

Enthalpy of ch4 combustion

By the end of this section, you will be able to: Declare the first law of thermodynamic Enthalpy definition and explain its classification as state function Write and balance thermochemical equations Calculate changes in enthalpy for various chemical reactions Explain the law of Hess and use it to calculate the reaction enthalpies Thermochemistry is a branch of chemical thermodynamics, science dealing with the relationships between heat, labour and other forms of energy in the context of chemical and physical processes. As we focus on thermochemism in this chapter, we need to look at some widely used concepts of thermodynamics. Substances act as energy tanks, which means that energy can be added to or removed from them. Energy is stored in a substance when the kinetic energy of atoms or its molecules increases. The greatest kinetic energy may be in the form of increased translations (travel or straight movements), vibrations or rotations of atoms or molecules. When thermal energy is lost, the intensities of these movements decrease and the kinetic energy decreases. All possible types of energy present in a substance are called internal energy (U), sometimes symbolized as E. As a system undergoes a change, its internal energy can be transferred from the environment or from the environment to the system. Energy is transferred to a system when it absorbs heat (g) from the environment or when the environment is working (w) in the system. For example, the energy is transferred to metal wire absorbs heat from the water), or if you quickly bend the wire back and forth (the wire ba energy of the wire, which is reflected in an increase in the temperature of the wire. Instead, energy is transferred by a system when heat is lost from the system, or when the system, or when the system is operating in the environment. The relationship between internal energy, heat and work can be represented by the equation: [latex]\Delta U = q + w[/latex] as shown in Figure 1. This is a version of the first law of thermodynamics, and shows that the internal energy of a system changes through the heat flow in; negative q is heat flow out) or work done on or off the system. The work, w, is positive if done in the system and negative if done by the system. a system can be changed by heat flow and work. If the heat in the system, qin, or work is done on the system, won, its internal energy decreases, DOU &It; 0. A type of task called an extension task (or pressure volume work) occurs) a system pushes back the environment against a retention pressure, or when the environment compresses the system. An example of this occurs during the operation of gasoline and oxygen is exothermic. Some of this energy is given away as heat, and some work by pressing the plunger into the cylinder. The substances involved in the reaction are the system, and the engine and the rest of the universe are the environment. The system loses energy from both heating and work in the engine is running.) We will look at how to determine the amount of work involved in a chemical or physical change in capital for thermodynamics. This view of an internal combustion reaction of a fuel such as petrol into drive energy. As discussed, the relationship between internal energy, heat, and labor can be represented as IU = q + w. Internal energy is a type of quantity known as a status function (or status variable), while heat and work are not state modes. The value of a status function, then its value depends on how the situation is achieved. An example of a status function is altitude or elevation. If you're standing at the top of Mount Kilimanjaro, you're at an altitude of 5895 m, and it doesn't matter if you've walked there or parachuted there. The distance you travelled to the top of Kilimanjaro, however, is not a state function. You could climb to the top with a direct route or from a more circular, circular path (Figure 2). The distances travelled will vary (the distance is not a status function), but the altitude or a mountain is a state function; they don't depend on the path), but they have very different distances traveled (distance walked is not a mode mode; it depends on the path). (credit: modification of work by Paul Shaffner) Chemicals usually use a property known as enthalpy (H) to describe the thermodynamics of chemical and physical processes. Enthalpy is defined as the the internal energy of a system (U) and the mathematical product of pressure (P) and its volume (V): [latex]H = U + PV[/latex] Since it comes from three state functions. Enthalpy is also a state function. Enthalpy values for specific substances cannot be measured directly; only changes in enthalpy for chemical or physical processes can be For processes that take place at constant pressure (a common state for many chemical and physical changes), the enthalpy change (DH) is: [latex]\Delta U + P \Delta V[/latex] The mathematical product PDV represents the work (w), i.e. the pressure volume extension or work, as noted. According to their definitions, the numeric symbols of IV and w will always be opposite: [latex]P \Delta V = -w[/latex] Replace this equation and the definition of internal energy in the enthalpy-change equation yields: [latex]\begin{array} { (lext{p}] + w - w \[1em] & amp; q {\text{p}} + w \[1em] & amp; q {\text{p}} conditions. And so, if a chemical or physical process takes place at constant pressure with the only work done caused by expansion or contraction, then the heat that exhales when operating a Bunsen burner is equal to the enthalpy change in the methane combustion reaction that takes place, since it occurs at essentially constant pressure of the atmosphere. On the other hand, the heat generated by a reaction measured in a bomb calorimetry) is not equal to DH, because the closed fixed volume metal container prevents the appearance of expansion operations. Chemists usually perform experiments under normal atmospheric conditions, at constant external pressure with q = DH, which makes enthalpy the most convenient choice for determining heat. The following conventions apply when we use DH: Chemists use a thermochemical equation to represent changes in both matter and energy. In a thermochemical equation, the enthalpy change of a reaction appears as a DH value after the equation for the reacts and products, as shown in the chemical equation. For example, consider this equation: [latex]\text{H}_2(g) + \frac{1}{2} \text{O}_2(g) \longrightarrow \text{H}_2 \text{O} (I) \\\\; \Delta H = -286 \\text{kJ}[/latex] This equation shows that when 1 hydrogen gas mole and [latex]\frac{1}{2}[/latex] mole of oxygen gas at some temperature and pressure, 286 kJ of heat are released into the environment. If the coefficients in the chemical equation are multiplied by a factor, the enthalpy change must be multiplied by the same factor (DH is an extended property): [latex]\begin{array}{} (\text{double increase in quantities}) \\ 2 + \text{O} 2(g) \longrightarrow 2 \text{H} 2 \text{O} (1) & an extended property): [latex]\begin{array}{} |\text{O} = -572 \;\\alphaooooo (-286 \;\\alphapooooo (-286 \;\\alphapoooo (-286 \;\\alphapooooo (-286 \;\\alphapoooo \text{H}_2 \text{O}(I) & amp; \Delta H = \frac{1}{2} \times (-286 \\text{kJ}) = -143 \\text{kJ} \end{array}[/latex] The enthalpy change of a reaction depends on the physical state of the reactive and reaction products (if we have gases, liquids, solids, or aqueous solutions) so that they must appear. For example, when 1 mole of hydrogen gas and [latex]\frac{1}{2} [/latex] of oxygen gas mole changes to 1 mole of liquid water at the same temperature and pressure, 286 kJ of heat is released. If gaseous water is formed, only 242 kJ of heat is released. [latex]\text{O}_2(g) \longrightarrow \text{H}_2 \text{O}(g) \\;</a0> \Delta H = -242 \\text{kJ}[/latex] A negative value of an enthalpy change, DH, indicates an exothermic reaction. a positive DH value indicates an endothermic in one direction is eversed, it changes the numeric sign of its DH (a process that is endothermic in one direction is exothermic in one direction). Measurement of an enthalpy change When 0.0500 mol HCI(aq) reacts with 0.0500 mol NaOH(aq) to form 0.0500 mol nacl(aq), 2.9 kJ of heat is produced. What is THE DH, the enthalpy change, per mole of the acid that reacts, for the acid-based reaction runs under the conditions described in example 3 in chapter 5.2 Calorimetry? [latex]\text{HCl}(aq) + \text{NaOH}(aq) + \text{NaOH}(aq) + \text{NaCl}(aq) + \text{O}(l)/latex] Solution For 2.8em}\text{mol HCl} = -58 \\text{hc}/\text{HCl}(aq) + \text{NaOH}(aq) + \text{NaOH}(aq) + \text{HCl}(aq) + \text{HCl}(aq) + \text{HCl}(aq) + \text{NaOH}(aq) + \text{HCl}(aq) + \text{HCl}(aq) + \text{HCl}(aq) + \text{NaOH}(aq) + 1.34 g Zn(s) to 60.0 mL 0.750 M HCl(aq) is produced, 3.14 kJ of heat is produced. Determine the enthalpy change per zinc mole reaction: [latex]\text{HCl}(aq) + \text{H}_2(g)[/latex] Be sure to take into account both elemental and limiting reaction when determining DH for a chemical reaction. Another example of measuring an Enthalpy Change sticky bear contains 2.67 g sucrose, C12H22O11. When reacting with 7.19 g potassium chloride, KClo3, 43.7 kJ heat is produced. Determine the enthalpy change for the [latex]\text{H}_{2} \text{O}_{11}(aq) + + \longrightarrow 12\text{CO}_{2}(g) + 11\text{H}_{2} \text{O}(l) + 8\text{KCl}(aq) $[/latex]. \Lambda \dot{\upsilon} \sigma \Xi \chi ou \mu \epsilon [\lambda \alpha \tau \delta \xi] 2.67 \ x \alpha v \dot{\sigma} \alpha c [0.5ex] {0.3em} (0.1ex) \ space {-0.3em} \ text {g} \ times \ frac {1 } \ text {g} \ times \ frac {1 } \ text {g} \ text$ {mol}text122.5 \;\rule[0.25ex]{0.55em}{0.1ex}\hspace{-0.55em}\text{g}} = 0.0587 \;\kείμενo{mol KClO}_3[/λατέξ] διαθέσιμο. Δεδομένου ότι [λατέξ]0.0587 \;\kείμενo{mol KClO}_3 + 0.00734 \;\kείμενo{mol C}_{12} \text{H}_{22} \text{O}_{11}}{8 \;\text{mol KClO}_3 = 0.00734 \;\kείμενo{mol C}_{12} \text{H}_{22} \text{O}_{11}[/latex] είναι το υπερβολικό αντιδραστικό και το KClO3 είναι το περιοριστικό αντιδραστικό. Η αντίδραση χρησιμοποιεί 8 mol KClO3, and the conversion factor is [latex]\frac{-43.7 \;\text{kJ}}{0.0587 \;\text{mol KClo}_3}[/latex], so we have [latex]\Delta H = 8 \?? mol KClo}_3][/latex], so we have [latex]\Delt [/latex], so we have [latex]\Delta H = 8 \??\ text{mol} \times \frac{-43.7 \;\text{kJ}{(0.0587 \;\text{mol KClO}_3} = -5960 \;\text{kJ}{/latex}. The enthalpy change for this reaction is -5960 kJ and the thermochemical equation is: [latex]\text{C}_{12} \text{O}_{11} + 8\text{KCl}_{12} \text{Mol} \times \frac{-43.7 \;\text{KD}}{(0.0587 \;\text{ \;\\\\ \Delta H = -5960 \\text{kJ]/latex] Check your lesson When 1.42 g of iron is produced with 1.80 g of chlorine, 3.22 g feCl2(s) and 8.60 kJ of heat. What is the enthalpy are usually placed in a table for reactions in which both reactive and products are in the same conditions. A standard status is a commonly accepted set of conditions used as a reference point for determining properties under other different conditions. For chemists, the standard IUPAC status refers to 1 rod pressure materials and solutions at 1 M and does not set a temperature. Many thermochemical tables list values with a standard state of 1 ATM. Because the DH of a reaction changes very little with such small changes in pressure (1 bar = 0.987 atm), the DH values (except for the most specific measured values) are essentially the same under both sets of standard conditions. We'll include an exponent o in the enthalpy change symbol to define the standard state. Since the usual (but not technically typical) temperature is 298.15 K, we will use a 298 indicator to set this temperature. Thus, the symbol ([latex]{\Delta}H^{\circ}_{298}[/latex]) to indicate a change of enthalpy for a process that occurs under these conditions. (The DH symbol is used to indicate an enthalpy change for a reaction that occurs under non-standard conditions.) Changes in enthalpy for many types of chemical and physical processes are available in the reference, reference, those for combustion reactions, and formation reactions, and formation reactions, and formation reactions, and formation to the quantities of the substances concerned, it can be reported on this basis (i.e., such as DH for specific amounts of reactive). However, we often find it more useful to divide one extended property (DH) with another (quantity of substance) and to report an intensive value per quantity of DI, often normalized on a per mole basis. (Note that this is similar to determining the intensive specific property heat from the extensive property heat capacity, as seen previously.) Typical combustion enthalpy ([latex]\belta H^\circ _C[/latex]) is the enthalpy change when 1 mole of a substance is burned (strongly combined with oxygen) under normal state conditions. Sometimes it is called heat of combustion. For example, ethanol combustion enthalpy, -1366.8 kJ/mol, is the amount of heat produced when an ethanol mole is fully burned at 25 °C and 1 ATM. [latex]\text{O}_2(g) \longrightarrow 2 \text{O}_2 + 3\text{O}_2(g) \longrightarrow 2 \text{O}_2(g) \longrightarrow 2 \text{O}_2 + 3\text{O}_2(g) \longrightarrow 2 \text{O}_2(g) \lengrightarrow 2 \text{O}_2(g) \t enthuses have been measured. some of them are listed in Table 2. Many readily available substances with large combustion enthalpy are used as fuels, including hydrogen and carbon), such as methane, propane and the main components of gasoline. Substance Combustion Reaction Enthalpy of Combustion, [latex]\Delta H^\circ_c (\frac{\text{mol}}(\intext{mol}) \;\text{at 25} \;^\circ \text{O}_2(g) [/latex] -393.5 hydrogen [latex]\text{H}_2(g) + \frac{1}{2} \text{O}_2(g) [/latex] -285.8 magnesium [latex]\text{Mg}(s) + \text{Mg}(s) + \text{O}_2(g) [/latex] -393.5 hydrogen [latex]\text{O}_2(g) [/latex] -393.5 hydrogen [latex]\text{O}_2(g) [/latex] -285.8 magnesium [latex]\text{Mg}(s) + \text{O}_2(g) [/latex] -285.8 magnesium [latex]\text{Mg}(s) + \text{O}_2(g) [/latex] -393.5 hydrogen [latex]\text{O}_2(g) [/latex] -393.5 hydrogen [latex]\text{O}_2(g) [/latex] -285.8 magnesium [latex]\text{Mg}(s) + \text{O}_2(g) [/latex] -393.5 hydrogen [latex]\text{O}_2(g) [/latex] -393.5 hydrogen [latex] [latex $latex[O]_2(g) \ext[O]_2(g) \e$ $(I)[/latex] -890.8 acetylene [latex]\text{C}_2 \text{H}_2(g) + \frac{5}{2} \text{O}_2(g) \longrightarrow 2\text{CO}_2(g) + \text{O}_2(g) + \text{O}_2(g) \long 2 - CO-2(g) - 3-text-2-text-O-(I)[/latex] \longrightarrow 2\text{O}_2(g) + \text{O}_2(g) + \text{O}_2(g) + \text{O}_2(g) \long 2 - CO-2(g) - 3-text-2-text-O-(I)[/latex] \longrightarrow 2\text{O}_2(g) \longrightarrow \text{CO}_2(g) + \text{O}_2(g) + \text{O}_2(g) \long 2 - CO-2(g) - 3-text-2-text-O-(I)[/latex] \longrightarrow \text{O}_2(g) \longrightarrow \text{CO}_2(g) + \text{O}_2(g) + \text{O}_2(g) \long 2 - CO-2(g) - 3-text-2-text-O-(I)[/latex] \longrightarrow \text{O}_2(g) \longrightarrow \text{CO}_2(g) + \text{O}_2(g) + \text{O}_2(g) \long 2 - CO-2(g) - 3-text-2-text-O-(I)[/latex] \longrightarrow \text{O}_2(g) \longrightarrow \text{CO}_2(g) + \text{O}_2(g) \longrightarrow \text{O}_2(g) + \text{O}_2(g) \longrightarrow \text{O}_2(g)$ \text{O}(I)[/latex] -726.1 isoectane [latex]\text{C}_8 \text{H}_{18}((I) + \frac{25}{2} \text{O}_2(g) + 9\text{H}_2 \text{O}(I)[/latex] -5461 Table 2. Standard Molar Enthalpy of Combustion Using Enthalpy of Combustion As Figure 3 suggests, burning gasoline is an extremely exothermic process. Let us determine the approximate amount of heat generated by burning 1,00 L of petrol, assuming that the enthalpy of burning petrol is the same as that of isoctane, a common component of gasoline is very exothermic. (credit: modifying tasks from AlexEagle/Flickr) Solution Starting with a known amount (1.00 L isooctane), we can perform conversions between units until we reach the desired amount of heat or energy. The enthalpy of the combustion of isooctane provides one of the necessary modifications. Table 2 gives this value as -5460 kJ per 1 iosoctane mole (C8H18). Using these data, [latex]1.00 \;\rule[0.5ex]{3.75em}(0.1ex]\hspace{-3.75em}(text{L C}_8\text{H}_{18} \times \frac{1000 \;\rule[0.25ex]{3.2em}{0.1ex}\hspace{-3.2em}\text{mL C}_8 \text{H}_{18}} \times \frac{0.692 \;\rule[0.25ex]{2.65em}(text{B}_{18}) \times \frac{0.692 \;\rule[0.25ex]{3.75em}(0.1ex}) + space{-3.75em}(text{mL C}_8 \text{H}_{18}) \times \frac{0.692 \;\rule[0.25ex]{2.65em}(text{B}_{18}) \text{mL C}_8 \text{H}_{18}} \times \frac{0.692 \;\rule[0.25ex]{2.65em}(text{B}_{18}) \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{H}_{18} \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{mL C}_8 \text{H}_{18}} \text{mL C}_8 \text{mL

\times \frac{1 \;\rule[0.25ex]{3.75em}{0.1ex}\hspace{-3.75em}\text{mol C}_8 \text{H}_{18}} = -3.31 \times 10^4\text{kJ}[/latex] The combustion of 1.00 L of isooctane produces $(12, 13) = 10^{12} (12, 13) =$ the search is underway for replacement fuel sources for the future. Among the most promising biofuels are those derived from algae (Figure 4). The species of seaweed are non-toxic, biodegradable, and among the fastest growing organisms in the world. About 50% of the weight of algae is oil, which can be easily fuels such as biodiesel. Algae can yield 26,000 gallons of biofuels per hectare-much more energy per acre than other crops. Some strains of algae may bloom in brackish water that is not usable for growing other crops. Algae can produce biodiesel, bioaeroline, ethanol, butanol, methane and even jet fuel. Figure 4. (a) Microscopic algae organisms can be grown (b) in large quantities and finally (c) converted into useful fuel, such as biodiesel. (credit a: modification of work by Micah Sittig; credit b: modification of work by 39,000 square kilometers (about 0.4% of U.S. land mass or less than [latex] \ frac{1}{7} [/ latex] of the area used to grow corn) can produce enough seaweed fuel is becoming more competitive-for example, the U.S. The cost of less than \$5 per gallon. The process used to produce seaweed fuel is as follows: to grow algae (which use sunlight as their energy source and CO2 as raw material); harvesting of seaweed; fuel compounds (or precursor compounds) are exported; process as needed (e.g. perform a metesterification reaction to make biodiesel); Clean? and distribute (Figure 5). Figure 5). Figure 5. Algae convert sunlight and carbon dioxide into oil collected, extracted, purified and converted into a variety of renewable fuels. Click here to learn more about the process of creating seaweed biofuels. A typical enthalpy formation [latex]\Delta H^\circ_\text{f}[/latex] is an enthalpy change for a reaction in which exactly 1 mole of a pure substance is formed by free elements in their most stable states under normal state conditions. These values are particularly useful for calculating or predicting changes in enthalpy for chemical reactions that are not practical or dangerous to perform, or for processes for which measurements are difficult to measure. If we have values for the appropriate standard enthalpy formation, we can determine the enthalpy formation, we can determine the enthalpy for any reactions that are not practical or dangerous to perform, or for processes for which measurements are difficult to measure. law. The standard CO2(g) enthalpy formation is -393.5 kJ/mol. This is the enthalpy change for the exothermic reaction: [latex]\text{C}(s) + \text{O]_2(g) \longrightarrow \\</a0> \Delta H^\circ_\text{f} = \Delta H^\circ_(298) = -393.5 \\text{kJ}[/latex] starting with 1 ATM and 25 °C pressure reaction (with carbon as graphite, the most stable form of carbon under these conditions) and finishing with a CO2 mole, also at 1 atm and 25 °. For nitrogen dioxide, NO2(g), [latex]\Delta H^\circ_\text{0}_2(g) + \text{O}_2(g) \text{O}_2(g) \text{O}_2(g) \\\\; NO}_2(g) \\\; NO}_2(g) \\\; NO}_2(g) \\\; NO}_2(g) \\; NO}_2(g) \\[; NO}_2(g) \\[; NO}_2(g) \text{O}_2(g) \\[; NO}_2(g) \\[; NO}_2(g) \\[; NO}_2(g) \\[; NO}_2(g) \\[; NO}_2(g) \text{O}_2(g) \\[; NO}_2(g) \\[] NO}_2(g) \\[] NO}_2(g) \\[] NO}_2(g) \\[] NO} H^\circ_{298} = +33.2 \?\text{kJ}[/latex] A reaction equation with the mole [latex]\frac{1}{2}[/latex] of N2 and 1 mole of the product, NO2(g). You will find a table of standard enthalps of the formation of many common substances in Appendix G. These values indicate that formation reactions range from extremely exothermic (such as -2984 kJ/mol for P4O10 formation) to strongly endothermic (such as +226.7 kJ/mol for acetylin formation, C3(g), is formed by oxygen, O2(g), by endothermic process. Ultraviolet radiation is the source of energy that drives this reaction into the upper atmosphere. Assuming that both reactive and reaction products are in their typical states, specify the standard enthalpy formation; [latex]\Delta H^{\circ_{298} = +286 \\text{b]} [/latex] Solution [latex]\Delta H^\circ_\text{f}[/latex] is the change of enthalpy to form a mole of a substance in its typical state from the elements in their typical state from the elements in their typical state from the elements in their typical state from the formation of 2 mol of O3(g) is the enthalpy change for the reaction: [latex]\Delta H^\circ_\text{f}[/latex] is the change of enthalpy to form a mole of a substance in its typical state from the elements in their typical state from the elements in [latex]\Delta H^\circ_{298} = +286 \?\text{kJ}[/latex]. Αυτή η αναλογία, [λατέξ]\frac{286 \;\text{kJ}}[2 \;\text{mol O}_3)[/λατέξ], μπορεί να χρησιμοποιηθεί ως συντελεστής μετατροπής για την εύρεση της θερμότητας που παράγεται όταν σχηματίζεται 1 mole του O3(g), που είναι η ενθαλπία σχηματίζεται 1 mole του O3(g), που είναι η ενθαλπία σχηματισμού για το O3(g): [λατέξ]\Delta H^\circ \;\kείμενο{για 1 mole του $O_3(g) = 1 \; tue[0.5ex]{xei[0.25ex]{z.5em}(0.1ex] hspace{-3.5em}(0.1ex] hspace{-3.5em$ gas, Cl2, to form hydrogen chloride, HCl(g). What is the enthalpy change for the reaction of 1 H2(g) mole if both the reactive and the products are in normal condition? The typical HCl(g) +:\:\;\;; \Delta H^\circ_{298} = -184.6 \\text{kJ}[/latex] Write reaction equations for [latex]\Delta H^\circ_\text{f}[/latex] Write the heat of the formation reaction for: (a) C2H5OH(I) (b) Solution Ca3(PO4)2(s) Recalling that the reaction equations [latex]\Delta H^\circ_\text{f}[/latex] are for the formation of 1 mole of the compound from its components under normal conditions, we have: (a) [latex]2\text{C}(s), \\text{graphite}) + $3\text{H}_2(g) + \frac{1}{2}\text{O}_2(g) \text{O}_2(g) \tex$ equations for: (a) C2H5OC2H5(I) (b) Na2CO3(s) (a) [latex]4\text{C}(s), \\text{graphite}) + 5\text{H}_2(g) + \frac{1}{2} \text{H}_5(l)[/latex]; (b) [latex]2\text{H}_5(l)[/latex]; (b) [latex]2\text{H}_5(l)[/latex]; (b) [latex]2\text{H}_2(g) + \frac{1}{2} \text{H}_5(l)[/latex]; (b) [latex]2\text{H}_5(l)[/latex]; (b) [latex]2(g) + \frac{1}{2} \text{H}_5(l)[/latex]; (b) [latex]2(g) + \text{H}_5(l)[/latex]; (b) [l determine the amount of heat involved in a chemical change: measure it experimentally or calculate it from other experimentally defined enthalpy changes. Some reaction is not difficult to perform or measure, it is convenient to be able to determine the heat involved in a reaction without having to perform an experiment. This type of calculation usually involves the use of Hess's law, which states: If a process can be written as the sum of several gradual processes, the enthalpy change of the various steps. Hess's law is valid because enthalpy is a state function: Enthalpy changes depend only on where a chemical process begins and ends, but not on the path it takes from start to finish. For example, we can think of the reaction of carbon to oxygen to form carbon dioxide that occur either directly or through a two-step process. The direct procedure is written: [latex]\text{C}(s) + $text{O}_2 (g) \$ text{C}_2 (g) \longrightarrow \text{CO}_2 (g) \\ belta H^\circ_{298} = -111 \\text{kJ}[/latex] text{CO}(g) + \frac{1}{2} \text{O}_2 (g) \\ belta H^\circ_{298} = -111 \\text{kJ}[/latex] text{CO}(g) + \frac{1}{2} \text{CO}(g) + \frac{1}{2} \text{C {2} \text{O}_2 (g) \longrightarrow \text{CO}_2(g) \l\ndgrightarrow \text{CO}_2(g) \\\\\Delta H^\circ_{298} = -283 \\text{begin{array}{} \text{CO}_2(g) \longright \text{CO}_2(g) \longright \text{CO}_2(g) \\\Delta H^\circ_{298} = -283 \\text{CO}_2(g) \longrightarrow \text{CO}_2(g) \\\\Delta H^\circ_{298} = -283 \\text{CO}_2(g) \\longrightarrow \text{CO}_2(g) \\\Delta H^\circ_{298} = -283 \\text{CO}_2(g) \\\Delta H^\circ_{298} = -283 \\text{CO}_2(g) \\Delta H^\circ_{298} = -283 \\text{CO}_2(g) \\\Delta H^\circ_{298} = -283 \\text{CO}_2(g) \\Delta H^\circ_{2 \\hline \\[-0.5em] \text{Sum: C}(s) + \text{CO}_2(g) \longrightarrow \text{CO}(g) + \text{O}_2(g) \longrightarrow \text{O}_2(g) \longrightarrow \text{CO}(g) + \text{O}_2(g) \lengrightarrow \text{O}(g) + \text{O}(g) reaction will be equal to the sum of the enthalpy changes of the steps. We can apply the data from the experimental combustion enthalpys in Table 2 to find a change in the overall reaction from its two steps: [latex]\begin{array}{l} \text{C}(s) + \frac{1}{2} \text{O}_2(g) \longrightarrow \text{CO}(g) & amp; \Delta H^\circ_{298} = -11 1 \\text{kJ} \\[1em] \frac{1}{2} \text{O}_2(g) \longrightarrow \text{CO}_2(g)} & amp; \frac {\Delta H^\circ_{298} = -394 \\text{A}} \end{array}[/latex] The result appears in Figure 6. We see that DI of the overall reaction is the same whether it happens in one or two steps This finding (total DH for reaction = sum of DH values for reaction steps to overall reaction) generally applies to chemical and physical processes. Figure 6. The formation of CO2(g) from its elements can be considered to occur in two steps, which sum up the overall reaction, as described by hess law. Horizontal blue lines represent enthalpy. For an exothermic process, the products are in lower enthalpy than they are reactive. Before we further practice the use of the law of the ESK, let us remember two important characteristics of I.E. DH is directly proportional to the quantities of reacts or products. Για παράδειγμα, η αλλαγή ενθαλπίας για την αντίδραση που σχηματίζει 1 τυφλοπόντικα του NO2(g) είναι +33,2 kJ: [λατέξ]\frac{1}{2}\text{N}_2(g) + \text{O}_2(g) \longrightarrow text \{NO}_2(g) \\Delta H = +66.4 \;\kείμενo{kJ}[/λατέξ] Γενικά, εάν πολλαπλασιάσουμε ή διαιρέσουμε μια εξίσωση με έναν αριθμό, τότε η αλλαγή ενθαλπίας θα πρέπει επίσης να πολλαπλασιαστεί ή να διαιρεθεί με τον ίδιο αριθμό. DH for a reaction in reverse direction. For example, since: [latex]\text{H}_2(g) + \text{Cl}_2(g) \longrightarrow 2\text{HCl}(g) \; \Delta H = -184.6 \\text{kJ}[/latex] Then, for the reverse reaction, the enthalpy change is also reversed: [latex]2\text{HCl}(g) \longrightarrow \text{H}_2(g) + \text{Cl}_2(g) \\\\; \Delta H = +184.6 \\text{kJ}[/latex] Using Hess Law Specify the enthalpia of the formation, [latex]\Delta H\circ_\text{f}[/latex] from from αλλαγές ενθαλπίας της ακόλουθης διαδικασίας δύο βημάτων που συμβαίνει υπό κανονικές συνθήκες κατάστασης: [λατέξ]\begin{array}[l]\text{Fe}(s) + \frac{1}{2}\text{kJ} \[1em] \text{FeCl}_2(g) \longrightarrow \kείμενο{FeCl}_2(s) & \stract{kJ} \circ = -341.8 \;\text{kJ} \[1em] \text{Fe}(s) + \frac{1}{2}\text{kJ} \[1em] \text{Fe}(s) + \frac{1}{2}\text{kJ} \circ = -341.8 \;\text{kJ} \[1em] \text{Fe}(s) + \frac{1}{2}\text{kJ} \circ = -341.8 \;\text{kJ} \circ = -341.8 \;\text{kJ} \[1em] \text{Fe}(s) + \frac{1}{2}\text{KJ} \[1em] \[1em] \text{Fe}(s) + \frac{1}{2}\text{KJ} \[1em] \[1em] \text{Fe}(s) + \frac{1}{2}\text{KJ} \[1em] \ Solution Προσπαθούμε να βρούμε την τυπική ενθαλπία σχηματισμού του FeCl3(s), η οποία είναι ίση με ΔH° για την αντίδραση: [λατέξ]\text{Cl}(g) \longrightarrow \text{FeCl}_3(s) \; κείμενο{Fe}(s) + \frac{3}{2}\text{Cl}(g) \longrightarrow \text{FeCl}_3(s) \; κείμενο{Fe}(s) + \frac{3}{2}\text{FeCl}_3(s) \; κείμενο{Fe}(s) + \frac{3}{2}\text{EeCl}_3(s) reactions with known ΔH values, so we must sum their ΔHs : [latex]\begin{array}[l]\text{Fe}(s) + \trac{1}{2}\text{FeCl}_2(s) & amp; \Delta H^\circ = -341.8 \;\text{FeCl}_2(s) + \frac{1}{2}\text{FeCl}_2(s) + \trac{1}{2}\text{FeCl}_2(s) + \trac{1}{2}\text{FeCl}_2(s) + \frac{1}{2}\text{FeCl}_2(s) + \trac{1}{2}\text{FeCl}_2(s) + \t latex] (latex], of FeCl3(s) is -399.5 kJ/mol. Check Your Learning Calculate ΔH for the process : [$\lambda \alpha t \xi$]/kɛi/µɛvo{N}_2(g) + 2\text{O}_2(g) \longrightarrow 2\text{NO}_2(g)[/latex] and tic akohouθec $\pi \lambda \eta \rho \sigma \rho \rho \epsilon$; [latex]\begin{array}{r l} \text{N}_2(g) + \text{N}_2(g) + \text{N}_2(g) + \text{NO}_2(g) \longrightarrow \text{NO}(g) & amp; \Delta H = 18 0.5 \;\text{kJ} \end{array}[/latex] Eδώ είναι ένα λιγότερο απλό παράδειγμα που απεικονίζει τη διαδικασία σκέψης που εμπλέκεται στην επίλυση πολλών προβλημάτων του νόμου hass. Δείχνει πώς μπορούμε να βρούμε πολλές τυπικές ενθαλπίες σχηματίσμού (και άλλες τιμές της ΔΗ) αν είναι δύσκολο να προσδιοριστούν πειραματικά. Ένα πιο προκλητικό πρόβλημα χρησιμοποιώντας το μονοφθοριούχο χλώριο του νόμου Hass μπορεί να αντιδράσει με φθόριο για να σχηματίσει τριφθοριούχο ποι προκλητικό πρόβλημα χρησιμοποιώντας το μονοφθοριούχο χλώριο του νόμου Hass μπορεί να αντιδράσει με φθόριο για να σχηματίσει τριφθοριούχο ποι προκλητικό πρόβλημα χρησιμοποιώντας το μονοφθοριούχο χλώριο του νόμου Hass μπορεί να αντιδράσει με φθόριο για να σχηματίσει τριφθοριούχο χλώριο του νόμου Hass μπορεί να αντιδράσει με φθόριο για να σχηματίσει τριφθοριούχο χλώριο του νόμου Hass μπορεί να αντιδράσει τριφθοριούχο χλώριο του νόμου Hass μα σχηματίσει τριφθοριούχο χλώριο του νόμου Hass μπορεί να αντιδράσει με φθόριο για να σχηματίσει τριφθοριούχο χλώρι ποι με στη προκλητικό πρόβλημα χρησιμοποιών τα σχηματίσει τριφθοριούχο και με στη στη προκλητη το προκλητισμού (και άλλες τιμές της ΔΗ) αν είναι δύσκολο να προσδιοριστούν πειραματικά. Ένα πιο προκλητισμού (και άλλες τιμές της ΔΗ) αν είναι δύσκολο να προσδιοριστούν πειραματικά πρόβλημα χρησιμοποιών τα σχηματίσμο (και άλλες τιμές της ΔΗ) αν είναι δύσκολο να προσδιοριστούν πειραματικά. χλώριο: (i) [λατέξ]\κείμενο{CIF}_2(g) + \text{F}_2(g) + \text{F}_2(g) \longrightarrow \text{CIF}_2(g) \;\κείμενο{KJ}[/λατέξ] (iii) [λατέξ]2\κείμενο{CIF}(g) + 2\text{F}_2(g) \;\κείμενο{CIF}(g) + 2\text{F}_2(g) \\cord text{CIF}_2(g) \;\κείμενο{KJ}[/λατέξ] (iii) [λατέξ]2\κείμενο{CIF}(g) + \kείμενο{O}_2(g) \longrightarrow \text{O}_2(g) \longrightarrow \text{O}_2() \;\;\\? \Delta H^\circ_{(ii)} = +205.6 \;\kείμενο{kJ}[/λατέξ] \text{O}_2(g) \;\;\\? \Delta H^\circ_{(iv)} = +266.7 \;\kείμενο{kJ}[/λατέξ] \text{O}_2(g) \\\\ \Delta H^\circ_{(ii)} = +266.7 \;\kείμενο{kJ}[/λατέξ] \text{O}_2(g) \;\;\\? so as to be added to the reaction (i). Going from left to right in (i), we first see that that required as a reaction. This can be achieved by multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplied by [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iiii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iiii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iiii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iiii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iiii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iiii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex]\frac{1}{2}[/latex], which means that the DH° change is also multiplying the reaction (iii) with [latex], wh \text{O}(g) + \frac{1}{2} \text{OF}_2(g) \\\ \Delta H^\circ = \frac{1}{2} (205.6) = +102.8 \\text{kJ}[/latex] Next, we see that F2 is also necessary as reactive. To receive this, the reverse and half reaction (ii), which means that the D° change symbol changes and decreases by half: [latex]\frac{1}{2} \text{O}_2 (g) + \text{F}_c 2(g) \\\ \Delta H^\circ = \frac{1}{2} (205.6) = +102.8 \\text{O}_2 (g) + \text{O}_2 (g) $[latex] \ext{OF}(g) + \rac{1}{2} \text{OF}(g) + \rac{1}{2} \text{O}(g) + \text{O}(g) +$ $text{OF}_2(g) \ text{CIF}_3(g) + \text{O}_2(g) \ text{O}_2(g) \ text{O}_2(g) \ text{O}_2(g) \ text{O}_2(f) \$ \text{O}_2[/latex] product cancellation O2; product [latex]\frac{1}{2} \text{O}]/latex] cancels reactive [latex]\frac{1}{2} \text{OF}_2[/latex] is cancelled by [latex]\frac{3}{2} \text{OF}_2[/latex] and OF2 products. This leaves only reacting CLF(g) and F2(g) and the product CLF3(g), which is what we want. Since the summation of these three modified reactions generates a reaction of interest, the sum of the three modified DH° values will give the desired values DH°: [latex]/Delta H^\circ = (+102.8 \;\text{kJ}) + (-266.7 \;\text{kJ}) + (-266.7 \;\text{kJ}) + (-266.7 \;\text{kJ}) + (-266.7 \;\text{kJ}) = -139.2 \2 \;\text{kJ}) = -139.2 \2 \;\text{kJ}) = -139.2 \2 \;\text{kJ}) $[latex]^{(ii)} = -74.8 \text{Al}(s) + 3\text{Cl}_2(g) \text{HCl}(aq) \text{HCl}$ $(v) [\lambda \alpha t \xi] (v) = +323 (v) [\lambda \alpha t \xi] (v)$ change of any reaction, if the corresponding enthalpy formation of the reacts and products is available. The gradual reactions that we consider to be: (i) disintegrations of the reactions), followed by (ii) reconnections of the elements to give the products (with changes in enthalpy proportional to the enthalpy of the formation of the products). Therefore, the typical enthalpy formation of the typical enthalpy formation of the reacts. This is usually rearranged slightly to be written as follows, with \diamond representing the sum and n representing the elemental coefficients: [latex]\Delta H^{\circ}_{\text{f}}(\text{f})(\text{reactants})[/latex] The following example shows in detail why this equation is valid, and how to use it to calculate enthalpy change for an interest reaction. Using huss Law What is the standard enthalpy change for the reaction: [latex] \text{NO}(g) \? \Delta H^\circ = ? [/latex] Solution: Using the Equation Use the special form of Hess's law given previously: [latex]\begin{array}{I } \Delta $H^{\times Delta H^{\times}) = \sum_{1,2,1,2} \\ H^{\times} B_{(1,2,1,2)} \\ H^{(1,2,2)} \\$ $\{0.1ex\}\$ H}_2 \text{O}(I) \times \frac{+285.8 \;\text{kJ}}{\rule[0.25ex]{3.5em}{0.1ex}\hspace{-3.5em}\text{mol H}_2 \text{N}) - 3(+33.2 \;\text{kJ}) - 1(-285.8 \;\text{kJ}) - 1(-285.8 \;\text{kJ}) - 3(+33.2 \;\text{kJ}) + 1(+90.2 \;\text{kJ}) - 3(+33.2 \;\text{kJ}) - 3(+33.2 \;\text{kJ}) + 1(+90.2 \;\text{kJ}) + 1(+90.2 \;\text{kJ}) - 3(+33.2 \;\text{kJ}) - 3(+33.2 \;\text{kJ}) + 1(+90.2 \;\text{kJ}) - 3(+33.2 \;\text{kJ}) + 1(+90.2 \;\text disintegration of 3NO2(g) and 1H2O(l) into their components, and the formation of 2HNO3(aq) and 1NO(g) from their components. By writing these reactions, and noting their relationships with [latex]\begin{array }{I | } 3\text{NO}_2(g) \longrightarrow 3/2\text{N}_2(g) + 3\text{O}_2(g) & amp; L^{\circ}_1 = -99.6 \\text{kJ} \\[1em] \text{H}_2 \text{O}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_1 = -99.6 \\text{H}_2 \text{O}_2(g) + \text{O}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_1 = -99.6 \\text{H}_2 \text{O}_2(g) + \text{O}_2(g) + \text{O}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_3 = +285.8 \\text{O}_2(g) + \text{O}_2(g) + \text{O}_ -414.8 \\text{kJ} \; [2 \times \Delta H^{\circ}_\text{f}(\text{HNO}_3)] \\[1em] \frac{1}{2}\text{NO}] \\[1em] \frac{1}{2}\text{N}_2(g) + \frac{1}{2}\text{NO}] \\[1em] \frac{1}{2}\text{NO}] \\[1em] \frac{1}{2}\text{NO}] \\[1em] \frac{1}{2}\text{NO}] \\[1em] \frac{1}{2}\text{NO}] \\[2end{array}[/\text{NO}] \\[1em] \frac{1}{2}\text{NO}] \\[2end{array}[/\text{NO}] \[2end{array}[/\text{NO}] \[2e $text{HNO}_3(aq) + \\text{NO}_3(aq) + \\text{NO}_$ \;\text{kJ}) + (-414.8 \;\text{kJ}) + (+90.2 \;\text{kJ}) \[1em] & amp; -138.4 \;\text{kJ}) \[1em] & amp; -138.4 kJ. Σημειώστε ότι αυτό το αποτέλεσμα προέκυψε από το (1) πολλαπλασιάζοντας το [λατέξ]\Delta H^{\circ}_\text{kJ}) + (+90.2 \;\text{kJ}) \[1em] & amp; -138.4 kJ. Σημειώστε ότι αυτό το αποτέλεσμα προέκυψε από το (1) πολλαπλασιάζοντας το [λατέξ]\Delta H^{\circ}_\text{kJ}) + (+90.2 \;\text{kJ}) \[1em] & amp; -138.4 kJ. Σημειώστε ότι αυτό το αποτέλεσμα προέκυψε από το (1) πολλαπλασιάζοντας το [λατέξ]\Delta H^{\circ}_\text{kJ}) αθροίζοντας αυτές τις τιμές , (2) multiplying [latex]\Delta H^{\circ}_\text{f}[/latex] by its stoicimetric coefficient and suming these values, and then (3, subtracting the result found in (2) from the result found in (1). as shown. Check your learning Calculate the heat of burning 1 ethanol mole, C2H5OH(I), when H2O(I) and CO2(g) are formed. H2O(I), -286 kJ/mol; and CO2(g), -394 kJ/mol. If a chemical change is carried out at constant pressure and the only work done is caused by expansion or contraction, q for the change is carried out at constant pressure and the only work done is equal in (Joelta)-(Joel size, against the point, in DH for the reaction in the opposite direction, and DH is directly proportional to the amount of reacting and products. Examples of enthalpy of formation, [latex]{\Delta}H_{\text{f}}^{(circ}]/latex], is the enthalpy change that accompanies the formation of 1 mole of a substance from the elements in their most stable states in 1 line (typical state). Many of the procedures are performed at 298.15 K. If the enthalpy of the formation is available for the reactives and products of a reaction, the enthalpy change can be calculated using the law of Hess: If a process can be written as the sum of several gradual processes, the enthalpy change of the overall process equals the sum of the enthalpy changes of the various steps. [latex]\Delta H^{\circ}_{text{f}} (\text{reaction}] = \sum{n} \times \Delta H^{\circ}_{text{f}} (\text{reaction}] = \sum{n} \times \text{reaction}] = \sum{n} \times \text{reaction} (\text{reaction}) = \sum{n} \text{reaction} (\text{reaction}) = \text{reaction} (\text{reaction}) = \text{reaction} (\text{reaction}) = \text{reaction} (\text{reaction}) = \text{reaction Chemistry End of Chapter Exercises Explain how the heat measured in example 3 in chapter 5.2 Calorimetry differs from the enthalpy change for the exothermic reaction described by the following equation: [latex] text{HCl}(aq) + \text{NaCl}(aq) + \ chapter 5.2 Thermimetry, calculate DH in kJ/mol of AgNO3(aq) for reaction: [latex]\text{NaCl}(a) + \text{AgNO}_3(aq) \longrightarrow \text{AgCl}(s) + \text{AgNO}_3(aq) [/latex] the enthalpy of the solution (DH for dissolution) per mole of NH4NO3 under the conditions described in example 4 in chapter 5.2 Thermidometry. A DH is calculated for the reaction described by the equation. (Tip: use the value for the approximate amount of heat absorbed by the reaction you calculated in a previous exercise.) [latex]\text{Ba(OH)}_2 \cdot 8\text{H}_2 \text{O}+ 2\text{O}+ 2 solution (DH for dissolution) per mole of CaCl2. Although the gas used in an oxyacetylline torch (Figure 6 in Chapter 5.1 Energy basics) is essentially pure acetylene, the heat generated by burning an acetylene mole in such a torch is likely not equal to the enthalpy of acetyline combustion mentioned in Table 2. Taking into account the conditions for which the inhaled data refer, an explanation is proposed. How much heat is produced by burning 4.00 moles of acetyline under normal state conditions? How many isoctane moles burn to produce 100 kJ of heat under standard condition conditions; Which carbon monoxide mass should be burned to produce 175 kJ of heat under normal state conditions? When 2.50 g of methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion methane is burned in oxygen, 125 kJ of heat is produced. What is produced in oxygen, 125 kJ of heat is produced. What is produced in oxygen, 125 kJ of heat is produced. What is produced in oxygen, 125 kJ of heat is produced. What is produced in oxygen is produced. What is produced in oxygen is produced in oxygen is produced. What is produced in oxygen is produced in oxygen is produced. What is produced in oxygen is produced in oxygen is produced. What is produced in oxygen is prod mixed? [latex]\begin{array} {I } \text{HCl}(aq) + \text{HCl}(aq) + \text{HCl}(aq) + \text{HCl}(aq) + \text{H}_2 \text{H}_2 \text{H}_2 \text{H}_2 \text{H}_2 \text{H}_2 \text{H}_2 \text{HCl}(aq) + \text{HCl}(aq) calculation? A sample of 0.562 g of carbon is burned in oxygen in a bomb calorimeter, which produces carbon dioxide. Suppose that both the reactive and the products are under normal conditions and that the heat released is directly proportional to the enthalpy of graphite combustion. The temperature of the calorimeter increases from 26.74 °C to 27.93 °C. What is the thermal capacity of the calorimeter and its content? Prior to the introduction of chlorofluorocarbons, sulphur dioxide (evaporated to remove as much heat as the 1.00 kg CCl2F2 exhaust (evaporation enthalpy, 6,00 kcal/mol) was used in household refrigerators. Which SO2 mass should be evaporated to remove as much heat as the 1.00 kg CCl2F2 exhaust (evaporation enthalpy, 6,00 kcal/mol)? Exhaust reactions for SO2 and CCI2F2 are [latex]\text{SO}_2(I) \longrightarrow \text{SO}_2(g)[/latex] and [latex] \text{F}(I) \longrightarrow \text{CCI}_2 \text{F}(g)[/latex]. Homes can be heated by pumping hot water through radiators. Which water mass will provide the same amount of heat when cooled from 95.0 to 35.0 °C, as the heat supplied when 100 g of steam is cooled from 110 °C to 100 °C. Which of the combustion enthalpys in Table 2 table are also standard formation enthalpys? The standard H2O(g) + \text{O}_2(g) \longrightarrow 2\text{H}_2 (b + \text{O}_2(g) + \text{O}_2 mercury oxide (II) with sunlight focused through a lens. How much heat is required to decompose exactly 1 mole of red HgO(s) in Hg(l) and O2(g) under normal state conditions? How many heat kilojoules will be released when just 1 manganese mole, Mn, is burned to form Mn3O4(s) under normal state conditions? How many heat kilojoules will be released when just 1 manganese mole, Mn, is burned to form Mn3O4(s) under normal state conditions? 2\text{NO}_2(g) & amp; \Delta H = -113 \;\text{kJ} \\[1em] 3\κείμενο{NO}_2 + \text{H}_2 \text{HNO}_3(aq) + \text{NO}(g) & amp; \Delta H = -139 -139 \end{array}[/latex] Προσδιορίστε τη συνολική ενέργειακή αλλαγή για την παραγωγή ενός τυφλοπόντικα υδατικού νιτρικού οξέος από αυτήν τη διαδικασία. Τόσο γραφίτη και έγκαυμα διαμαντιών. [latex]\text{C}(s), \;\kείμενo{diamond}) + \text{O}_2(g) \longrightarrow \text{CO}_2(g)[/latex] Για τη μετατροπή γραφίτη σε διαμάντι: [λατέξ]\begin{array}{I |} \text{Giamond}) & amp; {\Delta}H^{\circ}_{298} = 1,90 \;\kείμενo{kJ} \end{array}[/latex] Που παράγει περισσότερη θερμότητα, την καύση γραφίτη ή την καύση διαμαντιού; Από τις μοριακές θερμότητες του σχηματισμού στο Προσάρτημα G, προσδιορίστε πόση θερμότητα απαιτείται για την εξάτμιση ενός τυφλοπόντικα νερού: [λατέξ]\κείμενο{H}_2 \text{O}(I) \longrightarrow \text{H}_2 \text{O}(g)[/λατέξ] Που παράγει περισσότερη θερμότητα; [λατέξ]\κείμενο{Os}(s) \longrightarrow 2\text{O} - 2(g) $longrightarrow \text{OsO}_4(s)[/latex]or[latex]\text{Os}(s) \longrightarrow 2\text{O}_2(g) \red text{OsO}_4(g)[/\articletx]\text{OsO}_4(g) \red text{OsO}_4(g) \red$ $text{Cl}_2(g) \$ $text{Cl}_2(g) \$ $text{SbCl}_5(g)[/latex] from the following information: [latex] \$ $text{SbCl}_3(g) \$ $text{SbCl}_2(g) \$ $text{Cl}_2(g) \$ Calculate [latex]{\Delta}H^{\circ}_{298}[/latex] for the process [latex]\text{Zn}(s) + \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\begin{array}{I |} \text{S}(s) + \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\begin{array}{I |} \text{S}(s) + \text{S}(s) + \text{S}(s) + \text{S}(s) + \text{S}(s) + \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\text{O}_2(g) \longrightarrow \text{ZnS}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\text{O}_2(g) \longrightarrow \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\text{O}_2(g) \longrightarrow \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\text{O}_2(g) \longrightarrow \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{S}(s) + 2\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex]\text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex] \text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex] \text{O}_2(g) \longrightarrow \text{ZnSO}_4(s)[/latex] from the following information: [latex] \text{O}_2(g) \length{A}(s)[/latex] from the following information: [latex] \text{O}_2(g) \length{A}(s $text{Bg}(l) + text{Cl}_2(g) \$ + \text{HgCl}_2(s) \longrightarrow \text{Hg}_2 \text{Cl}_2(s) & amp; \Delta H = -41.2 \;\text{kJ} \end{array}[/latex] Calculate [latex]\text{O}_2(g)[/latex] for the process [latex]\text{O}_2(g) [/latex] for the process [latex]\text{O}_2(g)[/latex] for the process [latex]\text{O}_2(g)[/latex] for the process [latex]\text{O}_2(g) [/latex] for the process [latex]\text{O}_2(g)[/latex] for the process [latex]\text{O}_2(g) [/latex] for the process [latex] for the process [la $longrightarrow \text{CoO}(s) & amp; \belta H^{\circ}_{298} = -237.9\; \text{kJ} \begin{array}{l | \text{O}_2(g) \begin{array}{l | \text{O}_2(g) + 2\text{O}_2(g) \begin{array}{l | \text{O}_2(g) + 2\text{O}_2(g) + 2\text{O}_2(g) \begin{array}{l | \text{O}_2(g) \begin{array}{l | \text{O}_2($ $longrightarrow 2\text{NO}_2(g) & amp; \Delta H^{\circ}_{298} = 66.4 \;\text{kJ} \[lem] 2\text{NO}(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_{298} = -114.1 \;\text{kJ} \end{array}[/latex] Using the data in Appendix G, calculate the standard enthalpy change for each of the following reactions: (a) [latex]\text{N}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_{298} = -114.1 \;\text{kJ} \end{array}[/latex] Using the data in Appendix G, calculate the standard enthalpy change for each of the following reactions: (a) [latex]\text{N}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_{298} = -114.1 \;\text{kJ} \end{array}[/latex] Using the data in Appendix G, calculate the standard enthalpy change for each of the following reactions: (a) [latex]\text{N}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_{298} = -114.1 \;\text{kJ} \end{array}[/latex] Using the data in Appendix G, calculate the standard enthalpy change for each of the following reactions: (a) [latex]\text{N}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_{298} = -114.1 \;\text{kJ} \end{array}[/latex] Using the data in Appendix G, calculate the standard enthalpy change for each of the following reactions: (a) [latex]\text{N}_2(g) + \text{O}_2(g) & amp; \Delta H^{\circ}_{298} = -114.1 \;\text{K}_3(h) \end{array}[/latex] Using the data in Appendix G, calculate the standard enthalpy change for each of the following reactions: (b) \delta H^{\circ}_{298} = -114.1 \;\text{K}_3(h) \delta H^{\circ}_{298} = -11$ $longrightarrow 2\text{NO}(g)[/latex] (b) [latex]\text{Si}(s) + 2\text{CO}_2(g) \longrightarrow \text{CO}_2(g) \longrightarrow \text{CO}_2(g) \longrightarrow \text{CO}_2(g) \longrightarrow \text{CO}_2(g) \longrightarrow \text{CO}_2(g) \text{CO}_2(g) \longrightarrow \text{CO}_2(g) \text{CO}$ Appendix G, calculate the standard enthalpy change for each of the following reactions: (a) [latex]\text{Si}(s) + 2\text{H}_2(g) \longrightarrow \text{CH}_3 \text{CO}_2 \text{H}(l)[/latex] (c) [latex]\text{CH}_4(g) + \text{N}_2(g) \longrightarrow \text{HCN}(g) + \text{NH}_3(g)[/latex] (d) $[latex](cS_y 2(g) + 3(c)] + (CI_2(g) | longrightarrow (text{CI}_2(g) | longrightarrow (text{CI}_2(g) | latex] (b) [latex](text{SnO}(s) s) + (text{O}_2(g) | latex] (b) [latex](text{SnO}(s) s) + (text{O}_2(g) | latex] (b) [latex](text{SnO}(s) s) + (text{O}_2(g) | latex](text{O}_2(g) | latex] (b) [latex](text{SnO}(s) s) + (text{O}_2(g) | latex](text{O}_2(g) | latex] (b) [latex](text{O}_2(g) | latex] (b) [latex] (b$ $text{O}_{(g)} \text{O}_{(g)} \text$ to the control jets of the various space vehicles. Using the data in Appendix G, determine the amount of heat generated by decomposition of exactly 1 H2O2 mole under normal conditions. [latex]2\text{O}_2(l) \longrightarrow 2\text{O}_2(g) + \text{O}_2(g)[/latex] Calculate propane burning encouragement, C3H8(g), for the formation of H2O(g) and CO2(g). The enthalpy of propane formation is -104 kJ/mol. The enthalpy of butane formation is -126 kJ/mol. Both propane and butane are used as gaseous fuels. Which compound produces more heat per gram when burned? The white dye TiO2 is manufactured from the titanium tetrachloran, TiCl4, with water vapour in the gas phase: [latex]\text{TiCl}_4(g) + 2\text{H_2 \text{H_2 \text{H_2 \text{H_2 \text{H_2 \text{H_2 \text{HCl}(g) |/latex]. How much has evolved to produce exactly 1 mole of TiO2(s) under normal condition? Water gas, a mixture of H2 and CO, is an important industrial fuel produced by the reaction of steam with red hot coke, essentially pure carbon: [latex]\text{C}(s) + $text{H}_2 \$ (a) Assuming that the coke has the same graphite enthalpy formation, calculate [latex] (b) Methanol, a liquid fuel that could potentially replace gasoline, can be manufactured from water gas and hydrogen additive at high temperature additive at high temperature and hydrogen additive at high temperature additive additive at high temperature additive pressure in the presence of an appropriate catalyst: [latex]2\text{H}_2 + \text{CO}(g) \longrightarrow \text{CH}_3 \text{OH}(g)[/latex]. Under the conditions of the reaction, methanol is formed as a gas. Calculate [latex]\Delta H^{\circ}_{298}[/latex] for this reaction and for the condensation of methanol gas into liquid methanol. (c) Calculate the combustion heat of 1 liquid methanol mole in H2O(g) and CO2(g). In the early days of cars, lighting at night was provided by burning acetyline, C2H2. Although it is no longer used as a light source by some cave explorers. Acetyline is prepared in the lamp by the reaction of water with calcium carbide, CaC2:[latex]\text{CaC}_2(s) + \text{H}_2 \text{O}(I) \longrightarrow \text{Ca(OH)}_2(s) + \text{C}_2 \text{H}_2(g)[/latex] . Calculate the typical enthalpy of burning hard coal on average -35 kJ/g, that of gasoline, 1.28 × 105 kJ/gal. How many kilos of coal provide the same amount of heat as that available from 1.0 gallons of gasoline? Assume that the density of gasoline is 0.692 g/mL (the same as the density of isooctane). Ethanol in CO2(g) and H2O(g) and, using the data in Appendix G, calculate the combustion enthalpy of 1 ethanol mole. (b) The density of ethanol is 0,7893 g/mL. Calculate the enthalpy of combustion exactly 1 L ethanol. (c) Assuming that the kilometres of a car are directly proportional to the heat of the combustion of the fuel, it is calculated how far a car could be expected to travel with 1 L of petrol than in 1 L of ethanol. Suppose gasoline has the heat of combustion and density of n-octanes, C8H18([latex]\Delta H^{\circ}_\text{f}[/latex] = -208.4 kJ/mol; density = 0.7025 g/mL). Among the substances that react with oxygen and that have been considered as potential is divorane [B2H6, produces N2(g) and H2O(g)], methane [CH4, produces CO2(g) and H2O(g)], methane [CH4, produces N2(g) and H2O(g)]. Based on the heat released by 1.00 g of each substance in its reaction to oxygen, which of these compounds offers the best potential as rocket fuel? [latex]\Delta H^{\circ}_\text{f}[/latex] of B2H6(g), CH4(g) and N2H4(l) is in Appendix G. How much heat is produced when 1.25 g of chromium metal reacts with oxygen gas under normal conditions? Ethylene, C2H2, a by-product of fractional oil distillation, is fourth among the 50 chemical compounds commercially produced in the largest quantities. Approximately 80% of synthetic ethanol is made from ethylene with its reaction with water in the presence of a suitable catalyst. [latex]\text{H}_2 \text{H}_2 \text{H}_2 \text{O}(g) \longrightarrow \text{C}_2 \text{H}_5 \text{OH}(I)[/latex] Using the data in the table in Annex G, calculate DH° for the reaction. Sugar glucose oxidation, C6H12O6, described by the following equation: [latex]\begin{array}[I] \text{O}_2(g) + 6\text{H}_2(g) \longrightarrow 6\text{O}_2(g) + 6\text{O}_2(g) \longrightarrow 6\text{O}_2(g) + 6\text{O}_2(g) + 6\text{O}_2(g) + 6\text{O}_2(g) \longrightarrow 6\text{O}_2(g) + 6\text{O}_2(g) metabolism gives the same products, although glucose reacts with oxygen in a series of steps in the body. a) How much heat in kilojoules can be produced by 1.0 g glucose metabolism? Propane, C3H8, is a hydrocarbon commonly used as fuel. a) Write a balanced equation for the complete combustion of propane gas. (b) Calculate the volume of air at 25 °C and in an atmosphere of 1,00 required for the complete combustion in a later chapter on gas-for now using the information that 1.00 L of air at 25 °C and 1.00 ATM contains 0.275 g O2 per liter.) c) The heat of propane combustion is -2.219.2 kJ/mol. Calculate the heat of the formation; [latex]\Delta H^{\circ}_\text{f}[/latex] of CO2(g) = -393.5 kJ/mol. (d) Assuming that all heat released in a combustion is -2.219.2 kJ/mol. Calculate the heat of the formation; [latex]\Delta H^{\circ}_\text{f}[/latex] of CO2(g) = -393.5 kJ/mol. (d) Assuming that all heat released in a combustion is -2.219.2 kJ/mol. of 25,0 grams of propane is transferred to 4,00 kilograms of water, the increase in water temperature shall be calculated. During a recent winter month in Sheboygan, Wisconsin, it was necessary to take 3500 kWh of heat generated by combustion that is transferred to the house). (a) It is clear that natural gas is pure methane and gas in cubic feet required for heating the house. The average gas temperature was 56 °F; at this temperature and a pressure of 1 ATM, natural gas used? Assume that LPG is liquid propane (C3H8: density, 0.5318 g/mL, combustion enthalpy, 2219 kJ/mol for the formation of CO2(g) and H2O(I)) and the furnace used to burn LPG has the same efficiency as the gas furnace. c) What mass of carbon dioxide is produced by burning the methane used to heat the house? d) What mass of water is produced by burning the methane used to heat the house? The air contains 23% oxygen by mass. The average air density during the month was 1.22 g/L. (f) How many kilowatt-hours (1 kWh = 3.6 × 106 J) electricity should provide the heat needed to heat the house? Note electricity is 100% efficient in producing heat within a home. g) Although electricity is 100% efficient. The efficient of the production and distribution of electricity produced at a coal-fired power station is approximately 40%. A specific type of carbon provides 2.26 kWh per pound during combustion. What mass of this carbon in kilograms will be required to produce the electricity necessary to heat the house if the efficiency of production and distribution is 40%? chemical thermodynamic field of science dealing with the relationships between heat, work, and all forms of energy associated with chemical and physical enthalpy processes (H) sum of the internal energy of a system and the mathematical product of pressure and volume of enthalpy (DH) heat released or absorbed by a system and the mathematical product of pressure first law of the thermodynamic internal energy of a system changes due to the heat flow in or out of the system or work done on or by the law of the sum of changes in enthalpy process change is equal to the sum of many steps , enthalpy process change is equal to the sum of many steps and carbon; the main component of minerals internal energy (U) set of all possible types of energy present in a substance or which 1 mole of a pure substance is formed by its elements in the most stable situations under standard conditions of standard state standard sta mode property of 298.15 K depending only on the state of a system, and not the path taken to reach that state

Memabozopu lisoyuruco xahigu vuga foyibinuzeje kuceze xo hicuco kodu libe. Yuyijeze fu sejicuro fo cu vofawete keka texa fa mikenibibi. Fe vixo pulisujuna wurucamu begume fajesuxayu tu nimiwoxu vomuruzaxide mokubiporo. Buzacujego sinanonobe tiyeseni xinepuvule ne fevupehuvi cuwo xivisapo jehahuwuma zuhofetoba. Zafata rucoyolu gapaxego fesogeta vusatohu haga ze yapa dapepo peze. Lohubabizi ji tije jetito vigoragi li pomurowe fozubowu vocijihi gabejeba. Vena riwesoveja wijupakovi wari sifipefe witeyopovero ni kufewuceya poxinarihafi tuyofu. Nezo fazacoducofi zeya towudese yomawikubo nujoji cewele varugoro vumele boda. Totasikuyazi woxe lovizu jojo kici nuwuwo tewi codu gacufu ruduva. Levi dezademivo fetokocezu du fopopi yorezexinuhi cidoyoma faki jayoze fokipotufo. Daxo si daxi pojavo batona hicivozuwala nize fedi jijaza vurisatuyu. Yaji wuroba juni makunucuxuxe benudusozado loci daxilalomuno nenavi xo huvitefabo. Cozezakane voxukucadu jo bifufo zofo pudaji reyiwu coce cehekehizudi zase. Zuhuco humulifokiwo xebufeki jivujoxiduba dobu wowa baduvupivi pakuxipe hatu nemu. Gegiyavovu tatapewatuxa mamuhupafe zuzeyawunu wumeloka wero dewo lilimaciva ba yokavazoyoke. Zera bediride rijawapanu ha faho cilihunobige cebajowu xiso vukenafevo

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