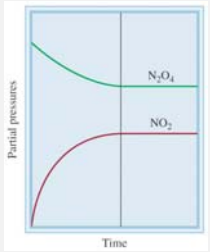


[TP] The figure shows how the partial pressures of the N_2O_4 and NO_2 change with time due to the chemical reaction

$$N_2O_4 \rightarrow 2\ NO_2$$

for certain initial conditions (far left). At these initial conditions, the following is known about the chemical reaction.

25% 1. It is spontaneous
25% 2. It is at equilibrium
25% 3. It is non-spontaneous
25% 4. Its spontaneity is not known without further information



Response Counter

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Lecture 13 CH102 A1 (MWF 9:05 am)

Tuesday, February 21, 2017

- Complete: Reaction quotient, *Q*, spontaneity, and equilibrium
- Predicting direction of change
- *Q* depends on how a reaction is written

Next: Continue ch13: Disturbing equilibrium (Le Chatelier); Knowing *K* does not fix individual concentrations

Reaction quotient *Q* measures progress

For $A \rightarrow B + C$, the reaction quotient is ...

$$Q = [B][C] / [A]$$

The numerical value of the reaction quotient when the concentrations have their equilibrium values ...

$[A]_e$, $[B]_e$ and $[C]_e$

and so no longer change with time, is called the equilibrium constant ...

$$K = [B]_e[C]_e / [A]_e$$

6

Q versus *K* is the key to assessing spontaneity

If $Q < K$, product must form to get to equilibrium,
so spontaneous

If $Q > K$, reactants must form to get to equilibrium,
so nonspontaneous

So, Q/K is the key quantity to monitor.

7

$N_2O_4 \rightarrow 2\ NO_2$

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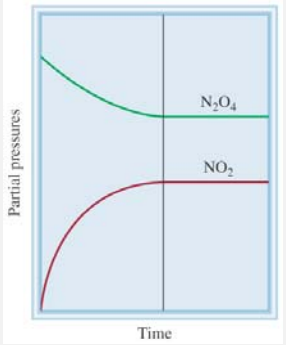

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$N_2O_4 \rightarrow 2\ NO_2$

The reaction quotient is

$Q = [NO_2]^2/[N_2O_4]$

The numerical value of the reaction quotient when the concentrations have their equilibrium values

$[N_2O_4]_e$ and $[NO_2]_e$

and so no longer change with time, is called the equilibrium constant

$K = [NO_2]_e^2/[N_2O_4]_e$

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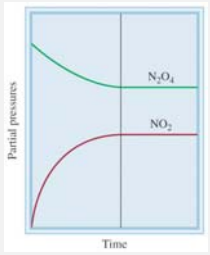

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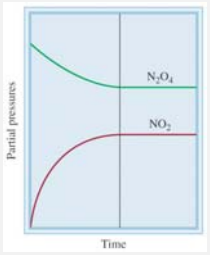
[TP] At the initial conditions (far left) for the reaction

$N_2O_4 \rightarrow 2\ NO_2$

the following is known about the ratio Q/K.

25% 1. It is greater than 1
25% 2. It is equal to 1
25% 3. It is less than 1
25% 4. The ratio is not known without further information



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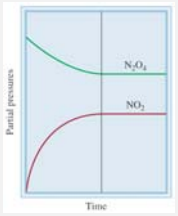
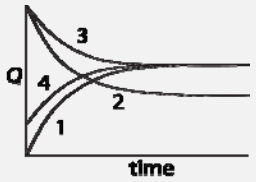
[TP] For the reaction

$N_2O_4 \rightarrow 2\ NO_2$

which curve on the right shows the corresponding change of Q with time?

20% 1. 1
20% 2. 2
20% 3. 3
20% 4. 4
20% 5. None





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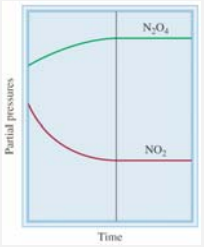
[Group Quiz] The figure shows how the partial pressures of the N_2O_4 and NO_2 change with time due to the chemical reaction

$N_2O_4 \rightarrow 2\ NO_2$

for certain initial conditions (far left). At these initial conditions, the following is known about the chemical reaction.

25% 1. It is spontaneous
25% 2. It is at equilibrium
25% 3. It is non-spontaneous
25% 4. Its spontaneity is not known without further information



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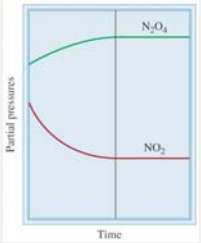
[TP] At the initial conditions (far left) for the reaction

$N_2O_4 \rightarrow 2\ NO_2$

the following is known about the ratio Q/K.

25% 1. It is greater than 1
25% 2. It is equal to 1
25% 3. It is less than 1
25% 4. The ratio is not known without further information



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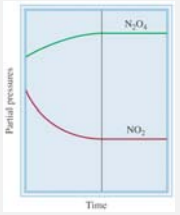
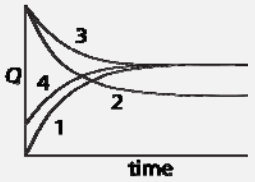
[TP] For the reaction

$N_2O_4 \rightarrow 2\ NO_2$

which curve on the right shows the corresponding change of Q with time? Recall that curve 1 was correct for the initial conditions (far left) seen in previous questions.

20% 1. 1
20% 2. 2
20% 3. 3
20% 4. 4
20% 5. None





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Q versus *K* is the key to assessing spontaneity

If $Q < K$, product must form to get to equilibrium,
so spontaneous

If $Q > K$, reactants must form to get to equilibrium,
so nonspontaneous

So, Q/K is the key quantity to monitor.

Predicting direction of change

[Quiz] For the reaction

$$2\,A + B \rightarrow 2\,C$$

at a certain time the value of its reaction quotient is $Q = 7$. This means the value of the equilibrium constant for the reaction is …

25% 1. < 7
25% 2. 7
25% 3. > 7
25% 4. Further information needed

Response Counter

[TP] The value of the equilibrium constant for the gas-phase reaction

$$2\,A + B \rightarrow C$$ is $K = 10$.

At a certain time the partial pressures are A, B and C are, respectively, 1 bar, 1 bar and 2 bar. The value of the reaction quotient is $Q =$ …

33% 1. 2
33% 2. 10
33% 3. Further information needed

Response Counter

[Quiz] The value of the equilibrium constant for the gas-phase reaction
$2\,A + B \rightarrow C$ is $K = 10$.
At a certain time the partial pressures are A, B and C are, respectively, 1 bar, 1 bar and 2 bar. Under these conditions, the value of the equilibrium constant is $K =$ ...

33% 1. 2
33% 2. 10
33% 3. Further information needed

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[TP] The value of the equilibrium constant for the gas-phase reaction
$2\,A + B \rightarrow C$ is $K = 10$.
At a certain time the partial pressures are A, B and C are, respectively, 0.2 bar, 1 bar and 4 bar. The value of the reaction quotient is $Q =$ ...

20% 1. 0.04
20% 2. 4
20% 3. 10
20% 4. 100
20% 5. None of the these

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[TP] The value of the equilibrium constant for the gas-phase reaction
$2\,A + B \rightarrow C$ is $K = 10$.
At a certain time the partial pressures are A, B and C are such that the value of the reaction quotient is $Q = 100$. As time passes, the value of Q will ...

33% 1. increase
33% 2. stay the same
33% 3. decrease

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[TP] The value of the equilibrium constant for the gas-phase reaction
$2\,A + B \rightarrow C$ is $K = 10$.
At a certain time the value of the reaction quotient is $Q = 6$. As time passes, the value of Q will ...

33% 1. increase
33% 2. stay the same
33% 3. decrease

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The value of Q (and so K) depends on how a chemical reaction is written.

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Q depends on how a reaction is written

At a certain time, the value of the reaction quotient for the reaction

$2\ A + B \rightleftharpoons 2\ C$

is $Q_1 = 4.0$.

At the same time, what would be the value of Q be for the reaction

$4\ A + 2\ B \rightleftharpoons 4\ C$?

$Q_4 = (C)^4/((A)^4(B)^2) = (Q_1)^2 = 16$

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Q depends on how a reaction is written

At a certain time, the value of the reaction quotient for the reaction

$2\ A + B \rightleftharpoons 2\ C$

is $Q_1 = 4.0$.

At the same time, what would be the value of Q be for the reaction

$2\ C \rightleftharpoons 2\ A + B$?

$Q_2 = (A)^2(B)/(C)^2 = 1/Q_1 = 0.25$

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Q depends on how a reaction is written

At a certain time, here are the values of the reaction quotients for two different reactions,

$2\ A \rightleftharpoons B$, $Q_5 = (B)/(A)^2 = 2$

$C \rightleftharpoons 3\ D$, $Q_6 = (D)^3/(C) = 5$

At the same time, what would be the value of Q be for the reaction

$2\ A + C \rightleftharpoons B + 3D$?

$Q_7 = (B)(D)^3/((A)^2(C)) = Q_5 \times Q_6 = 10$

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[TP] The value of the equilibrium constant for the reaction

$2\ A + B \rightleftharpoons C$

is $K = 10$. The value of the equilibrium constant for the reaction

$6\ A + 3\ B \rightleftharpoons 3\ C$

is ...

20% 1. 10
20% 2. 30
20% 3. 100
20% 4. 1000
20% 5. None of the above

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[TP] The value of the equilibrium constant for the reaction

$2\ A + B \rightleftharpoons C$

is $K = 10$. The value of the equilibrium constant for the reaction

$2\ C \rightleftharpoons 4\ A + 2\ B$

is ...

20% 1. -10
20% 2. 0.1
20% 3. 0.01
20% 4. -0.001
20% 5. None of the above

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[Group Quiz] The value of the equilibrium constant for the reaction

$2\ A \rightleftharpoons C$ is $K_1 = 4$

and that for the reaction

$D \rightleftharpoons C$ is $K_2 = 0.5$.

The value of the equilibrium constant for the reaction

$2\ A \rightleftharpoons D$ is $K_3 = ...$

20% 1. 2
20% 2. 4
20% 3. 6
20% 4. 8
20% 5. None of the above

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