

[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

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Lecture 24 CH101 A1 (MWF 9:05 am)

Friday, November 3, 2017

For today ...

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

Next lecture: Temperature equilibration; Heating curves; Enthalpy change of reaction, $\Delta_r H$; [Calorimetry, pp 231–232, done in lab]; Hess's law; Standard states and standard $\Delta_r H$; Standard enthalpy of formation, $\Delta_f H°$; using $\Delta_f H°$ to compute *any* $\Delta_r H$; bond enthalpies, $\Delta_b H$; Using $\Delta_b H$ to *estimate* $\Delta_r H$.

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Heat depends on whether there is work

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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 measure to see...

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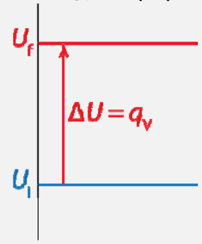
The reaction $NaHCO_3(s) + H_3O^+(aq) \rightarrow CO_2(g) + Na^+(aq) + 2\ H_2O(l)$ is endothermic, $q > 0$ (solution/surroundings cool). Assume that the flask is open, so that gas generated can escape, and so that work is done by the released CO_2 ($w < 0$).

Draw a new energy diagram showing just U_i, U_f, and $\Delta U = q_V$.



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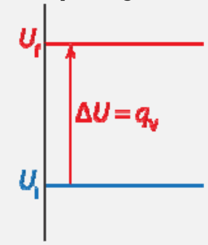
Add an arrow starting at U_i corresponding to w.



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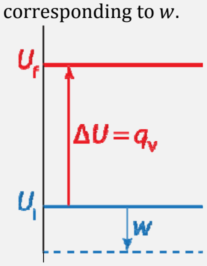

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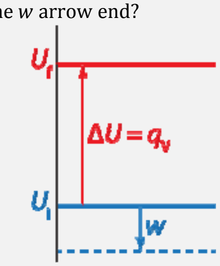
At what value of U does the w arrow end?



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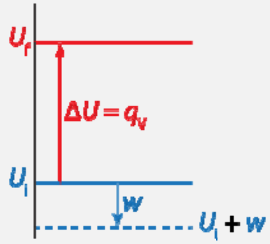
At what value of U does the w arrow end?

$U_i + w$



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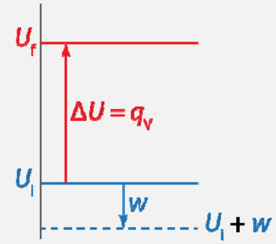
Draw an arrow a from the head of w (that is, $U_i + w$) to U_f



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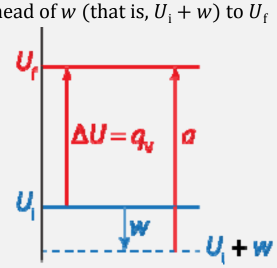

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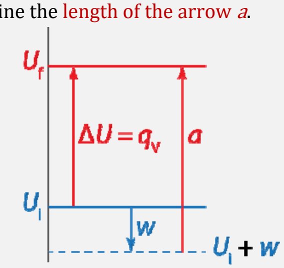
Use the first law to determine the length of the arrow a.



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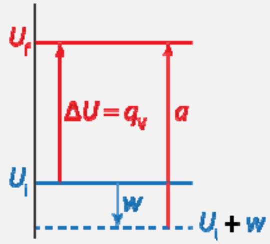
The length of the arrow a is ...

a = head – tail

$= U_f - (U_i + w)$

$= U_f - U_i - w$



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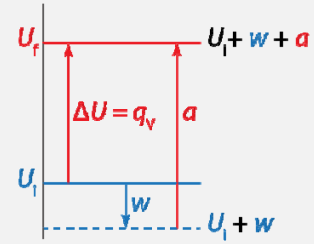
The length of the arrow a is ...

a = head – tail

$= U_f - (U_i + w)$

$= U_f - U_i - w$

$= \Delta U - w$



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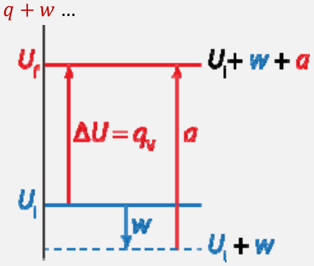
Heat depends on whether there is work

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 open, so that gas generated can escape, and so that work is done by the released CO_2 ($w < 0$).

Since $a = \Delta U - w$ and $\Delta U = q + w$ ...

$a = q + w - w$

$= q$ in the open flask



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Heat depends on whether there is work

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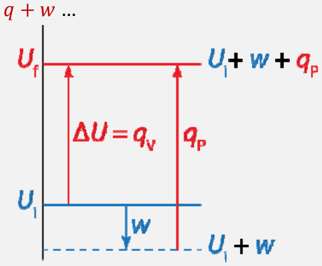
Since $a = \Delta U - w$ and $\Delta U = q + w$ ...

$a = q + w - w$

$= q$ in the open flask

$= q_P$



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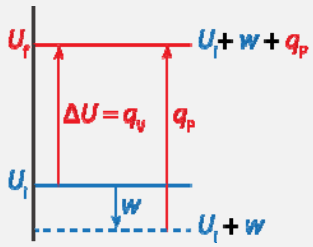
Heat depends on whether there is work

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



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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

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Response Counter

10

18

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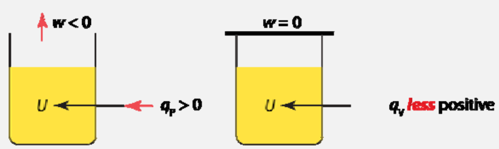
Heat depends on whether there is work



Endothermic reaction that does work on surroundings will get less cold at constant volume.

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Heat depends on whether there is work

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$ 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.

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[Quiz] $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$ 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

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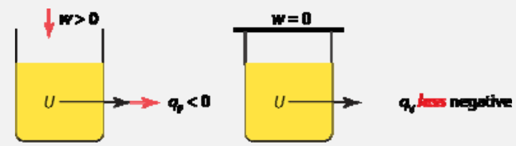
Response Counter 10

Heat depends on whether there is work



Exothermic reaction that has work done on it will get less hot at constant volume.

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Heat depends on whether there is work

What we have learned …

ΔU never changes for a reaction, whether there is work or not.

The numerical value of ΔU is q_V, the heat were the process to be carried out in a sealed, rigid container (constant volume).

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 $q_V = \Delta U$.

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