Announcements – Lecture XIV – Tuesday, Oct 30th

1. Lab 4 … Saturday, November 3rd, 1:00-4:00 pm ISB 155/160 A-E

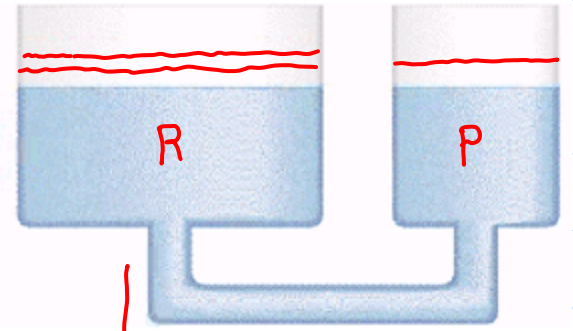
2. Exam II … Thursday, November 8th, In Class, 12:45-2:15pm

3. Final Exam … Wednesday, December 12th, ISB 135, 8:00-10:00am
   Final Review … Sunday, December 9th, ISB 135, 1:00-3:00pm

7.7 What Is Le Chatelier's Principle

Adding/Removing Reactants .

Add Reactant



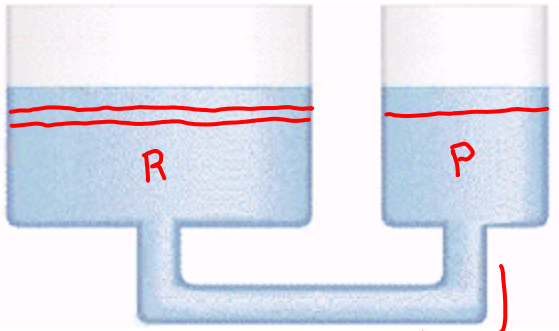
Reaction flows towards P (products)

Add R ... shift towards P ...

more P produced.

Adding R changes the value of [P]/[R] ...
Reaction wants to return to the original value of [P]/[R] ... K

Remove Reactant



Reaction flows towards R (reactants)

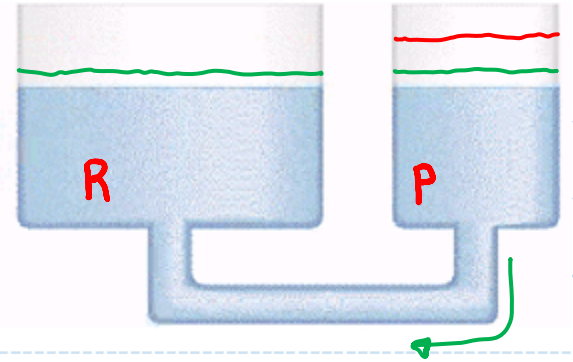
Remove R .... shift towards R ....

more R produced

Remove R changes the value of [P]/[R] ...
Reaction wants to return to the original value of [P]/[R] ... K

7.7 What Is Le Chatelier's Principle
Adding/Removing Products .

Add Product

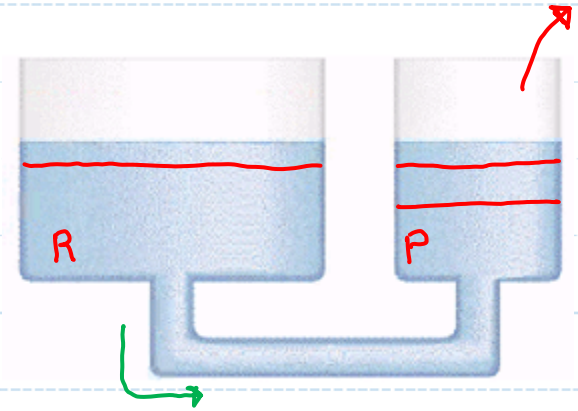


Reaction flows towards R

Add P ... shift towards R ... more R produced.

Adding more P changes the value of [P]/[R] ...
Reaction wants to return to the original [P]/[R]
... K

Remove Product.



Reaction flows towards P

Remove P ... shift towards P ... more P produced.

Removing P changes the value of [P]/[R] ...
Reaction wants to return to the original
[P]/[R] ... K

7.7 What Is Le Chatelier's Principle
Adding/Removing Reactant and Products

HCN is a weak acid –

$$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$$

Removal of H_3O^+ from this equilibrium will cause the $[CN^-]$ to

a) Increase
b) Decrease
c) Remain unchanged
d) Impossible to determine

$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$

↳ Remove H_3O^+ ... removing P

⟶ shift towards P ... $[CN^-]\uparrow$

7.7 What Is Le Chatelier's Principle
Adding/Removing Reactant and Products

HCN is a weak acid –

$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$

Addition of OH^- to this equilibrium will cause the $[CN^-]$ to

a) Increase
b) Decrease
c) Remain unchanged
d) Impossible to determine

At first glance you might think c), since OH^- is neither a P or an R ... but!

$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$

$OH^- = 2\,H_2O(l)$

Adding OH^- removes H_3O^+ (a P)

→ shift towards P ... $[CN^-]\uparrow$

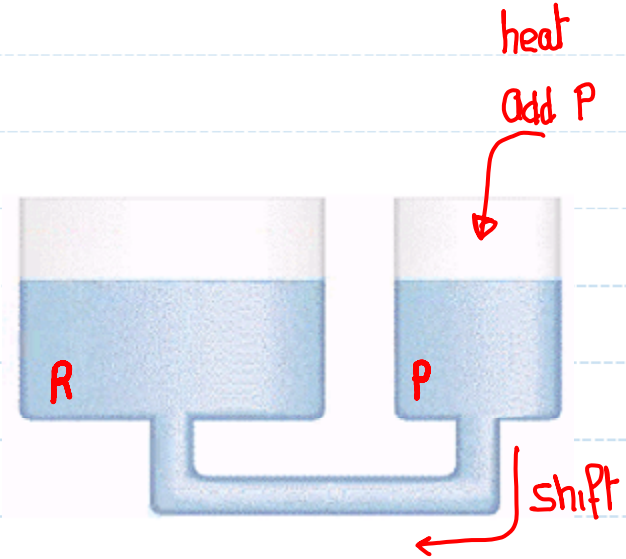
7.7 What Is Le Chatelier's Principle

Changing the Temperature – Exothermic

↳ Reaction that gives off heat

'Heat is a product'

$R \Leftrightarrow P + heat$



If we heat this reaction ... the equivalent of adding a product ... the equilibrium will shift towards Reactants.

Why does this happen ? $K = \frac{[P]}{[R]}$ ... heat is not part of the expression.

But when ↑ heat reaction, $[R]\uparrow$, $[P]\downarrow$ and thus $[P]/[R]\downarrow$ ... ie $K\downarrow$

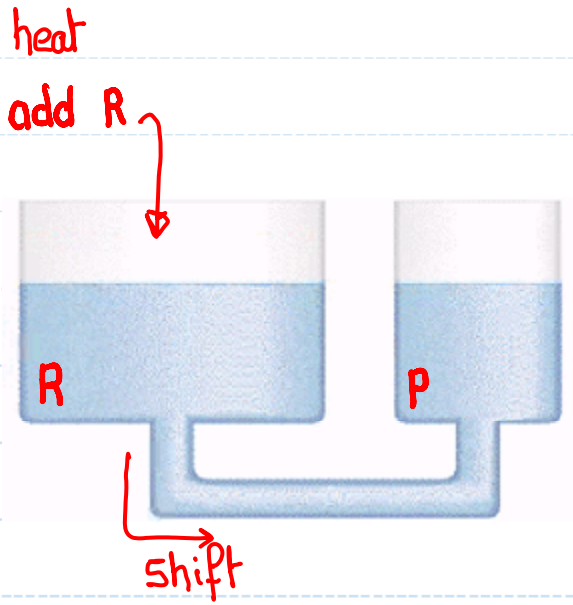
K is dependant on T ... exothermic reaction, as $T\uparrow$: $[R]\uparrow$, $[P]\downarrow$ and $K\downarrow$

7.7 What Is Le Chatelier's Principle

Changing the Temperature – Endothermic

↳ Reaction that requires heat

'Heat is a reactant'



$R + heat \Leftrightarrow P$

If we heat this reaction ... the equivalent of adding more reactant ... the equilibrium will shift towards products.

Why does this happen ... $K = [P]/[R]$ ... heat is not part of the expression!

But when I heat the reaction $[P]\uparrow$, $[R]\downarrow$ and thus $[P]/[R]\uparrow$, ie $K\uparrow$.

K is dependant on T ... endothermic reaction, as $T\uparrow$: $[P]\uparrow$, $[R]\downarrow$ and $K\uparrow$

7.7 What Is Le Chatelier's Principle

Changing the Temperature – Summary

a) Exothermic $R \Leftrightarrow P + heat$

Action	Equilibrium Shift	Why
Add heat (heat the RXN)	Towards Reactants	K↓
Remove heat (cool the RXN)	Towards products	K↑

b) Endothermic $R + heat \Leftrightarrow P$

Action	Equilibrium Shift	Why
Add heat (heat the RXN)	Towards products	K↑
Remove heat (cool the RXN)	Towards Reactants	K↓

7.7 What Is Le Chatelier's Principle

Changing the Temperature

The production of ammonia is an exothermic process –

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

To maximize the $[NH_3]$ at equilibrium it is best to

a) Heat the reaction
b) Cool the reaction
c) Leave it as is!

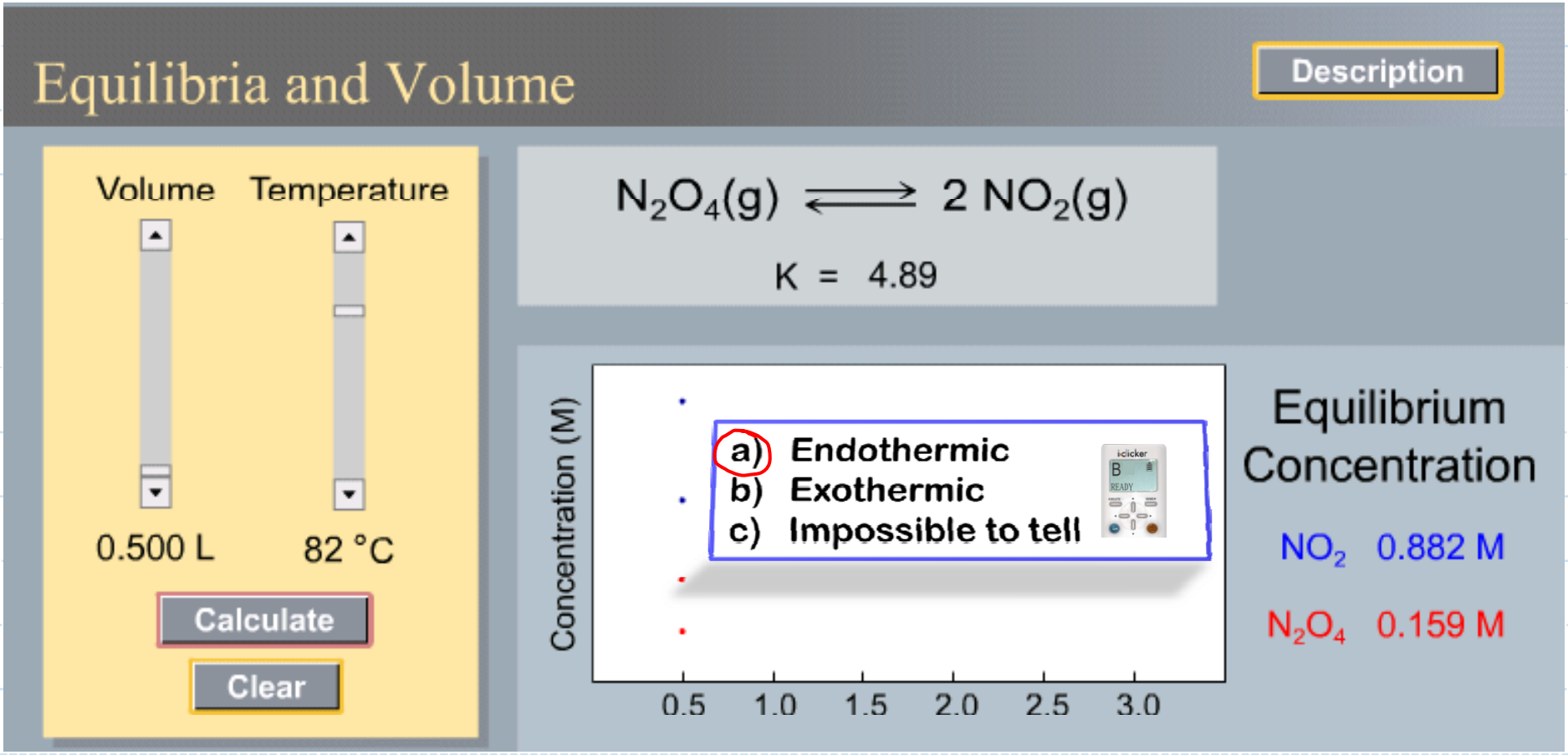
R ⇔ P + heat

↑

Maximize P ... $[NH_3]$ ... you want a shift towards P ... cool the reaction.

7.7 What Is Le Chatelier's Principle

Changing the Temperature



? What is happening to K as I increase the temperature

K is increasing ... shift towards products ... must be endothermic