[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). Make a prediction about how much cooling there is when the flask is sealed (constant volume) compared to when the flash is open (constant pressure).

25% 1. Cooling is smaller at constant volume, $q_V < q_P$
25% 2. Cooling is the same at constant volume, $q_V = q_P$
25% 3. Cooling is greater at constant volume, $q_V > q_P$
25% 4. Unable to know without further information

Response Counter 10

Lecture 24 CH101 A1 (MWF 9 am)

Friday, November 4, 2016

- Complete: Amount of heat depends on whether there is work

Next lecture: Temperature equilibration (heat leveling); heating curves; enthalpy change of reaction, $\Delta_r H$; [Calorimetry, pp 231–232, done in lab]

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…

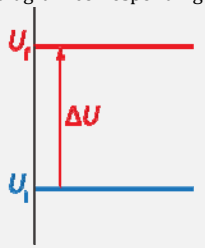
ΔU is always the same for a given reaction

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 ($w = 0$).

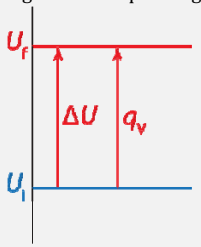
Add an arrow to the energy diagram corresponding to q_V.



Heat depends on whether there is work

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.

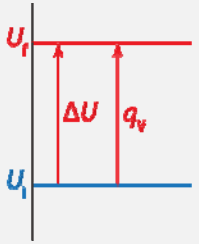


BOSTON UNIVERSITY

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 ($w = 0$).

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



BOSTON UNIVERSITY

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 ($w = 0$).

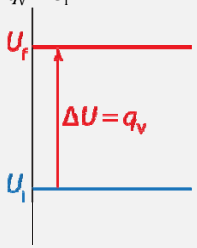
Since $U_i + q_V$ ends at U_f, $U_i + q_V = U_f$ ...

$U_f - U_i = \Delta U = q_V$

The value of q_V is ΔU

For a given reaction ...

$\Delta U = q_V$ never changes



BOSTON UNIVERSITY

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 measure to see...

BOSTON UNIVERSITY

Heat depends on whether there is work

Analysis of experiments

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

BOSTON UNIVERSITY

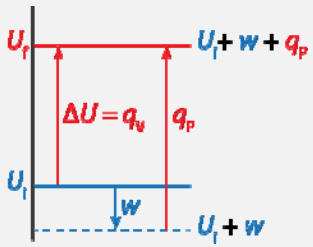
Heat depends on whether there is work

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 would your energy diagram change if the flask were open?

BOSTON UNIVERSITY

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 would your energy diagram change if the flask were open?



BOSTON UNIVERSITY

[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). Comparing your two energy diagrams, make a prediction about how much cooling there is when the flask is sealed (constant volume) compared to when the flash is open (constant pressure).

25% 1. Cooling is smaller at constant volume, $q_V < q_P$
25% 2. Cooling is the same at constant volume, $q_V = q_P$
25% 3. Cooling is greater at constant volume, $q_V > q_P$
25% 4. Unable to know without further information

BOSTON UNIVERSITY

Response Counter 10

Can *w* change the sign of *q*?

Answer: In principle yes; in practice, no.

w is always very small compared with q_V,

and so q_P always has the same sign as q_V.

BOSTON UNIVERSITY

[Quiz] Combustion $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$ is exothermic, $q < 0$ (solution/surroundings warm). Based on the energy diagrams, how much warming is there at constant volume (q_V), compared to that at constant pressure (q_P)?

25% 1. Warming is greater at constant volume, $|q_V| > |q_P|$

25% 2. Warming is the same at constant volume, $|q_V| = |q_P|$

25% 3. Warming is smaller at constant volume, $|q_V| < |q_P|$

25% 4. Unable to know without further information

BOSTON UNIVERSITY

Response Counter 10

Heat depends on whether there is work

The combustion $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$ is exothermic, $q > 0$ (solution/surroundings warm). Sketch the two energy diagrams for this process, once for a sealed flask, one for an open flask.

BOSTON UNIVERSITY

Heat depends on whether there is work

What we have learned …

ΔU never changes for a reaction, whether there is work or not. Its numerical value is q_V, the heat were the process to be carried out in a sealed, rigid container (constant volume).

$\Delta U = q_V$ always.

$\Delta H = q_P$ always.

If work is present, construct the energy diagram connecting U_i and U_f for the process, to determine how $q = q_P = \Delta H$ compares to $q_V = \Delta U$

BOSTON UNIVERSITY