2.3 What Causes an Equilibrium?

A reaction will either:

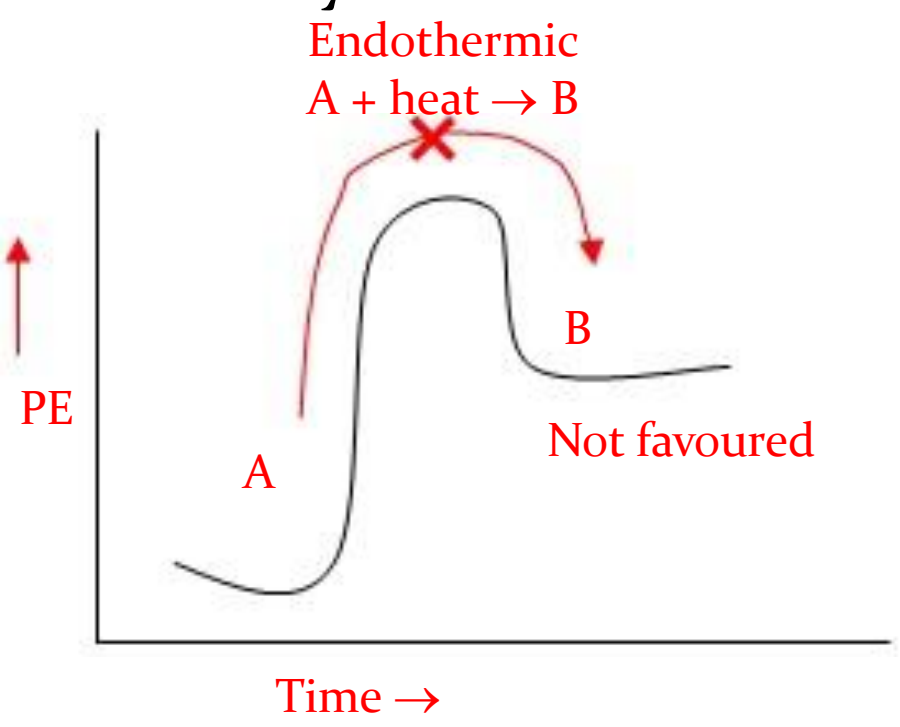
1. *proceed forward*
2. *not proceed (proceed in reverse)*
3. *form an equilibrium.*

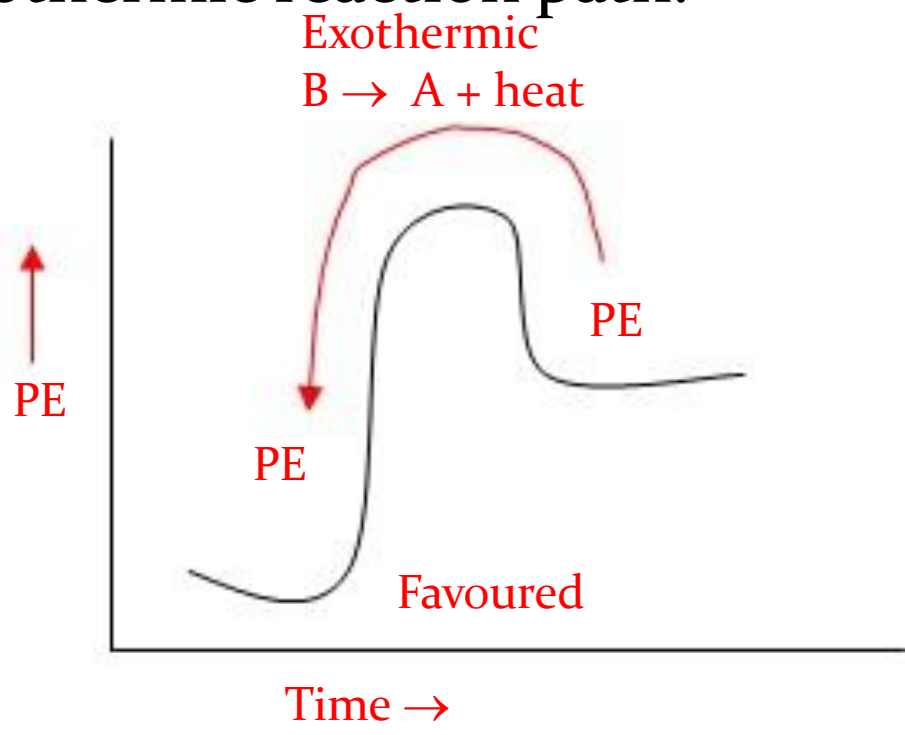
2.3 What Causes an Equilibrium?

a) Enthalpy

i) The side of the reaction having the **least enthalpy** is favored.

ii) In other words, the exothermic reaction path is more likely to occur than the endothermic reaction path.





2.3 What Causes an Equilibrium?

iii) Therefore, we should expect exothermic reactions to go to completion and not be reversible or at least in equilibrium!

iv) We should also expect endothermic reaction to never occur spontaneously.

(i.e.: without cranking up the temperature, or other outside forces)

But both (iii) and (iv) occur!! Think "Cold Packs" for (iv)!!!

So there must be another factor that affects equilibrium!

2.3 What Causes an Equilibrium?

b) Entropy

i) What is "entropy"?

disorder, randomness, unorganized

ii) How is entropy related to our universe?

Probability is high that events occurring in life will lead to more disorder!

Example: When you open a box of Smarties after shaking, are all the colours in order?!

No! Probability of reorganizing low…

Example: Why doesn't an ordered crystal of salt stay ordered when placed in water? What happens to the ions?! (see pg 44)

2.3 What Causes an Equilibrium?

- So there are two 'tendencies' of any reaction

1. Tendency to go to the side with MINIMUM enthalpy
2. Tendency to go to the side with MAXIMUM entropy

2.3 What Causes an Equilibrium?

iii) How does entropy affect reaction equilibrium?

The side of the reaction having most entropy is favored

c) How do we Decide which Side of a Reaction has the most Entropy?

i) Phase Most entropy ⟵ Least entropy

Gases > Solutions(aq) > Liquids > Solids

e.g.: $C_2H_2Cl_{4\,(l)} \rightarrow C_2H_{2\,(g)} + 2Cl_{2\,(g)}$

least entropy most entropy

2.3 What Causes an Equilibrium?

ii) Number of Molecules

The side of the reaction having the most molecules has most entropy

e.g.: $3H_{2\,(g)} + N_{2\,(g)} \rightarrow 2NH_{3\,(g)}$

most entropy — least entropy

But what if more than one phase is present in the reaction??

iii) Combo of (i) and (ii)

Maximum entropy is the side that has the most particles of the most random phase!!

2.3 What Causes an Equilibrium?

d) Examples

(1) Consider the reaction: $CaCO_{3\,(s)} + \text{energy} \rightarrow CaO_{\,(s)} + CO_{2\,(g)}$

a) **minimum enthalpy** favors the formation of _____

reactants, products

b) **maximum entropy** favors the formation of _____

reactants, products

c) Overall, the reaction will _____

form an equilibrium, go forward only, go in reverse only

2.3 What Causes an Equilibrium?

(2) Consider the reaction: $2NF_{3\,(l)} \rightarrow N_{2\,(g)} + 3F_{2\,(g)} + \text{energy}$

a) **minimum enthalpy** favors the formation of _____

reactants, products

b) **maximum entropy** favors the formation of _____

reactants, products

c) Overall, the reaction will _____

form an equilibrium, go forward only, go in reverse only

2.3 What Causes an Equilibrium?

(3) Consider the reaction: $2XeO_{3\,(s)} \rightarrow 2Xe_{(g)} + 3O_{2\,(g)} + \text{energy}$

a) **minimum enthalpy** favors the formation of _____

reactants, products

b) **maximum entropy** favors the formation of _____

reactants, products

c) Overall, the reaction will _____

form an equilibrium, go forward only, go in reverse only

2.3 What Causes an Equilibrium?

(4) Consider the reaction: $H_{2\,(g)} + Zn(ClO_3)_{2\,(s)} + \text{energy} \rightarrow 2HClO_{3\,(l)} + Zn_{\,(s)}$

a) **minimum enthalpy** favors the formation of _____

reactants, products

b) **maximum entropy** favors the formation of _____

reactants, products

c) Overall, the reaction will _____

form an equilibrium, go forward only, go in reverse only

Hebden: work through examples on page 47-48

Do questions: #14-16 page 48-49