Class Announcements

Exam II : Tuesday, November 8 12:45-2:15, In class.

Review ... Sunday, Nov 6, 3:00-4:45, ISB ?

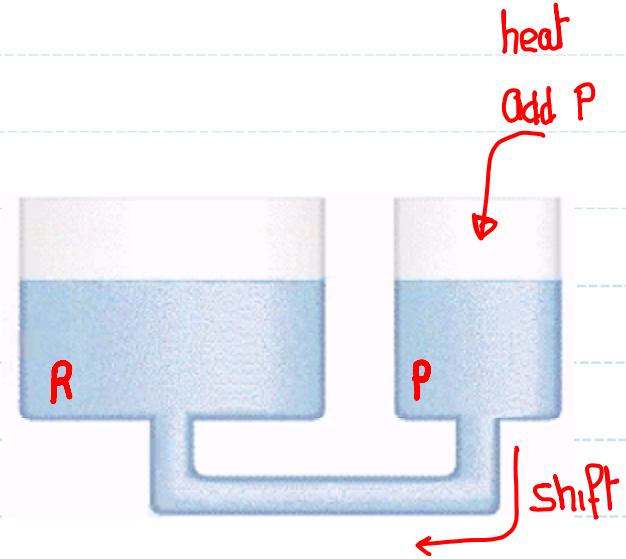
7.7 What Is Le Chatelier's Principle

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 $K\downarrow$

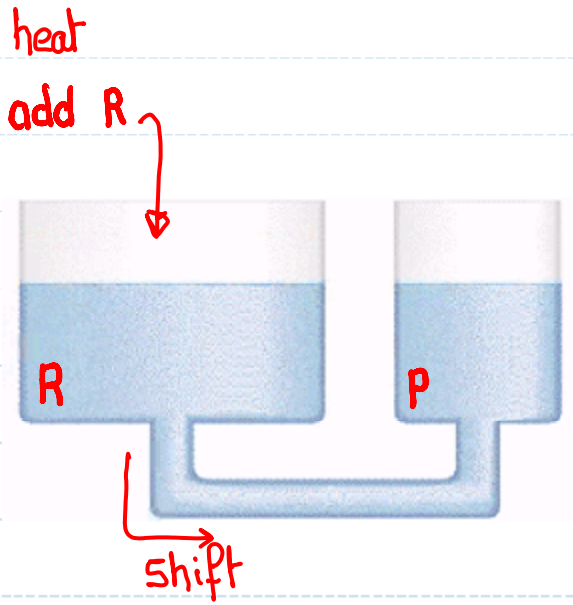
K is dependant on T ... exothermic reaction, as $T\uparrow$: $[R]\uparrow$, $[P]\downarrow$ and $K\downarrow$

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!

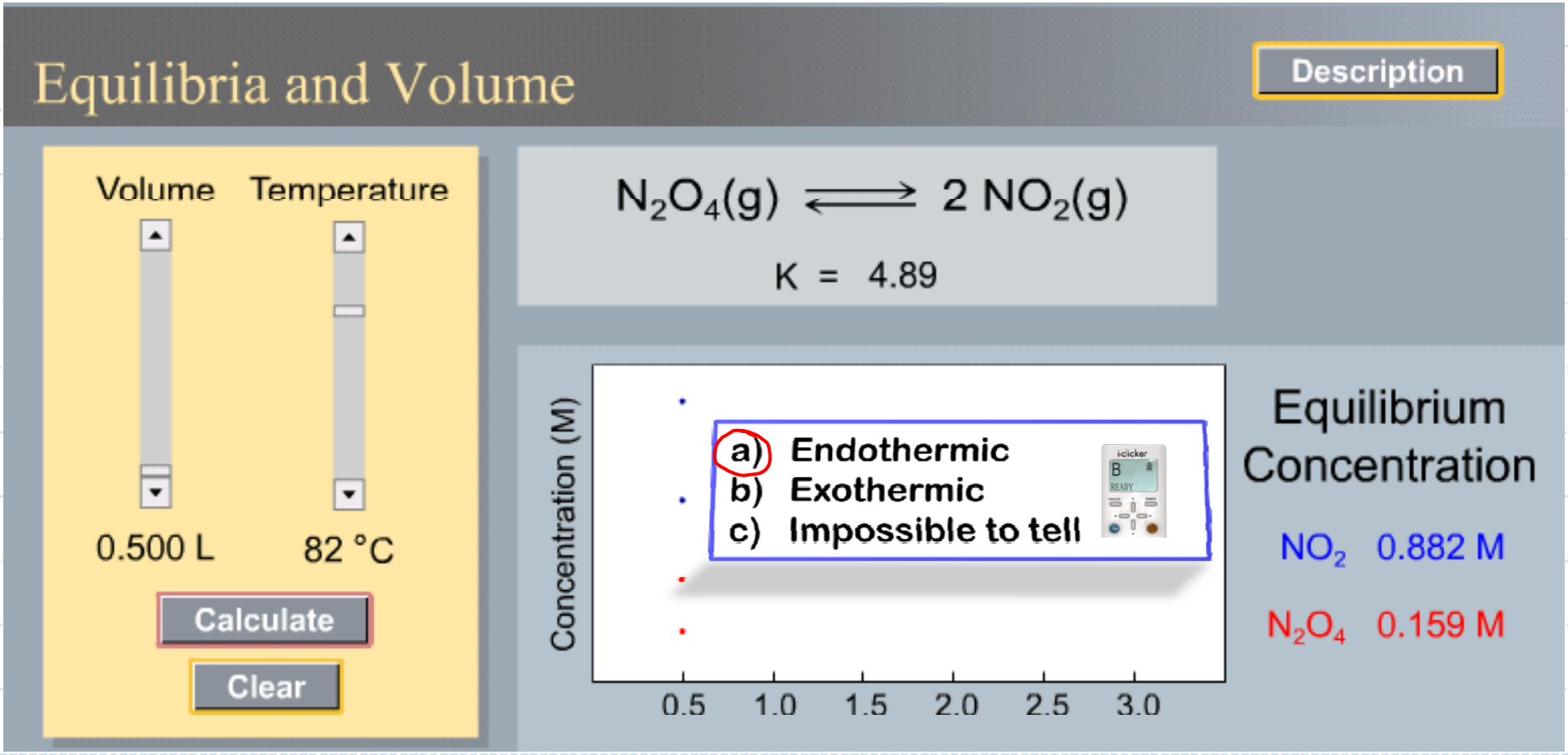
$R \Leftrightarrow P + heat$

↑

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

7.7 What Is Le Chatelier's Principle

Changing the Temperature



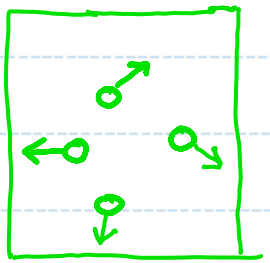
? What is happening to K as I increase the temperature

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

7.7 What Is Le Chatelier's Principle

Pressure – Gas Phase Equilibria

Pressure : Force per unit area



1. Collisions
2. Momentum.

$$R \Leftrightarrow P$$

$$K = \frac{[P]}{[R]}$$

$$[\ ] = \#\ mol/V(L)$$

Gas Reactions :

1. $\frac{[P]}{[R]}$ $\quad \bullet \Leftrightarrow \bullet$

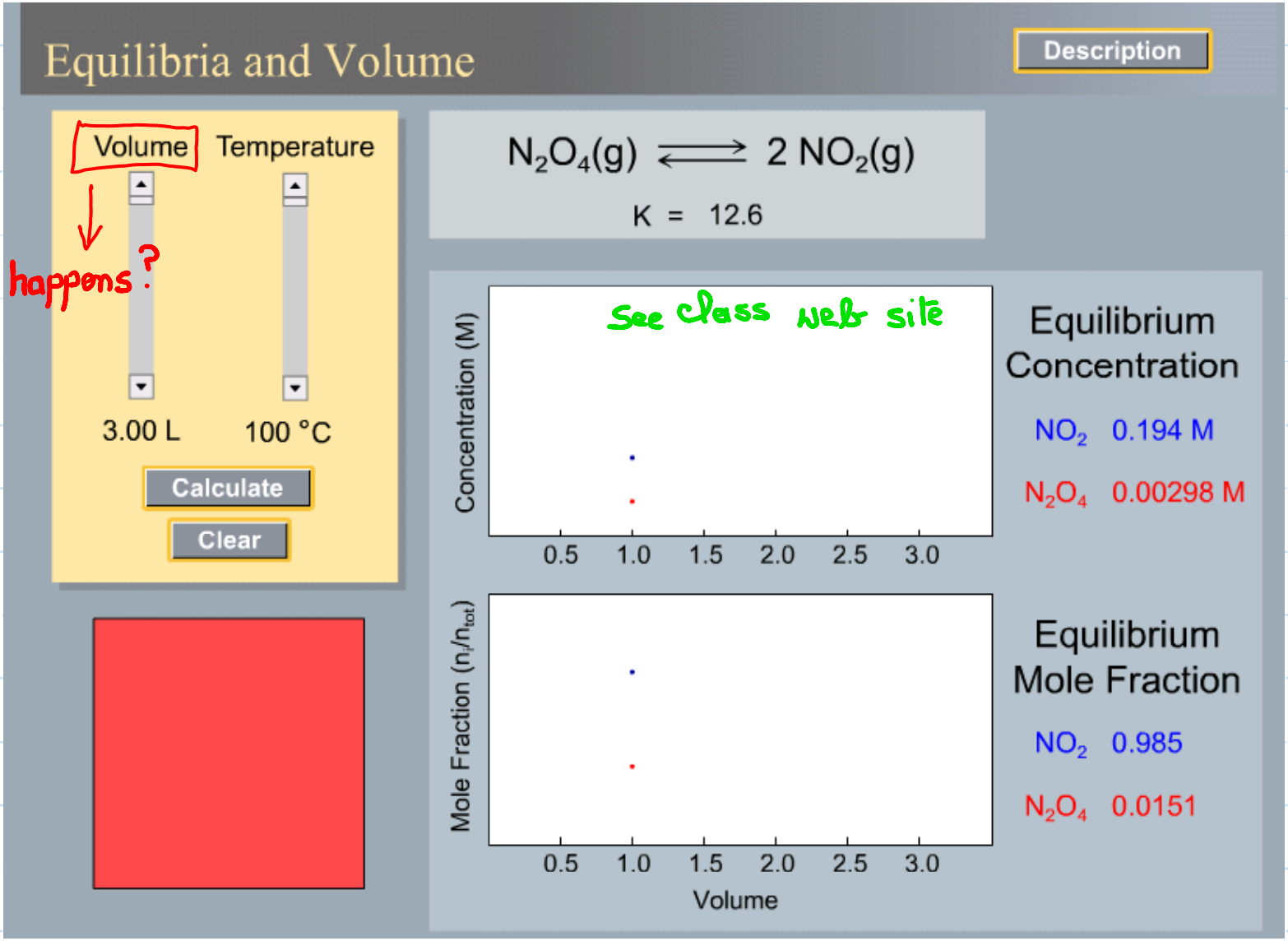
2. $\frac{[P][P]}{[R]}$ $\quad \bullet \Leftrightarrow \bullet + \bullet$

3. $\frac{[P]}{[R][R]}$ $\quad \bullet + \bullet \Leftrightarrow \bullet$

$\bullet$ = Gas molecule

7.7 What Is Le Chatelier's Principle

Changing the Pressure – Gas Phase Equilibria



7.7 What Is Le Chatelier's Principle

Changing the Pressure – Gas Phase Equilibria

Reactants (g) $\Leftrightarrow$ Products (g)

Action	Equilibrium Shift
Volume ↑, pressure decrease:	Towards the side with the greater number of gas molecules ... trying to restore the pressure ... if it can.
Volume ↓, pressure increase:	Towards the side with the fewest number of gas molecules ... trying to reduce the pressure ... if it can.

7.7 What Is Le Chatelier's Principle

Changing the Pressure – Summary

1. $O_3(g) + NO(g) \Leftrightarrow O_2(g) + NO_2(g)$ ● + ● ⇔ ● + ●

Action	Equilibrium shift.	Why
V↑, P↓	No shift	K is unaffected
V↓, P↑	No shift	

2. $2\ NOCl(g) \Leftrightarrow 2\ NO(g) + Cl_2(g)$ ● + ● ⇔ ● + ● + ●

Action	Equilibrium shift	Why
V↑, P↓	Towards products	K↑
V↓, P↑	Towards Reactants	K↓

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

Action	Equilibrium shift	Why
V↑, P↓	Towards Reactants	K↓
V↓, P↑	Towards products	K↑