

Lecture 22 CH101 A1 (MWF 9:05 am) Fall 2018 Copyright © 2016 Dan Dill dan@bu.edu

[TP] Aqueous solutions at the same temperature are combined, a reaction occurs, and the temperature of the combined solutions goes up. The **water** is ...

33% 1. the system
33% 2. the surroundings
33% 3. neither system nor surroundings

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Response Counter 10 1

Lecture 22 CH101 A1 (MWF 9:05 am)

Friday, October 26, 2018

For today ...

- System vs. surroundings
- Detecting heat
- Predicting the sign of heat

Next lecture: Detecting work; Amount of heat depends on whether there is work

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System vs. surroundings

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Chemical system, chemical surroundings

In chemical reactions, energy change is due to bond breaking and bond making as reactants become products.

The “system” is the **collection of reactants and products**.

The “surroundings” is **everything else**.

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Chemical system, chemical surroundings

In **aqueous reactions**, the containing water is part of the surroundings.

Heat released by the "system" **warms the solution**.


Heat absorbed by the "system" **cools the solution**.

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33% 1. the system
33% 2. the surroundings
33% 3. neither system nor surroundings

 Response Counter 10 7

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[TP] Aqueous solutions at the same temperature are combined, a reaction occurs, and the temperature of the combined solutions goes up. The **reactants** are ...

25% 1. the system
25% 2. the surroundings
25% 3. part of the system
25% 4. part of the surroundings


 Response Counter 10 8

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[Quiz] Acetic acid dissolves in water as a weak electrolyte,

$$\text{CH}_3\text{COOH}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{CH}_3\text{COO}^-(aq)$$
 In the acetic acid solution, the acetate ion, $\text{CH}_3\text{COO}^-(aq)$, is ...

25% 1. the system
25% 2. the surroundings
25% 3. part of the system
25% 4. part of the surroundings

 Response Counter 10 9

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Detecting heat

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How do we know heat is present?

Since $q_{\text{surr}} = m c \Delta T_{\text{surr}}$...
 we can use **temperature change of surroundings** to monitor **heat flow**.

Temperature **increase in surroundings**, $\Delta T_{\text{surr}} > 0$, means ...
 energy flow **out of system** into surroundings ...
 energy of system **goes down** ...
 and so, $q < 0$.

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How do we know heat is present?

Since $q_{\text{surr}} = m c \Delta T_{\text{surr}}$...
 we can use **temperature change of surroundings** to monitor **heat flow**.

Temperature **decrease in surroundings**, $\Delta T_{\text{surr}} < 0$ means ...
 energy flow from surroundings **into system** ...
 energy of system **goes up** ...
 and so, $q > 0$.

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For chemical processes, T_{sys} does not change

For $A-A \rightleftharpoons 2 A$, energy is required to break the bonds
 Energy **comes from surroundings** and so T_{sur} **goes down**
 Since this energy is **used to break the bonds**, T_{sys} **does not change**

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[TP] When $\text{NaHCO}_3(s)$ is dissolved in 200 mL of $\text{HCl}(aq)$, the **temperature of the solution goes down**. This means the chemical reaction between the $\text{NaHCO}_3(s)$ and the $\text{HCl}(aq)$ results in the chemical **system** ...

- 25% 1. giving off heat and so $q > 0$
- 25% 2. giving off heat and so $q < 0$
- 25% 3. absorbing heat and so $q < 0$
- 25% 4. absorbing heat and so $q > 0$



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[TP] Is $2 A-B \rightleftharpoons 2 A + 2 B$ endothermic ($q > 0$) or exothermic ($q < 0$)?

- 33% 1. Endothermic
- 33% 2. Exothermic
- 33% 3. Further information needed



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[TP] Is $2 A \rightleftharpoons A-A$ endothermic ($q > 0$) or exothermic ($q < 0$)?

- 33% 1. Endothermic
- 33% 2. Exothermic
- 33% 3. Further information needed



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[TP] Is $2 A-B \rightleftharpoons A-A + B-B$ endothermic ($q > 0$) or exothermic ($q < 0$)?

- 33% 1. Endothermic
- 33% 2. Exothermic
- 33% 3. Further information needed



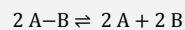
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Reactants are only part of the system

In general, energy changes in chemical reactions are due to both **bond breaking** and **bond breaking**.



is endothermic, since **breaking bonds** always **requires energy**



are each exothermic, since **making bonds** always **releases energy**



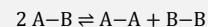
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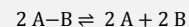
Reactants are only part of the system

We **cannot know** whether

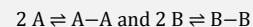


is endothermic ($q > 0$) or exothermic ($q < 0$) ...

without knowing whether the **energy need** for bond breaking



is larger or smaller than the **energy release** of bond making



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Reactants are only part of the system

To know the sign of q we must always consider **both reactants and products**, and for this reason, in chemical reactions, the **system consists of both the reactants and products**.



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[Quiz] Consider the reaction $2 H_2O(l) + 3 CH_4(g) + CO_2(g) \rightleftharpoons 4 CH_3OH(l)$. This reaction must ...

- 20% 1. give off heat and so $q > 0$
- 20% 2. give off heat and so $q < 0$
- 20% 3. absorb heat and so $q < 0$
- 20% 4. absorb heat and so $q > 0$
- 20% 5. Further information needed



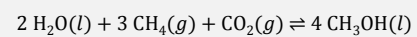
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Reactants are only part of the system

To know the sign of q we must always consider **both reactants and products**.
For the reaction



It turns out that

$$q = +236.2 \text{ kJ}$$

That is, the cost of bond breaking in the reactants exceeds the gain of bond making in the products.



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