Announcements – Lecture XVI – Thursday, Nov 5th

1. **Fifth Lab – Saturday, November 14th … 1-4pm … ISB 155/160 (A-E)**

   a) Print lab prior to coming to lab -- use the 'Print Friendly Version' located on the top left hand side of the page – this is the version that contains the 'Data Sheet' that you will hand in upon completing the lab.

   b) Final set of Lab Owls will appear in Owl after this lab. There are worth 25% of the Lab Grade.

2. **Exam II – Tuesday, November 10th, 1:00-2:15pm, In Class**

3. 

iClicker:
Choose any letter: A-E

7.7 What Is Le Chatelier's Principle

Changing the Temperature – Summary

Action	Equilibrium Shift	Why
1) Exothermic : $R \Leftrightarrow P + heat$		
Add heat (heat the rxn)	Shift towards reactants	K↓
Remove heat (cool the rxn)	Shift towards products	K↑
2) Endothermic : $R + heat \Leftrightarrow P$		
Add heat (heat the rxn)	Shift towards products	K↑
Remove heat (cool the rxn)	Shift towards reactants	K↓

1) Adding and removing reactants and products does not change the value of K.
2) Heating or cooling a reaction, changes the value of K. Whether K increases or decreases depends on whether the reaction is exothermic or endothermic.

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!

$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g) + \text{heat}$

↳ Want a shift towards products.

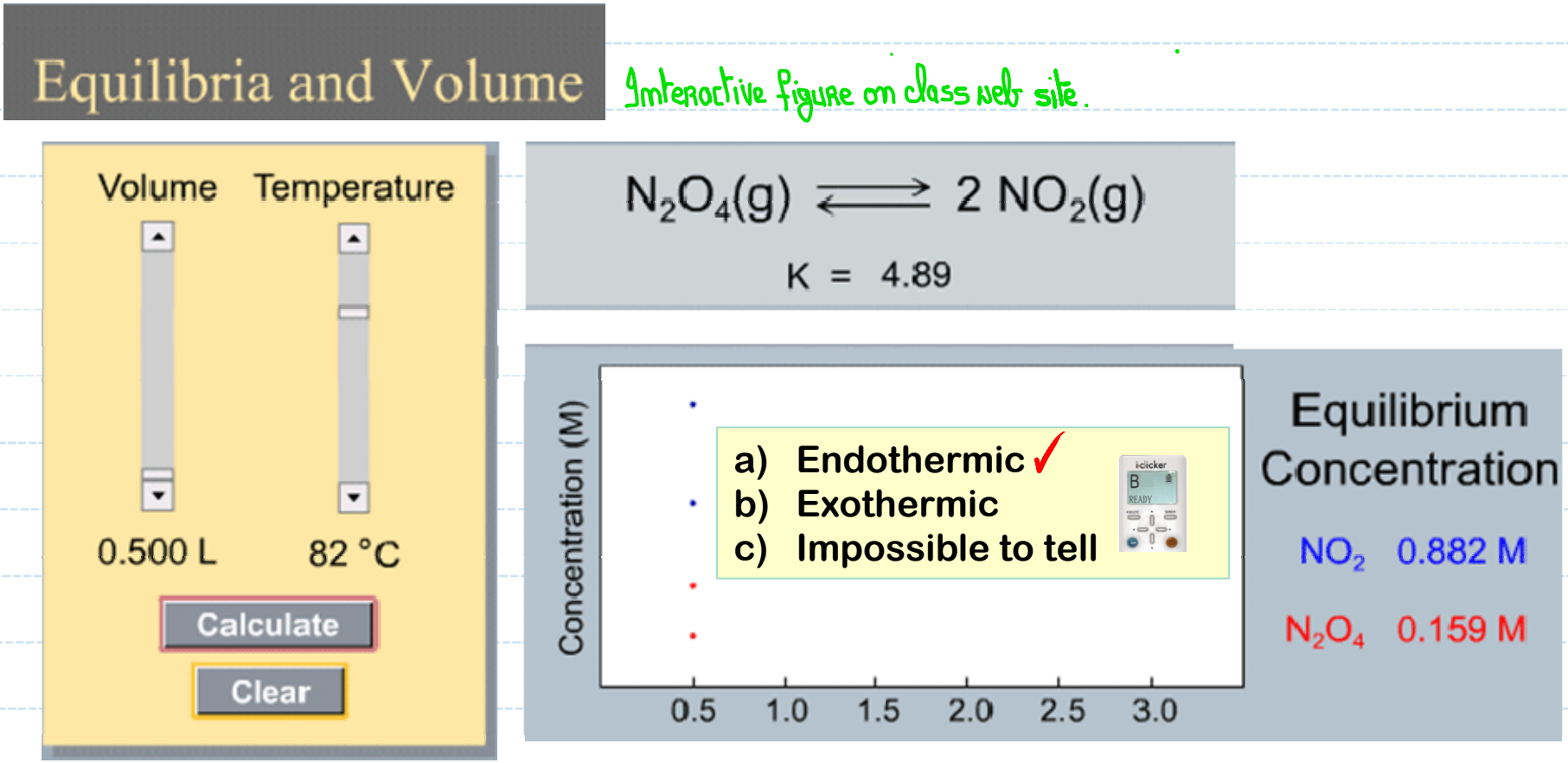
Cool the reaction ... removes heat ...

removes a product ... shift towards

product ... $[NH_3(g)]\uparrow$

7.7 What Is Le Chatelier's Principle

Changing the Temperature



Interactive figure on class web site.

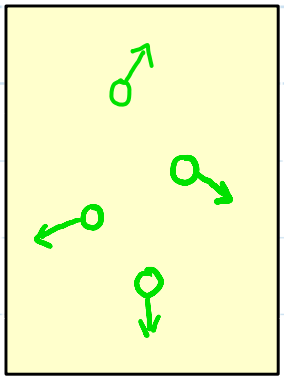
What is happening to K as you increase the temperature?

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

7.7 What Is Le Chatelier's Principle

Changing the Pressure – Gas Phase Equilibria

PRESSURE : Force per unit area.



1) Collisions

2) Momentum

$R \Leftrightarrow P$

$$K = \frac{[P]}{[R]} \qquad [\,] = \frac{\#\,mol}{V(L)}$$

GAS Reactions : • = Gas molecule

1) $\bullet \Leftrightarrow \bullet$ $\quad K = \dfrac{[P]}{[R]}$

2) $\bullet \Leftrightarrow \bullet + \bullet$ $\quad K = \dfrac{[P][P]}{[R]}$

3) $\bullet + \bullet \Leftrightarrow \bullet$ $\quad K = \dfrac{[P]}{[R][R]}$

7.7 What Is Le Chatelier's Principle

Changing the Pressure – Gas Phase Equilibria

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

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

8.8 What Is Le Chatelier's Principle

Changing the Pressure – Summary

Action:	Equilibrium Shift:	Why:
1) $O_3(g) + NO(g) \Leftrightarrow O_2(g) + NO_2(g)$		• + • ⇔ • + •
V↑, P↓	No shift.	The $\frac{[O_2][NO_2]}{[O_3][NO]}$ ratio is unaffected, the system remains at equilibrium.
V↓, P↑	No shift.	
2) $2\,NOCl(g) \Leftrightarrow 2\,NO(g) + Cl_2(g)$		
V↑, P↓	Towards products.	The $\frac{[NO]^2[Cl_2]}{[NOCl]^2}$ ratio is changed, the system shifts to restore this ratio back to K.
V↓, P↑	Towards reactants.	
3) $N_2(g) + 3\,H_2(g) \Leftrightarrow 2\,NH_3(g)$		
V↑, P↓	Towards reactants.	The $\frac{[NH_3]^2}{[N_2][H_2]^3}$ ratio is changed, the system shifts to restore this ratio back to K.
V↓, P↑	Towards products.	

7.7 Le Chatelier's and Hemoglobin