

172 MEASURING AND EXPRESSING ENTHALPY CHANGES SECTION REVIEW WORKSHEET ANSWERS

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IN THE STUDY OF THERMODYNAMICS, ENTHALPY IS A KEY CONCEPT THAT HELPS US UNDERSTAND ENERGY CHANGES IN CHEMICAL REACTIONS. THE 172 MEASURING AND EXPRESSING ENTHALPY CHANGES SECTION REVIEW WORKSHEET IS DESIGNED TO REINFORCE THE UNDERSTANDING OF HOW TO MEASURE AND EXPRESS ENTHALPY CHANGES IN VARIOUS CHEMICAL PROCESSES. THIS ARTICLE WILL DELVE INTO THE ESSENTIAL ASPECTS OF ENTHALPY CHANGES, METHODS TO MEASURE THEM, AND PROVIDE DETAILED EXPLANATIONS OF THE ANSWERS TO COMMON QUESTIONS PRESENTED IN THE WORKSHEET.

UNDERSTANDING ENTHALPY

ENTHALPY (H) IS A THERMODYNAMIC QUANTITY THAT REFLECTS THE TOTAL HEAT CONTENT OF A SYSTEM. IT COMBINES INTERNAL ENERGY (U) WITH THE PRODUCT OF PRESSURE (P) AND VOLUME (V) OF THE SYSTEM:

$$[H = U + PV]$$

ENTHALPY IS PARTICULARLY USEFUL IN CHEMISTRY BECAUSE IT ALLOWS FOR THE ANALYSIS OF HEAT CHANGES DURING CHEMICAL REACTIONS AT CONSTANT PRESSURE. THE CHANGE IN ENTHALPY (ΔH) DURING A REACTION CAN INDICATE WHETHER A REACTION IS EXOTHERMIC (RELEASES HEAT) OR ENDOTHERMIC (ABSORBS HEAT).

TYPES OF ENTHALPY CHANGES

THERE ARE SEVERAL TYPES OF ENTHALPY CHANGES THAT ARE COMMONLY STUDIED:

1. ENTHALPY OF REACTION (ΔH_{rxn}): THE HEAT CHANGE ASSOCIATED WITH A CHEMICAL REACTION.
2. ENTHALPY OF FORMATION (ΔH_{f}): THE HEAT CHANGE WHEN ONE MOLE OF A COMPOUND IS FORMED FROM ITS ELEMENTS IN THEIR STANDARD STATES.
3. ENTHALPY OF COMBUSTION (ΔH_{c}): THE HEAT CHANGE WHEN ONE MOLE OF A SUBSTANCE IS COMPLETELY BURNED IN OXYGEN.
4. ENTHALPY OF SOLUTION (ΔH_{sol}): THE HEAT CHANGE THAT OCCURS WHEN A SOLUTE DISSOLVES IN A SOLVENT.

MEASURING ENTHALPY CHANGES

MEASURING ENTHALPY CHANGES CAN BE ACCOMPLISHED USING A VARIETY OF EXPERIMENTAL METHODS. THE MOST COMMON INCLUDE CALORIMETRY, HESS'S LAW, AND STANDARD ENTHALPY VALUES.

CALORIMETRY

CALORIMETRY IS A TECHNIQUE USED TO MEASURE THE AMOUNT OF HEAT INVOLVED IN A CHEMICAL REACTION. THERE ARE TWO MAIN TYPES OF CALORIMETERS:

- COFFEE CUP CALORIMETER: A SIMPLE, INSULATED CONTAINER USED TO MEASURE THE HEAT CHANGES AT CONSTANT PRESSURE. IT TYPICALLY CONSISTS OF TWO STYROFOAM CUPS, A LID, AND A THERMOMETER.
- BOMB CALORIMETER: A MORE COMPLEX DEVICE USED FOR MEASURING THE HEAT OF COMBUSTION REACTIONS AT CONSTANT VOLUME. IT IS DESIGNED TO WITHSTAND HIGH PRESSURE AND TEMPERATURE.

TO DETERMINE THE CHANGE IN ENTHALPY USING CALORIMETRY, THE FOLLOWING STEPS ARE GENERALLY FOLLOWED:

1. MEASURE THE INITIAL TEMPERATURE OF THE REACTANTS.
2. ALLOW THE REACTION TO PROCEED.
3. MEASURE THE FINAL TEMPERATURE AFTER THE REACTION HAS COMPLETED.
4. USE THE FORMULA:

$$Q = mc\Delta T$$

WHERE:

- Q = HEAT ABSORBED OR RELEASED
- m = MASS OF THE SUBSTANCE
- c = SPECIFIC HEAT CAPACITY
- ΔT = CHANGE IN TEMPERATURE

5. CALCULATE ΔH PER MOLE OF REACTANT IF NECESSARY.

HESS'S LAW

HESS'S LAW STATES THAT THE TOTAL ENTHALPY CHANGE FOR A REACTION IS THE SUM OF THE ENTHALPY CHANGES FOR THE INDIVIDUAL STEPS OF THE REACTION, REGARDLESS OF THE PATHWAY TAKEN. THIS PRINCIPLE ALLOWS CHEMISTS TO CALCULATE ENTHALPY CHANGES FOR REACTIONS THAT ARE DIFFICULT TO MEASURE DIRECTLY BY USING KNOWN ENTHALPY CHANGES OF RELATED REACTIONS.

TO APPLY HESS'S LAW:

1. IDENTIFY THE TARGET REACTION AND THE ENTHALPY CHANGES FOR RELATED REACTIONS.
2. MANIPULATE THE EQUATIONS AS NECESSARY (REVERSING REACTIONS CHANGES THE SIGN OF ΔH).
3. ADD THE ENTHALPY CHANGES TO FIND THE OVERALL ΔH .

STANDARD ENTHALPY VALUES

STANDARD ENTHALPY VALUES (ΔH°) FOR VARIOUS SUBSTANCES CAN BE FOUND IN THERMODYNAMIC TABLES. THESE VALUES REPRESENT THE ENTHALPY CHANGE WHEN ONE MOLE OF A SUBSTANCE IS FORMED FROM ITS ELEMENTS IN THEIR STANDARD STATES AT 1 ATMOSPHERE AND 25°C. BY USING THESE VALUES, ONE CAN CALCULATE THE ENTHALPY CHANGE FOR COMPLEX REACTIONS.

EXPRESSING ENTHALPY CHANGES

ENTHALPY CHANGES CAN BE EXPRESSED IN VARIOUS WAYS DEPENDING ON THE CONTEXT OF THE REACTION BEING STUDIED.

UNITS OF ENTHALPY CHANGE

THE STANDARD UNIT FOR ENTHALPY CHANGE IS JOULES (J), BUT IT IS OFTEN EXPRESSED IN KILOJOULES (kJ) FOR PRACTICALITY, ESPECIALLY IN CHEMISTRY.

$$1 \text{ kJ} = 1000 \text{ J}$$

IN MANY CASES, ENTHALPY CHANGES ARE REPORTED PER MOLE OF A SUBSTANCE, WHICH CAN BE DENOTED AS:

$$\Delta H \text{ (kJ/mol)}$$

SIGN CONVENTION

WHEN EXPRESSING ENTHALPY CHANGES, IT IS CRUCIAL TO APPLY THE CORRECT SIGN CONVENTION:

- EXOTHERMIC REACTIONS: (ΔH) IS NEGATIVE (HEAT IS RELEASED).
- ENDOTHERMIC REACTIONS: (ΔH) IS POSITIVE (HEAT IS ABSORBED).

COMMON QUESTIONS AND ANSWERS FROM THE WORKSHEET

THE 172 MEASURING AND EXPRESSING ENTHALPY CHANGES SECTION REVIEW WORKSHEET OFTEN POSES QUESTIONS TO TEST UNDERSTANDING OF THESE CONCEPTS. BELOW ARE SOME COMMON QUESTIONS AND THEIR ANSWERS.

QUESTION 1: WHAT IS THE SIGNIFICANCE OF THE ENTHALPY OF FORMATION?

ANSWER: THE ENTHALPY OF FORMATION IS SIGNIFICANT BECAUSE IT PROVIDES A MEASURE OF THE ENERGY REQUIRED TO FORM A COMPOUND FROM ITS ELEMENTS IN THEIR STANDARD STATES. THIS VALUE IS CRUCIAL FOR CALCULATING THE ENTHALPY CHANGES IN CHEMICAL REACTIONS USING HESS'S LAW.

QUESTION 2: HOW WOULD YOU CALCULATE THE ENTHALPY CHANGE FOR A COMBUSTION REACTION?

ANSWER: TO CALCULATE THE ENTHALPY CHANGE FOR A COMBUSTION REACTION, YOU WOULD:

1. WRITE THE BALANCED CHEMICAL EQUATION FOR THE COMBUSTION.
2. USE STANDARD ENTHALPY VALUES OF FORMATION FOR THE PRODUCTS AND REACTANTS.
3. APPLY THE FORMULA:

$$\Delta H_{\text{rxn}} = \sum \Delta H_f \text{ (products)} - \sum \Delta H_f \text{ (reactants)}$$

ENSURE TO MULTIPLY THE ENTHALPY VALUES BY THE COEFFICIENTS FROM THE BALANCED EQUATION.

QUESTION 3: EXPLAIN HOW CALORIMETRY CAN BE USED TO DETERMINE THE ENTHALPY CHANGE OF A REACTION.

ANSWER: CALORIMETRY MEASURES THE HEAT TRANSFER DURING A CHEMICAL REACTION. BY RECORDING THE TEMPERATURE CHANGE OF THE CALORIMETER BEFORE AND AFTER THE REACTION, AND KNOWING THE SPECIFIC HEAT CAPACITY AND MASS OF THE SUBSTANCES INVOLVED, YOU CAN CALCULATE THE HEAT ABSORBED OR RELEASED, WHICH CORRESPONDS TO THE ENTHALPY CHANGE OF THE REACTION.

CONCLUSION

UNDERSTANDING HOW TO MEASURE AND EXPRESS ENTHALPY CHANGES IS FUNDAMENTAL IN THE STUDY OF THERMODYNAMICS AND CHEMISTRY. THE 172 MEASURING AND EXPRESSING ENTHALPY CHANGES SECTION REVIEW WORKSHEET SERVES AS AN EXCELLENT TOOL FOR REINFORCING THESE CONCEPTS. BY EMPLOYING CALORIMETRY, HESS'S LAW, AND STANDARD ENTHALPY VALUES, STUDENTS CAN GAIN A COMPREHENSIVE UNDERSTANDING OF HOW TO QUANTIFY ENERGY CHANGES IN CHEMICAL REACTIONS. MASTERY OF THESE PRINCIPLES NOT ONLY AIDS IN ACADEMIC PURSUITS BUT ALSO LAYS THE GROUNDWORK FOR PRACTICAL APPLICATIONS IN VARIOUS SCIENTIFIC FIELDS.

FREQUENTLY ASKED QUESTIONS

WHAT IS ENTHALPY AND WHY IS IT IMPORTANT IN THERMODYNAMICS?

ENTHALPY IS A THERMODYNAMIC QUANTITY THAT REPRESENTS THE TOTAL HEAT CONTENT OF A SYSTEM. IT IS IMPORTANT BECAUSE IT HELPS TO UNDERSTAND HEAT TRANSFER IN CHEMICAL REACTIONS AND PHYSICAL CHANGES AT CONSTANT PRESSURE.

HOW DO YOU CALCULATE THE CHANGE IN ENTHALPY (ΔH) FOR A REACTION?

THE CHANGE IN ENTHALPY (ΔH) FOR A REACTION CAN BE CALCULATED USING THE FORMULA $\Delta H = H(\text{PRODUCTS}) - H(\text{REACTANTS})$, WHERE H REPRESENTS THE ENTHALPY OF THE RESPECTIVE SUBSTANCES.

WHAT ARE THE STANDARD CONDITIONS FOR MEASURING ENTHALPY CHANGES?

STANDARD CONDITIONS FOR MEASURING ENTHALPY CHANGES ARE TYPICALLY DEFINED AS 1 ATMOSPHERE OF PRESSURE AND A SPECIFIED TEMPERATURE, USUALLY 25 DEGREES CELSIUS (298 K).

WHAT IS THE SIGNIFICANCE OF A POSITIVE ΔH VALUE?

A POSITIVE ΔH VALUE INDICATES THAT THE REACTION IS ENDOTHERMIC, MEANING THAT IT ABSORBS HEAT FROM ITS SURROUNDINGS DURING THE PROCESS.

WHAT DOES A NEGATIVE ΔH VALUE SIGNIFY?

A NEGATIVE ΔH VALUE SIGNIFIES THAT THE REACTION IS EXOTHERMIC, INDICATING THAT IT RELEASES HEAT TO ITS SURROUNDINGS.

HOW CAN HESS'S LAW BE APPLIED TO CALCULATE ENTHALPY CHANGES?

HESS'S LAW STATES THAT THE TOTAL ENTHALPY CHANGE FOR A REACTION IS THE SUM OF THE ENTHALPY CHANGES FOR INDIVIDUAL STEPS. THUS, YOU CAN USE IT TO CALCULATE ΔH BY COMBINING KNOWN ENTHALPY CHANGES FROM RELATED REACTIONS.

WHAT ROLE DOES CALORIMETRY PLAY IN MEASURING ENTHALPY CHANGES?

CALORIMETRY IS AN EXPERIMENTAL TECHNIQUE USED TO MEASURE THE AMOUNT OF HEAT ABSORBED OR RELEASED DURING A CHEMICAL REACTION, WHICH ALLOWS FOR THE DETERMINATION OF THE ENTHALPY CHANGE (ΔH) OF THAT REACTION.

WHAT IS THE DIFFERENCE BETWEEN SPECIFIC HEAT AND MOLAR HEAT CAPACITY?

SPECIFIC HEAT IS THE AMOUNT OF HEAT REQUIRED TO RAISE THE TEMPERATURE OF 1 GRAM OF A SUBSTANCE BY 1 DEGREE CELSIUS, WHILE MOLAR HEAT CAPACITY IS THE AMOUNT OF HEAT REQUIRED TO RAISE THE TEMPERATURE OF 1 MOLE OF A SUBSTANCE BY 1 DEGREE CELSIUS.

HOW DO PHASE CHANGES AFFECT ENTHALPY CHANGES?

PHASE CHANGES, SUCH AS MELTING OR VAPORIZATION, INVOLVE SIGNIFICANT ENTHALPY CHANGES BECAUSE THEY REQUIRE THE ABSORPTION OR RELEASE OF HEAT TO OVERCOME INTERMOLECULAR FORCES, WHICH IS QUANTIFIED AS LATENT HEAT.

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