

[TP] Consider the reaction $2\ H_2O(l) + 3\ CH_4(g) + CO_2(g) \rightleftharpoons 4\ CH_3OH(l)$.
This chemical system must be …

20% 1. doing work and so $w > 0$
20% 2. doing work and so $w < 0$
20% 3. having work done on it and so $w > 0$
20% 4. having work done on it and so $w < 0$
20% 5. Further information needed

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Lecture 23 CH101 A2 (MWF 11:15 am)

Wednesday, October 31, 2018

For today …
- Detecting work
- Amount of heat depends on whether there is work

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

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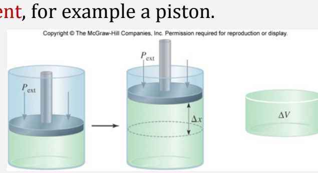
How do we know if work is present?

Macroscopic movement, for example a piston.



Work done by gas: force × distance = $(F / A) \times (\Delta x\ A) = P_{ext}\ \Delta V$

Work done on gas: $w = -P_{ext}\ \Delta V$

Expansion of gas pushes against P_{ext}, gas expends energy, $w < 0$

Compression of gas pushed on by P_{ext}, gas gains energy, $w > 0$

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[Quiz] When $NaHCO_3(s)$ is dissolved in 200 mL of $HCl(aq)$, $CO_2(g)$ bubbles form. This means the chemical reaction between the $NaHCO_3(s)$ and the $HCl(aq)$ must be ...

20% 1. doing work and so $w > 0$
20% 2. doing work and so $w < 0$
20% 3. having work done on it and so $w > 0$
20% 4. having work done on it and so $w < 0$
20% 5. Further information needed

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The amount of heat depends on whether there is work

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

Complete this sentence: If you carry out a reaction in a sealed, rigid container the heat ...

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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).

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

Let's carry out the reaction to see.

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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).

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

Let's learn how to predict the difference between q_V and q_P.

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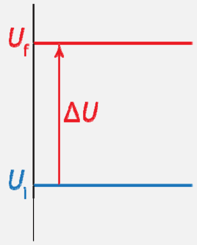
Heat depends on whether there is work

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). 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.



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[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

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[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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[Quiz] 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

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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

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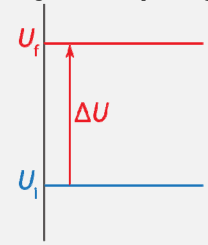
Heat depends on whether there is work

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). 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.



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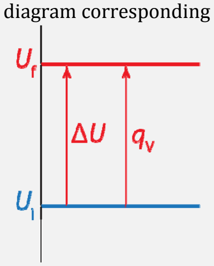

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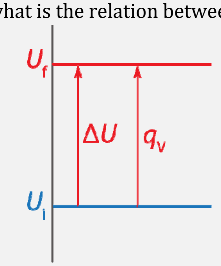
Based on your q_V arrow, what is the relation between ΔU and q_V?



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Heat depends on whether there is work

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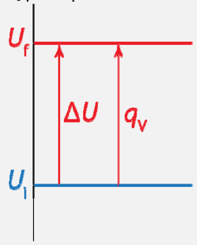
Since $U_i + q_V$ ends at U_f, $U_i + q_V = U_f$ ...

$U_f - U_i = \Delta U = q_V$



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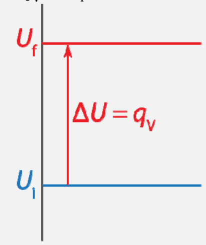
Since $U_i + q_V$ ends at U_f, $U_i + q_V = U_f$ ...

$U_f - U_i = \Delta U = q_V$

The value of q_V *is* ΔU

For a given reaction ...

$\Delta U = q_V$ never changes



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