

Thermochemistry Worksheet – Energy changes involving phase changes

Sample Problem: How much energy is needed to convert 23.0 grams of ice at -10.0°C into steam at 109°C ?

When solving problems involving phase changes, it is helpful to draw a diagram to visualize the different steps involved.

Each of these steps (1-5) is associated with an energy change that is reflected in a calculation.

Step 1: If we start by looking at melting a specific amount of ice, the amount of heat needed to bring the ice up to 0°C is calculated by the equation $\Delta H = mC\Delta T$ with:

ΔH = amount of energy (J)

m = mass (grams)

C = specific heat capacity, $C_{\text{ice}} = 2.10 \text{ J/g}^{\circ}\text{C}$

ΔT = change in temperature ($^{\circ}\text{C}$)

So, for this sample problem: $\Delta H = 23.0 \text{ grams} \times 2.10 \text{ J/g}^{\circ}\text{C} \times 10^{\circ}\text{C} = \underline{483 \text{ J}}$

Step 2: The next step occurs while the ice is melting. There is no temperature change so we cannot use the same equation as before. A particular amount of ice takes a constant amount of heat to melt it. This energy is used to break those hydrogen bonds that hold the water in the crystal structure that makes it ice. This amount of heat is called the heat (or enthalpy) of fusion. Heat of fusion, $\Delta H_{\text{fus}} = 334 \text{ J/g}$ for water.

$23.0 \text{ grams} \times 334 \text{ J/g} = \underline{7682 \text{ J}}$

Step 3: During this step there is a temperature change again, so we use the same equation as in Step 1, $\Delta H = mC\Delta T$ to calculate the energy changes. However, we are now working with a different state of matter, liquid water, so the specific heat value is different. $C_{\text{water}} = 4.18 \text{ J/g}^{\circ}\text{C}$. The temperature change is the difference between the melting point and the boiling point, so 0°C to 100°C .

Solving this step, we get $\Delta H = 23.0 \text{ grams} \times 4.18 \text{ J/g}^{\circ}\text{C} \times 100^{\circ}\text{C} = \underline{9614 \text{ J}}$

Step 4: While the water is boiling, the temperature does not change. The heat of vaporization is the amount of energy it takes to vaporize a particular quantity of a substance. For water, $\Delta H_{\text{vap}} = 2260 \text{ J/g}$.

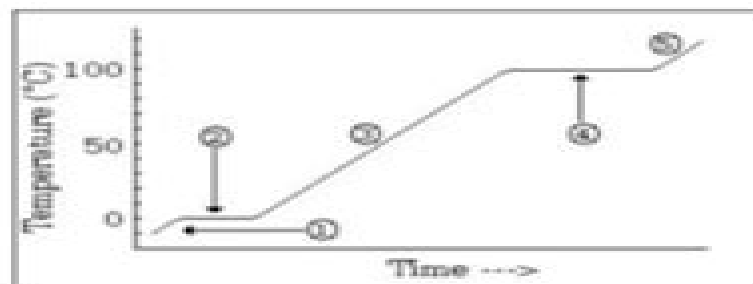
$23.0 \text{ grams} \times 2260 \text{ J/g} = \underline{51980 \text{ J}}$

Step 5: Once the water is in the gas phase, a temperature change occurs again to increase the steam from 100°C to 109°C , so the equation $\Delta H = mC\Delta T$ is used once more. However, we're using a different state of matter now, water vapor, so the specific heat value is $C_{\text{steam}} = 1.70 \text{ J/g}^{\circ}\text{C}$.

Solving this last step, $\Delta H = 23.0 \text{ grams} \times 1.70 \text{ J/g}^{\circ}\text{C} \times 9^{\circ}\text{C} = \underline{351.9 \text{ J}}$

Now, add all 5 steps together. At the end you should probably convert to kJ.

$483 \text{ J (step 1)} + 7682 \text{ J (step 2)} + 9614 \text{ J (step 3)} + 51980 \text{ J (step 4)} + 351.9 \text{ J (step 5)} = \underline{70110.9 \text{ J or } 70.1 \text{ kJ}}$



Not all problems will go through all 5 steps. Diagram it out and choose the appropriate ones.

Thermochemistry Answers Energy Changes

Neil D. Jespersen, Alison Hyslop



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Teaching and Learning of Energy in K - 12 Education Robert F. Chen, Arthur Eisenkraft, David Fortus, Joseph Krajcik, Knut Neumann, Jeffrey Nordine, Allison Scheff, 2014-04-09 This volume presents current thoughts research and findings that were presented at a summit focusing on energy as a cross cutting concept in education involving

scientists science education researchers and science educators from across the world The chapters cover four key questions what should students know about energy what can we learn from research on teaching and learning about energy what are the challenges we are currently facing in teaching students this knowledge and what needs be done to meet these challenges in the future Energy is one of the most important ideas in all of science and it is useful for predicting and explaining phenomena within every scientific discipline The challenge for teachers is to respond to recent policies requiring them to teach not only about energy as a disciplinary idea but also about energy as an analytical framework that cuts across disciplines Teaching energy as a crosscutting concept can equip a new generation of scientists and engineers to think about the latest cross disciplinary problems and it requires a new approach to the idea of energy This book examines the latest challenges of K 12 teaching about energy including how a comprehensive understanding of energy can be developed The authors present innovative strategies for learning and teaching about energy revealing overlapping and diverging views from scientists and science educators The reader will discover investigations into the learning progression of energy how understanding of energy can be examined and proposals for future directions for work in this arena Science teachers and educators science education researchers and scientists themselves will all find the discussions and research presented in this book engaging and informative

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3 1 number and qualifications the business and affairs of the corporation shall be

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board should plan to attend the annual international conference whenever possible the club treasury will assume the cost of
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section 1 the board of directors shall consist of the elected officers of the club the present ambassador or host coordinator standing committee chairpersons and any additional members appointed by a majority vote of the existing board

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the secondary purpose mission of the club is to promote international understanding within the local community all programs are carried out in accordance with the policies and guidelines of friendship force international inc this club is not organized and shall not be operated for pecuniary gain or profit

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