[TP] The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). How will ΔU change depending on whether the reaction is run in a sealed flask (constant V) or an open flask (constant P)?

33% 1. ΔU will not change

33% 2. ΔU will change depending on work w

33% 3. Cannot know without further information

Lecture 23 CH101 A1 (MWF 9:05 am)

Wednesday, November 1, 2017

For today ...

- Practice with first law
- Amount of heat depends on whether there is work

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

Practice with first law

Gaseous reactants are turned into gaseous products in a cylinder with piston that moves to maintain constant pressure of the mixture at 1 atm. The cylinder is submerged in a large insulated water bath.

The chemical reaction is known to absorb 325 kJ of energy.

From the temperature change of the water bath it is determined that 450 kJ of heat flows into the system.

What is ΔU? What is q? What is w?

Practice with first law

Gaseous reactants are turned into gaseous products in a cylinder with piston that moves to maintain constant pressure of the mixture at 1 atm. The cylinder is submerged in a large insulated water bath.

The chemical reaction is known to absorb 325 kJ of energy.

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What is ΔU? What is q? What is w?

$\Delta U = q + w = 325$ kJ

$q = +450$ kJ

$w = \Delta U - q = -125$ kJ

Practice with first law

Gaseous reactants are turned into gaseous products in a cylinder with piston that moves to maintain constant pressure of the mixture at 1 atm. The cylinder is submerged in a large insulated water bath.

The chemical reaction is known to absorb 325 kJ of energy.

From the temperature change of the water bath it is determined that 450 kJ of heat flows into the system.

Is the reaction exothermic or endothermic?

Since $q = +450$ kJ > 0, the reaction is endothermic.

Practice with first law

Gaseous reactants are turned into gaseous products in a cylinder with piston that moves to maintain constant pressure of the mixture at 1 atm. The cylinder is submerged in a large insulated water bath.

The chemical reaction is known to absorb 325 kJ of energy.

From the temperature change of the water bath it is determined that 450 kJ of heat flows into the system.

Does the water bath temperature increase or decrease?

Since $q = +450$ kJ > 0, the heat bath temperature has gone down.

Practice with first law

Gaseous reactants are turned into gaseous products in a cylinder with piston that moves to maintain constant pressure of the mixture at 1 atm. The cylinder is submerged in a large insulated water bath.

The chemical reaction is known to absorb 325 kJ of energy.

From the temperature change of the water bath it is determined that 450 kJ of heat flows into the system.

Does the piston move in or out of the container?

Since $w = -125$ kJ < 0, the system has done work; the piston moves out

The amount of heat depends on whether there is work

$\Delta U = q_V$ can be different from $\Delta H = q_P$

Express this in a sentence, without using symbols or jargon

Heat depends on whether there is work

The reaction

$NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$

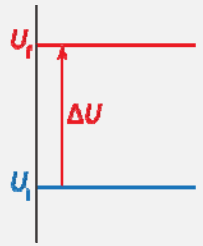
is endothermic, $q > 0$ (solution/surroundings cool).

How much cooling is there at constant volume (q_V) compared to that at constant pressure (q_P)?

Let's learn how to predict what we expect…

Heat depends on whether there is work

The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). Sketch the energy diagram for this reaction: Indicate the initial and final energy by horizontal lines labeled U_i and U_f, respectively, and connect the lines by an arrow labeled ΔU.



[TP] The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). How will U_i change depending on whether the reaction is run in a sealed flask (constant V) or an open flask (constant P)?

33% 1. U_i change will not change
33% 2. U_i change will change depending on work w
33% 3. Cannot know without further information

[TP] The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). How will U_f change depending on whether the reaction is run in a sealed flask (constant V) or an open flask (constant P)?

33% 1. U_f change will not change
33% 2. U_f change will change depending on work w
33% 3. Cannot know without further information

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Heat depends on whether there is work

The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). Since U_i and U_f are not affected by how the reaction is carried out…

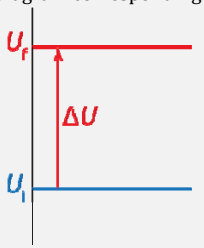
ΔU is always the same for a given reaction

ΔU is like a social security number of the reaction; it never changes

Heat depends on whether there is work

The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). Assume that the flask is sealed, so that gas generated cannot escape, and so no work is done ($w = 0$).

Add an arrow to the energy diagram corresponding to q_V.



Heat depends on whether there is work

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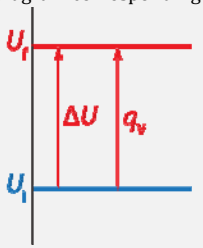

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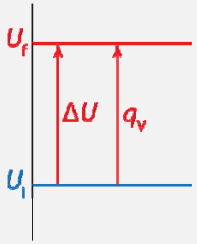
Based on your q_V arrow, what is the relation between ΔU and q_V?



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Heat depends on whether there is work

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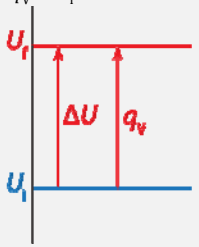
Since $U_i + q_V$ ends at U_f, $U_i + q_V = U_f$ ...

$U_f - U_i = \Delta U = q_V$



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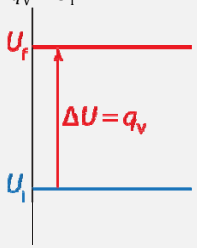
Since $U_i + q_V$ ends at U_f, $U_i + q_V = U_f$ ...

$U_f - U_i = \Delta U = q_V$

The value of q_V *is* ΔU

For a given reaction ...

$\Delta U = q_V$ never changes



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