

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[TP] For the reaction $2 \text{H}_2\text{O}(g) \rightarrow 2 \text{H}_2(g) + \text{O}_2(g)$, what temperature range will result in the **greatest amount of products (largest K)**?

25% 1. Very low T
 25% 2. Very high T
 25% 3. The amount will be the same at all T
 25% 4. More information needed

BOSTON UNIVERSITY Response Counter 10 1

Lecture 32 CH102 A1 (MWF 9:05 am)
 Friday, April 13, 2018

- Complete: $\Delta G, E, \Delta H, \Delta S, Q, K,$ and T

Next lecture: Begin ch18: Definition of "rate"; rate versus [...] from experiment; making sense of rate versus [...]: Reaction mechanisms

BOSTON UNIVERSITY

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

$\Delta G, \Delta H, \Delta S, E, Q, K,$ and T

$$\Delta G = -nFE_{\text{cell}} = RT \ln(Q/K) = \Delta H - T\Delta S$$

How about for standard states?

$$\Delta G^\circ = -nFE_{\text{cell}}^\circ = RT \ln(1/K) = \Delta H^\circ - T\Delta S^\circ$$

BOSTON UNIVERSITY 5

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

Connection between T and K

$$RT \ln(1/K) = \Delta H^\circ - T\Delta S^\circ$$

For values of T near 298 K, ΔH° and ΔS° are nearly constant.
 What does this tell us about the graph of $\ln(K)$ versus $1/T$?

BOSTON UNIVERSITY 6

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

Connection between T and K

Rearrange $RT \ln(1/K) = \Delta H^\circ - T\Delta S^\circ$ into the equation $y = mx + b$ with

$$y = \ln(K)$$

$$x = 1/T \dots$$

$$\ln(K) = -\Delta H^\circ/R(1/T) + \Delta S^\circ/R$$

$$y = m x + b$$

BOSTON UNIVERSITY

7

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[TP] What do we need to know to sketch $\ln(K) = -\Delta H^\circ/R(1/T) + \Delta S^\circ/R$?

- 17% 1. How K changes with T
- 17% 2. The sign of ΔH°
- 17% 3. The sign of ΔS°
- 17% 4. All of the above
- 17% 5. Either (1), or (2) and (3)
- 17% 6. Some other factor(s)

BOSTON UNIVERSITY

Response Counter

10

8

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

Connection between T and K

What do we need to make a sketch of $y = \ln(K)$ versus $x = 1/T$ for the process **steam** \rightarrow **water**?

Can we get what we need to make the sketch?

BOSTON UNIVERSITY

9

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

Connection between T and K

Make a sketch of $y = \ln(K)$ versus $x = 1/T$ for the process **steam** \rightarrow **water**.
If it crosses the $1/T$ axis, specify where relative to $1/(298 \text{ K})$.

BOSTON UNIVERSITY

10

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018

Copyright © 2018 Dan Dill dan@bu.edu

[TP] For the reaction $\text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l)$, at what temperature range will result in the **greatest amount of products (largest K)**?

- 25% 1. Very low T
 25% 2. Very high T
 25% 3. The amount will be the same at all T
 25% 4. More information needed



Response Counter



11

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018

Copyright © 2018 Dan Dill dan@bu.edu

[TP] For the reaction $2 \text{H}_2\text{O}(g) \rightarrow 2 \text{H}_2(g) + \text{O}_2(g)$, what temperature range will result in the **greatest amount of products (largest K)**?

- 25% 1. Very low T
 25% 2. Very high T
 25% 3. The amount will be the same at all T
 25% 4. More information needed



Response Counter



12

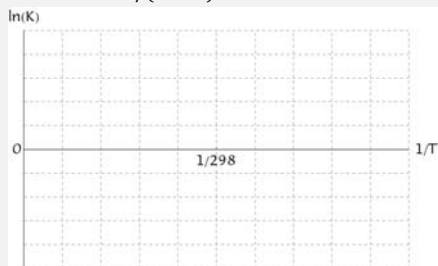
Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018

Copyright © 2018 Dan Dill dan@bu.edu

Connection between T and K

$$\ln(K) = -\Delta H^\circ/R(1/T) + \Delta S^\circ/R$$

Sketch $\ln(K)$ versus $1/T$ for $2 \text{H}_2\text{O}(g) \rightarrow 2 \text{H}_2(g) + \text{O}_2(g)$. If it crosses the $1/T$ axis, specify where relative to $1/(298 \text{ K})$.



13

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018

Copyright © 2018 Dan Dill dan@bu.edu

[TP] For the reaction $2 \text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$, what temperature range will result in the **greatest amount of products (largest K)**?

- 25% 1. Very low T
 25% 2. Very high T
 25% 3. The amount will be the same at all T
 25% 4. More information needed



Response Counter



14

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[Quiz] The reaction $2 \text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$ is **exothermic**. What temperature range will result in the **greatest amount of products (largest K)**?

25% 1. Very low T
 25% 2. Very high T
 25% 3. The amount will be the same at all T
 25% 4. More information needed

BOSTON UNIVERSITY Response Counter 10 15

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[Group Quiz] The exothermic reaction $2 \text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$ has the greatest amount of products (largest K) at very low T . The reason for this is that ...

17% 1. $\Delta_r S^\circ < 0$
 17% 2. heat is a "product" so removing heat (decreasing T) shifts equilibrium to products
 17% 3. $\Delta_r H^\circ < 0$ and so K increases as T is decreased.
 17% 4. 1, 2 and 3
 17% 5. 1 and 3
 17% 6. Something else

BOSTON UNIVERSITY Response Counter 10 17

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[TP] A certain chemical reaction is **not spontaneous when $Q = 1$** at 300 K. The **entropy change** for the reaction is **+130 J/K**. The reaction **must be ...**

25% 1. endothermic
 25% 2. exothermic
 25% 3. neither ($\Delta H = 0$)
 25% 4. More information needed

BOSTON UNIVERSITY Response Counter 10 22

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[TP] A chemical reaction is **endothermic** and has **$\Delta S_{\text{sys}} < 0$** . This means the reaction **will be spontaneous when $Q = 1$...**



0% 1. only at low temperature
 0% 2. only at high temperature
 0% 3. always
 0% 4. never
 0% 5. Further information required

BOSTON UNIVERSITY Response Counter 10 23

Lecture 32 CH102 A1 (MWF 9:05 am) Spring 2018 Copyright © 2018 Dan Dill dan@bu.edu

[Quiz] At 300 K, when $Q = 1$ hydrogen burns vigorously in oxygen to form water. At **very high temperature**, water will ...

- 0% 1. decompose into H_2 and O_2
- 0% 2. will not decompose into H_2 and O_2
- 0% 3. More information needed

 Response Counter  24