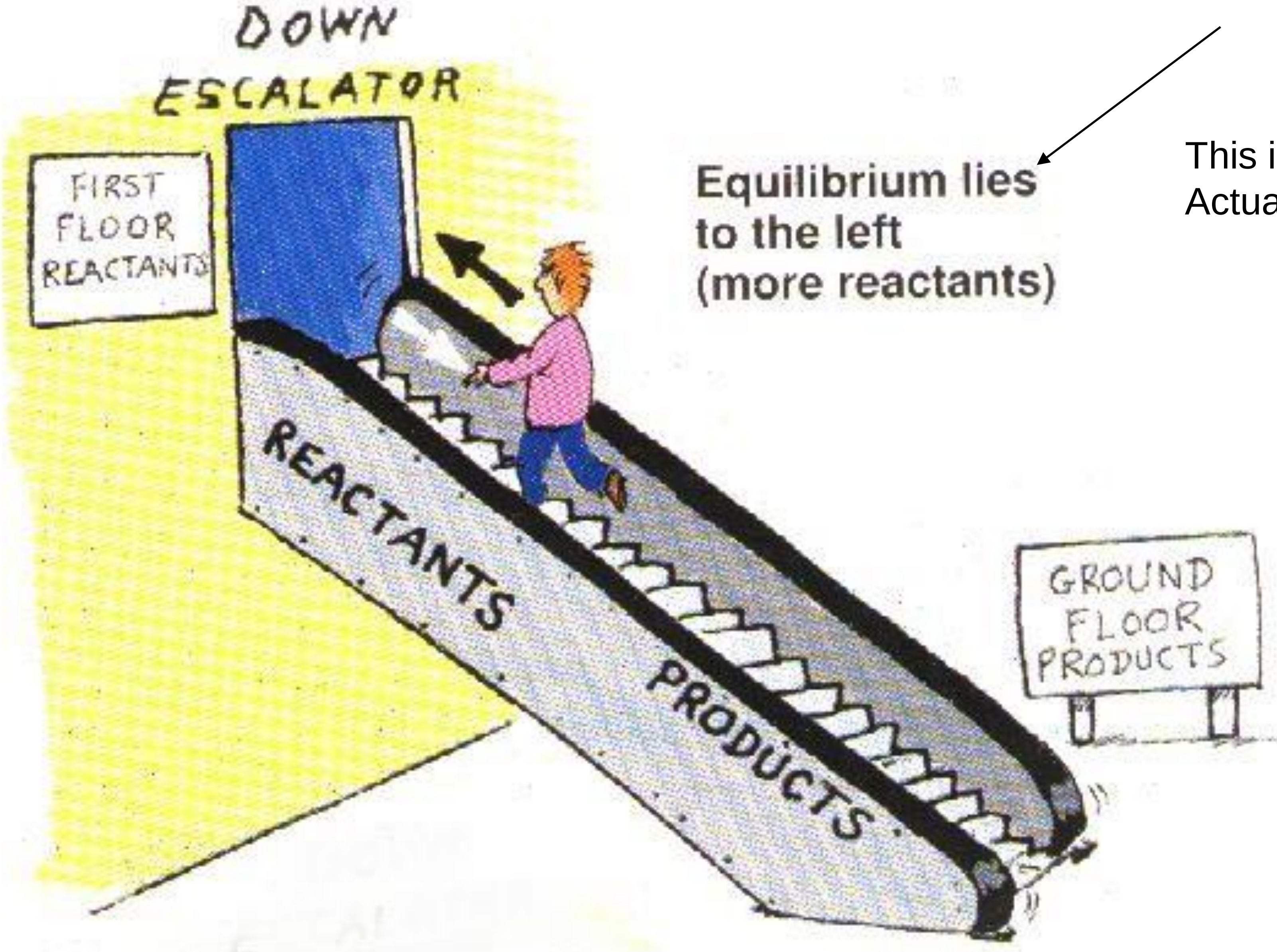
2 HI(g) ⇔ H_2(g) + I_2(g)

Imagine you start with 0.100 M HI. It breaks down to form H_2 and I_2. However, H_2 and I_2 react to form HI.

After a time, equilibrium is reached with the rate at which HI decomposes equals the rate at which it is formed.



Why is the blue line twice as steep?

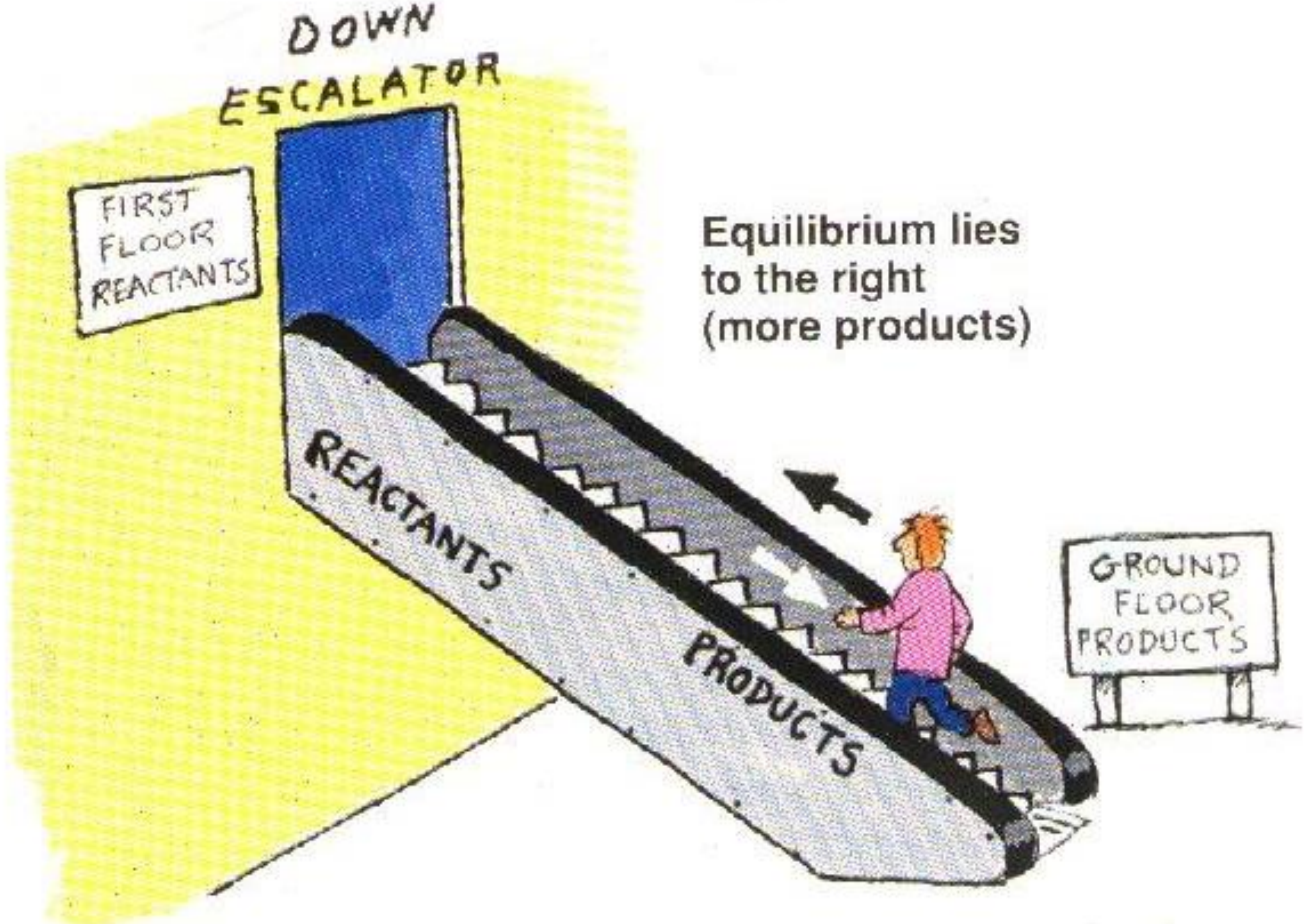


This is an
Actual phrase

$$3\ H_2(g) \quad + \quad N_2(g) \quad \Leftrightarrow \quad 2\ NH_3(g)$$

when equilibrium lies to the left:

there are more reactants than products (i.e. more H_2 and N_2 than NH_3)


DOWN
ESCALATOR
FIRST
FLOOR
REACTANTS
Equilibrium lies
to the right
(more products)
REACTANTS
PRODUCTS
GROUND
FLOOR
PRODUCTS

$$3\ H_2(g) \quad + \quad N_2(g) \quad \leftrightarrow \quad 2\ NH_3(g)$$

when equilibrium lies to the right:

there are more products than reactants (i.e. more NH_3 than H_2 and N_2)

Law of Mass Action
(Equilibrium Expression)

- For a reaction:

  $jA + kB \leftrightarrow lC + mD$

- The law of mass action is represented by the Equilibrium Expression: where K is the Equilibrium Constant.

$$K = \frac{[C]^l [D]^m}{[A]^j [B]^k}$$

This is not the same as the rate law!!!

QUESTION

One of the environmentally important reactions involved in acid rain production has the following equilibrium expression. From the expression, what would be the balanced chemical reaction?
Note: all components are in the gas phase.

$K = [SO_3]/([SO_2][O_2]^{1/2})$

A. $SO_3(g) \leftrightarrows SO_2(g) + 2O_2(g)$
B. $SO_3(g) \leftrightarrows SO_2(g) + 1/2O_2(g)$
C. $SO_2(g) + 2O_2(g) \leftrightarrows SO_3(g)$
D. $SO_2(g) + 1/2O_2(g) \leftrightarrows SO_3(g)$

Answer

D) properly shows the product SO_3 on the right and incorporates the previous exponents from the equilibrium expression as coefficients in the chemical equation.

Properties of K

- 1) If a reaction is re-written where the reactants become products and products-reactants, the new Equilibrium Expression is the reciprocal of the old.

$$K_{new} = 1 / K_{original}$$

- 2) When the entire equation for a reaction is multiplied by n,

$$K_{new} = (K_{original})^n$$

Calculating K_c from Concentration Data

$$2\ HI_{(g)} \rightleftharpoons H_{2\,(g)} + I_{2\,(g)}$$

4.00 mol HI was placed in a 5.00 L vessel at 458°C, the equilibrium mixture was found to contain 0.442 mol I_2. What is the value of K_c ? Calculate the molar concentrations, and put them into the equilibrium expression to find it's value.

$$\text{Starting conc. of HI} = \frac{4.00\ \text{mol}}{5.00\ \text{L}} = 0.800\ M$$

$$\text{Equilibrium conc. of } I_2 = \frac{0.442\ \text{mol}}{5.00\ \text{L}} = 0.0884\ M$$

Conc. (*M*)	**$2HI_{(g)}$** ⇌	**$H_{2\,(g)}$**	**$I_{2\,(g)}$**
Initial	0.800	0	0
Change	- 2x	x	x
Equilibrium	0.800 - 2x	x	x = 0.0884

Calculating K_c from Concentration Data *(continued)*

$$2\,HI_{(g)} \rightleftharpoons H_{2\,(g)} + I_{2\,(g)}$$

$[HI] = M = (0.800 - 2 \times 0.0884)\ M = 0.623\ M$

$[H_2] = x = 0.0884\ M = [I_2]$

$$K_c = \frac{[H_2]\,[I_2]}{[HI]^2} = \frac{(0.0884)(0.0884)}{(0.623)^2} = 0.0201$$

What does the value 0.0201 mean? Does the decomposition proceed very far under these temperature conditions?

Note: *The initial concentrations, and one at equilibrium were provided. The others that were needed to calculate the equilibrium constant were deduced algebraically.*

homework

- Questions 9-11 on page 73

LE CHATELIER'S PRINCIPLE

- If the conditions of an equilibrium are changed, the position of the equilibrium moves to oppose the change.

Make it hotter – equilibrium moves to cool it.

Make it colder – equilibrium moves to heat it.

Raise the pressure – equilibrium moves to lower it.

Lower the pressure – equilibrium moves to raise it.

Add a chemical – equilibrium moves to get rid of it.

Remove a chemical – equilibrium moves to make more.

THE EFFECT OF CONCENTRATION

$[Co(H_2O)_6]^{2+}$ + 4 Cl^- ⇔ $[CoCl_4]^{2-}$ + 6 H_2O

pink blue

add Cl^-

add H_2O

add Cl^-

THE EFFECT OF TEMPERATURE

$$3\,H_2(g) \quad + \quad N_2(g) \quad \leftrightarrow \quad 2\,NH_3(g)$$

forward reaction is exothermic: – 76 kJ mol^{-1}

reverse reaction is endothermic : + 76 kJ mol^{-1}

If the temperature is raised – the equilibrium moves to cool down by moving in the endothermic direction.

If the temperature is lowered – the equilibrium moves to heat up by moving in the exothermic direction.

THE EFFECT OF TEMPERATURE

$$[Co(H_2O)_6]^{2+} + 4\ Cl^- \leftrightarrow [CoCl_4]^{2-} + 6\ H_2O$$

pink blue

forward reaction is endothermic

reverse reaction is exothermic

heat up the equilibrium mixture:

cool down the equilibrium mixture:

high temperature | low temperature

$[Co(H_2O)_6]^{2+}$ + $4\ Cl^-$ ↔ $[CoCl_4]^{2-}$ + $6\ H_2O$ forward endothermic

pink blue

THE EFFECT OF TEMPERATURE

$$2\,NO_2(g) \leftrightarrow N_2O_4$$

brown — colourless

forward reaction is exothermic

reverse reaction is endothermic

heat up the equilibrium mixture:

cool down the equilibrium mixture:

high temperature

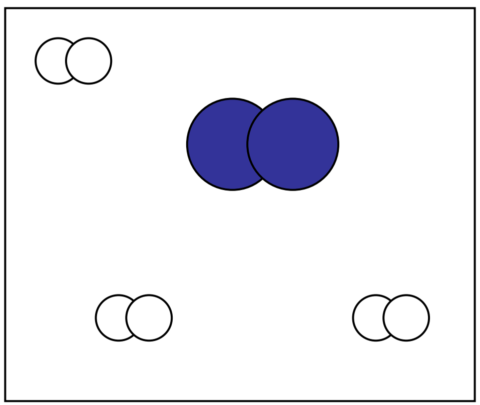
low temperature

$2\ NO_2 \leftrightarrow N_2O_4$ forward exothermic

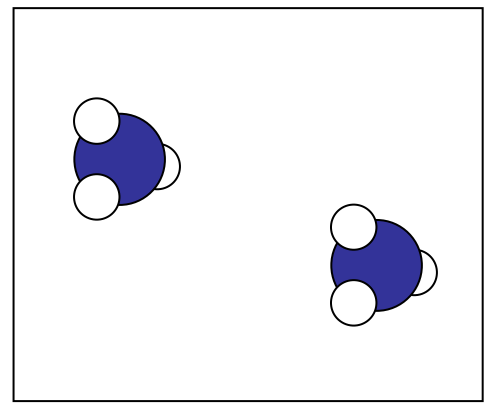
brown colourless

THE EFFECT OF PRESSURE

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



4 molecules
More pressure



2 molecules
Less pressure

THE EFFECT OF PRESSURE

If the pressure is raised – the equilibrium moves to reduce the pressure by moving to the side with fewest gas molecules.

If the pressure is lowered – the equilibrium moves to increase the pressure by moving to the side with most gas molecules.

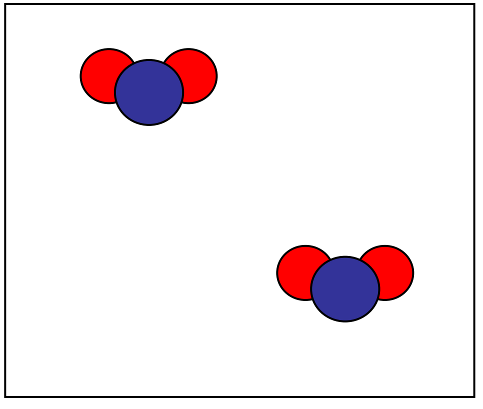
If there are the same number of gas molecules on both sides of the equation, then the equilibrium cannot move to oppose the change.

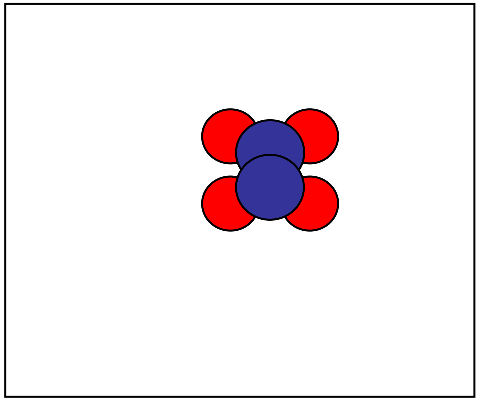
e.g. $2\,HI(g) \leftrightarrow H_2(g) + I_2(g)$

THE EFFECT OF PRESSURE

$$2\,NO_2(g) \leftrightarrow N_2O_4(g)$$

brown colourless





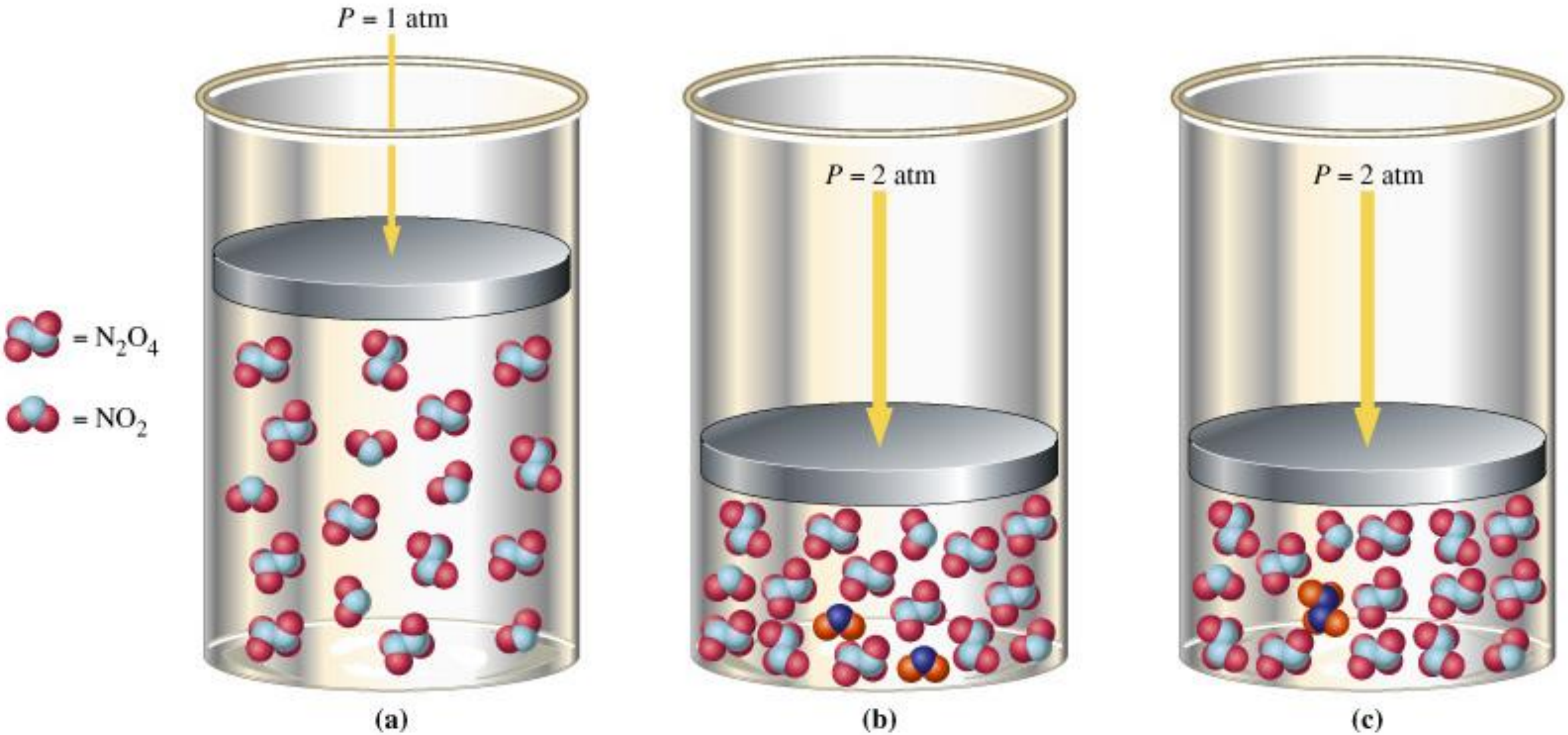
2 molecules
More pressure

1 molecule
Less pressure


HAMILTON CO. RENO, NE
GASTIGHT ® #1025
15
10
5

HAMILTON C
GASTIGHT ® #1025
10
5

HAMILTON C
GASTIGHT ® #1025
10
5



(a) Equilibrium is established at a total pressure of 1 atm. For every 17 molecules, 5 are NO_2 and 12 are N_2O_4.

(b) The total pressure is increased to 2 atm. Momentarily, the same 17 molecules are present.

(c) The system accommodates to the reduced volume. Two NO_2 molecules combine to form one N_2O_4 molecule. The new equilibrium has 16 molecules in place of the original 17. Of these, 3 are NO_2 and 13 are N_2O_4.

[Notice that in every case the same total number of atoms is present: 29 N atoms and 58 O atoms.]

Homework

- Page 2.2
- 1,3,4,5,6,8,
- On your book