1. Calculate the change in enthalpy for the reaction. (Use 1.0g/mL 1.0\;{\rm{g}}/{{\rm{mL}}}as the density of the solution and 4.18J/g⋅ ∘ C 4.18\;{\rm{J}}/{{\rm{g}} \cdot {\rm{^\circ C}}}as the specific heat capacity.)?

Instant cold packs, often used to ice athletic injuries on the field, contain ammonium nitrate and water separated by a thin plastic divider. When the divider is broken, the ammonium nitrate dissolves according to the following endothermic reaction:   
NH 4 NO 3 (s)→NH 4 + (aq)+NO 3 − (aq) {\rm{NH}}_4 {\rm{NO}}_3 (s)\; \rightarrow \;{\rm{NH}}_4{} ^ + (aq)\; + \;{\rm{NO}}_3{}^ - (aq)  
In order to measure the enthalpy change for this reaction, 1.25 g {\rm g}of NH 4 NO 3 {\rm{NH}}_4 {\rm{NO}}_3is dissolved in enough water to make 25.0 mL {\rm mL}of solution. The initial temperature is 25.8 ∘ C ^\circ {\rm C}and the final temperature (after the solid dissolves) is 21.9 ∘ C ^\circ {\rm C}.

1. When 0.501g gof biphenyl (C 12 H 10 ) {\rm{(C}}_{12} {\rm{H}}_{10} )undergoes combustion in a bomb calorimeter, the temperature rises from 25.2 ∘ C ^\circ Cto 29.4 ∘ C. Find ΔE rxn \Delta {\kern 1pt} E_{{\rm{rxn}}}for the combustion of biphenyl in kJ/mol \rm {kJ}/{mol}biphenyl. The heat capacity of the bomb calorimeter, determined in a separate experiment, is 5.86 kJ/ ∘ C \rm {kJ}/{^\circ C}.
2. What is the enthalpy for reaction 1 reversed? Express your answer numerically in kilojoules per mole. reaction 1 reversed: N 2 O 4 →N 2 + 2O 2
3. Calculate the enthalpy of the reaction

2NO(g)+O 2 (g)→2NO 2 (g) given the following reactions and enthalpies of formation:

1. 1/ 2 N 2 (g)+O 2 (g)→NO 2 (g), ΔH ∘ A =33.2 kJ
2. 1/ 2 N 2 (g)+ 1/ 2 O 2 (g)→NO(g), ΔH ∘ B =90.2 kJ

Express your answer with the appropriate units.

1. Calculate the enthalpy of the reaction

4B(s)+3O 2 (g)→2B 2 O 3 (s) {\rm 4B}({\rm s}) + {\rm 3O_2}({\rm g}) \rightarrow{\rm 2B_2O_3}({\rm s})

given the following pertinent information:

1. B 2 O 3 (s)+3H 2 O(g)→3O 2 (g)+B 2 H 6 (g), ΔH ∘ A =+2035 kJ
2. 2B(s)+3H 2 (g)→B 2 H 6 (g), ΔH ∘ B =+36 kJ
3. H 2 (g)+ 1 2 O 2 (g)→H 2 O(l), ΔH ∘ C =−285 kJ
4. H 2 O(l)→H 2 O(g), ΔH ∘ D =+44 kJ

Express your answer with the appropriate units.

1. Ozone, O 3 is destroyed when ClO \rm ClOlevels are high. ClO \rm ClOis likely formed from the decomposition of chlorofluorocarbons (CFCs) in sunlight.

Standard enthalpies of formation for selected substances are given in the table below.

|  |  |
| --- | --- |
| Substance | ΔH ∘ f \Delta H^{\circ}_{\rm f} (kJ/mol \rm kJ/mol) |
| ClO(g) \rm ClO(g) | 101.0 |
| ClO 2 (g) \rm ClO_2(g) | 102.0 |
| O(g) \rm O(g) | 247.5 |
| O 2 (g) \rm O_2(g) | 0 |
| O 3 (g) \rm O_3(g) | 142.3 |

* 1. Calculate the standard enthalpy change of the reaction

ClO(g)+O 3 (g)→ClO 2 (g)+O 2 (g) \rm ClO(g)+O_3(g)\rightarrow ClO_2(g)+O_2(g) Express your answer in kilojoules using four significant figures.

* 1. Calculate the standard enthalpy change of the reaction

ClO 2 (g)+O(g)→ClO(g)+O 2 (g) \rm ClO_2(g)+O(g)\rightarrow ClO(g)+O_2(g)Express your answer in kilojoules using four significant figures.

* 1. Add the following reactions together:

ClO(g)+O 3 (g) ClO 2 (g)+O(g) → → ClO 2 (g)+O 2 (g) ClO(g)+O 2 (g) Identify which species cancel and which do not.

1. Consider the reaction N 2 (g)+3H 2 (g)→2NH 3 (g), ΔH =−92.3kJ

What will ΔH \Delta Hbe for the reaction if it is reversed?

Express your answer with appropriate units.

1. calculate the change in enthalpy for Reaction 2.

Reaction 1: C 3 H 8 (g)+5O 2 (g)→3CO 2 (g)+4H 2 O(g), \rm C_3H_8 (g) +5 O_2(g)\rightarrow3 CO_2(g) + 4 H_2O(g), ΔH 1 =−2043 kJ \Delta H_1 = -2043~ \rm kJ

Reaction 2: 4C 3 H 8 (g)+20O 2 (g)→12CO 2 (g)+16H 2 O(g), \rm 4C_3H_8 (g) +20O_2(g) \rightarrow 12CO_2(g) + 16H_2O(g), ΔH 2 =? \Delta H_2 = ?

Express your answer to four significant figures and include the appropriate units.

1. calculate the reaction enthalpy, ΔH \Delta H, for the following reaction:

CH 4 (g)+2O 2 (g)→CO 2 (g)+2H 2 O(l) \rm CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)

Use the series of reactions that follow:

1. C(s)+2H 2 (g)→CH 4 (g) \rm C(s) + 2H_2(g) \rightarrow CH_4(g), ΔH \Delta H=−74.8 = -74.8kJ \rm kJ.
2. C(s)+O 2 (g)→CO 2 (g) \rm C(s) + O_2(g) \rightarrow CO_2(g), ΔH \Delta H=−393.5 = -393.5kJ \rm kJ.
3. 2H 2 (g)+O 2 (g)→2H 2 O(g) \rm 2H_2(g) + O_2(g) \rightarrow 2H_2O(g), ΔH \Delta H=−484.0 = -484.0kJ \rm kJ.
4. H 2 O(l)→H 2 O(g) \rm H_2O(l) \rightarrow H_2O(g), ΔH \Delta H=44.0 = 44.0kJ \rm kJ.

Express your answer with appropriate units.

1. Calculate the standard enthalpy change for the reaction

2A+B⇌2C+2D \rm 2A+B \rightleftharpoons 2C +2D

Use the following data:

|  |  |
| --- | --- |
| Substance | ΔH ∘ f \Delta H^{\circ}_{\rm f} (kJ/mol) \rm kJ/mol) |
| A \rm A | -267 |
| B \rm B | -383 |
| C \rm C | 191 |
| D \rm D | -481 |

Express your answer to three significant figures and include the appropriate units.

1. What is ΔH ∘ rxn\Delta H_{\rm rxn}^{\circ}for the following chemical reaction?

H 2 O(l)+CCl 4 (l)→COCl 2 (g)+2HCl(g) \rm H_2O(l) + CCl_4(l)\rightarrow COCl_2(g) + 2HCl(g)

You can use the following table of standard heats of formation (ΔH ∘ f ) (\Delta H_{\rm f}^{\circ})to calculate the enthalpy of the given reaction.

|  |  |  |  |
| --- | --- | --- | --- |
| **Element/ Compound** | **Standard Heat of Formation (kJ/mol)** | **Element/ Compound** | **Standard Heat of Formation (kJ/mol)** |
| H(g) \rm H {(g)} | 218 218 | N(g) \rm N{(g)} | 473 473 |
| H 2 (g) \rm H_{2}{(g)} | 0 0 | O 2 (g) \rm O_2{(g)} | 0 0 |
| CCl 4 (l)                <tex>\rm CCl_4(l)</tex> | −139.5          -139.5 | O(g) \rm O{(g)} | 249 249 |
| H 2 O(l)                <tex>\rm H_2O(l)</tex> | −285.8          -285.8 | HCl(g) \rm HCl(g) | −92.30kJ          -92.30<units>kJ</units> |
| C(g) \rm C{(g)} | 71 71 | COCl 2 (g) \rm COCl_2(g) | −218.8kJ          -218.8<units>kJ</units> |
| C(s) \rm C{(s)} | 00 | HNO 3 (aq) \rm HNO_3{(aq)} | −206.6 -206.6 |

Express the standard enthalpy of reaction to three significant figures and include the appropriate units.

1. The combustion of ethene, C 2 H 4 \rm C_2H_4, occurs via the reaction

C 2 H 4 (g)+3O 2 (g)→2CO 2 (g)+2H 2 O(g) \rm C_2H_4 (g) + 3O_2(g)\rightarrow 2CO_2(g) + 2H_2O(g)

with heat of formation values given by the following table:

|  |  |
| --- | --- |
| **Substance** | ΔH ∘ f \Delta H^\circ_{\rm f} (kJ/mol\rm kJ/mol) |
| C 2 H 4 \rm C_2H_4(g) \!\rm (g) | 52.47 |
| CO 2 (g) \rm CO_2(g) | −-393.5 |
| H 2 O(g) \rm H_2O(g) | − -241.8 |

Calculate the enthalpy for the combustion of ethene.

Express your answer to four significant figures and include the appropriate units.

1. For which of the following reactions is ΔH ∘ rxn \Delta H^\circ _{\rm rxn}equal to ΔH ∘ f \Delta H^\circ_{\rm f}of the product(s)?

You do *not* need to look up any values to answer this question.

Check all that apply.

Check all that apply.

|  |  |
| --- | --- |
|  | Na(s)+ 1 2 F 2 (l)→NaF(s) \rm Na(s) + \frac {_1} {^2} F_2(l)\rightarrow NaF(s) |
|  | 2H 2 (g)+O 2 (g)→2H 2 O(g) \rm 2H_2(g) +  O_2(g)\rightarrow 2H_2O(g) |
|  | H 2 (g)+ 1 2 O 2 (g)→H 2 O(g) \rm H_2(g) + \frac {_1} {^2} O_2(g)\rightarrow H_2O(g) |
|  | H 2 O 2 (g)→ 1 2 O 2 (g)+H 2 O(g) \rm H_2O_2(g)\rightarrow \frac {_1} {^2} O_2(g) + H_2O(g) |
|  | 2Na(s)+F 2 (g)→2NaF(s) \rm 2Na(s) + F_2(g)\rightarrow 2NaF(s) |
|  | Na(s)+ 1 2 F 2 (g)→NaF(s) \rm Na(s) + \frac {_1} {^2} F_2(g)\rightarrow NaF(s) |

1. What is the balanced chemical equation for the reaction used to calculate ΔH ∘ f  \Delta H_{\rm f}^{\circ}of BaCO 3 (s) \rm BaCO_3(s)? If fractional coefficients are required, enter them as a fraction (i.e. 1/3). Indicate the physical states using the abbreviation (s \rm s), (l \rm l), or (g \rm g) for solid, liquid, or gas, respectively. Use (aq \rm aq) for aqueous solution.

Express your answer as a chemical equation

The *standard enthalpy of formation* (ΔH ∘ f ) (\Delta H_{\rm f}^{\circ})is the enthalpy change that occurs when exactly 1 mol \rm molof a compound is formed from its constituent elements under standard conditions. The standard conditions are 1 atm \rm atmpressure, a temperature of 25 ∘ C \rm ^{\circ}C, and all the species present at a concentration of 1 M M. A "standard enthalpies of formation table" containing ΔH ∘ f \Delta H_{\rm f}^{\circ}values might look something like this:

|  |  |
| --- | --- |
| Substance | ΔH ∘ f \Delta H_{\rm f}^{\circ} |
| H(g) \rm H{(g)} | 218 kJ/mol \rm kJ/mol |
| H 2 (g) \rm H_2{(g)} | 0 kJ/mol \rm kJ/mol |
| Ba(s) \rm Ba(s) | 0 kJ/mol \rm kJ/mol |
| Ba 2+ (aq) \rm Ba^{2+}(aq) | − -538.4 kJ/mol ~\rm kJ/mol |
| C(g) \rm C{(g)} | 71 kJ/mol \rm kJ/mol |
| C(s) \rm C{(s)} | 0 kJ/mol \rm kJ/mol |
| N(g)\rm N{(g)} | 473 kJ/mol \rm kJ/mol |
| O 2 (g) \rm O_2{(g)} | 0 kJ/mol \rm kJ/mol |
| O(g) \rm O{(g)} | 249 kJ/mol \rm kJ/mol |
| S 2 (g) \rm S_2{(g)} | 129 kJ/mol \rm kJ/mol |

1. nitrogen triiodide, NI 3 \rm NI_3, and determine which of the following statements are correct.

Check all that apply.

|  |  |
| --- | --- |
|  | NI 3 \rm NI_3is a highly stable compound when it is dry. |
|  | In this reaction, heat is absorbed from the surroundings. |
|  | The enthalpy of NI 3 \rm NI_3is greater than the enthalpy of the decomposition products. |
|  | In this reaction, iodine is produced as one of the products. |
|  | The decomposition of NI 3 \rm NI_3is an exothermic reaction. |

1. The decomposition of NI 3 \rm NI_3to form N 2 \rm N_2and I 2 \rm I_2releases − -290.0 kJ \rm kJof energy. The reaction can be represented as

2NI 3 (s)→N 2 (g)+3I 2 (g), ΔH rxn =−290.0 kJ {\rm 2 NI_3 (s)\rightarrow N_2 (g) + 3 I_2 (g)},~{{\Delta H}}_{\rm rxn} = -290.0~{\rm kJ}

Find the change in enthaply when 19.0g gof NI 3 \rm NI_3decomposes.

Express your answer to three significant figures and include the appropriate units.

17-Consider the exothermic reaction

2C 2 H 6 (g)+7O 2 (g)→4CO 2 (g)+6H 2 O(g) \rm 2C_2H_6(g) + 7O_2(g)\rightarrow 4CO_2(g) + 6H_2O(g)

Calculate the standard heat of reaction, or ΔH ∘ rxn \Delta H{^\circ}_{\rm rxn}, for this reaction using the given data. Also consider that the standard enthalpy of the formation of elements in their pure form is considered to be zero.

|  |  |
| --- | --- |
| **Reactant or product** | **ΔH ∘ f (kJ/mol) \Delta H{^\circ}_{\rm f}~({\rm kJ/mol})** |
| C 2 H 6 (g) \rm C_2H_6(g) | -84.7 |
| CO 2 (g) \rm CO_2(g) | -393.5 |
| H 2 O(g) \rm H_2O(g) | -241.8 |

Express your answer to four significant figures and include the appropriate units.

1. Enthalpy H His a measure of the energy content of a system at constant pressure. Chemical reactions involve changes in enthalpy, ΔH which can be measured and calculated:ΔH rxn ∘ =∑ products mΔH f ∘ −∑ reactants nΔH f ∘ where the subscript "rxn" is for "enthalpy of reaction" and "f" is for "enthalpy of formation" and m mand n nrepresent the appropriate stoichiometric coefficients for each substance.The following table lists some enthalpy of formation values for selected substances.

|  |  |
| --- | --- |
| Substance | ΔH f ∘ \Delta {H_{\rm f}}^{\circ}(kJ/mol) (\rm kJ/mol) |
| HCl(g) \rm HCl (g) | −92         -92 |
| Al(OH) 3 (s) \rm Al(OH)_3 (s) | −1277         -1277 |
| H 2 O(l) \rm H_2O (l) | −285.8         -285.8 |
| AlCl 3 (s) \rm AlCl_3 (s) | −705.6         -705.6 |
| H 2 O(g) \rm H_2O (g) | −241.8 |

* 1. Determine the enthalpy for this reaction:Al(OH) 3 (s)+3HCl(g)→AlCl 3 (s)+3H 2 O(l) \rm Al(OH)_3 (s) + 3HCl (g) \rightarrow AlCl_3 (s) + 3H_2O (l)Express your answer in kilojoules per mole to four significant figures.
  2. Consider the reaction 2Al(OH) 3 (s)→Al 2 O 3 (s)+3H 2 O(l) with enthalpy of reaction

ΔH rxn ∘ =21.00kJ/mol.  \Delta {H_{\rm rxn}}^{\circ} =21.00<units>kJ/mol</units> 
    What is the enthalpy of formation of Al 2 O 3 (s)? Express your answer in kilojoules per mole to four significant figures.

1. Use the data below to answer the questions.

|  |  |
| --- | --- |
| Substance | ΔH ∘ f (kJ/mol) \Delta H _{\rm f}^{\circ}~(\rm kJ/mol) |
| C(g) \rm C(g) | 718.4 |
| CF 4 (g) \rm CF_4(g) | − -679.9 |
| CH 4 (g) \rm CH_4(g) | − -74.8 |
| H(g) \rm H(g) | 217.94 |
| HF(g) \rm HF(g) | − -268.61 |

Keep in mind that the enthalpy of formation of an element in its standard state is zero.

* + 1. Suppose that 0.610mol molof methane, CH 4 (g) is reacted with 0.760mol molof fluorine, F 2 (g) \rm F_2(g), forming CF 4 (g) \rm CF_4(g)and HF(g) \rm HF(g)as sole products. Assuming that the reaction occurs at constant pressure, how much heat is released?Express your answer to three significant figures and include the appropriate units.