Heat of Formation

Activity 1: Equations

Question Group 1

Question 1

The standard heat of formation of $CH_{4(g)}$ is -74.8 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$C_{(s)} + 2\ H_{2(g)} \Longrightarrow CH_{4(g)}$	ΔH = -74.8 kJ
$CH_{4(g)} \Longrightarrow C_{(s)} + 2\ H_{2(g)}$	ΔH = +74.8 kJ
$C_{(s)} + H_{4(g)} \Longrightarrow CH_{4(g)}$	ΔH = -74.8 kJ
$CH_{4(l)} \Longrightarrow CH_{4(g)}$	ΔH = -74.8 kJ
$C_{(g)} + 4\ H_{(g)} \Longrightarrow CH_{4(g)}$	ΔH = -74.8 kJ
$CH_{4(g)} \Longrightarrow C_{(s)} + 4\ H_{(g)}$	ΔH = +74.8 kJ

Question 2

The standard heat of formation of $C_3H_{8(g)}$ is -104 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$3\ C_{(s)} + 4\ H_{2(g)} \Longrightarrow C_3H_{8(g)}$	ΔH = -104 kJ
$C_3H_{8(g)} \Longrightarrow 3\ C_{(s)} + 4\ H_{2(g)}$	ΔH = +104 kJ
$3\ C_{(s)} + 8\ H_{(g)} \Longrightarrow C_3H_{8(g)}$	ΔH = -104 kJ
$C_3H_{8(g)} \Longrightarrow 3\ C_{(s)} + 8\ H_{(g)}$	ΔH = +104 kJ
$C_{3(s)} + 4\ H_{2(g)} \Longrightarrow C_3H_{8(g)}$	ΔH = -104 kJ
$C_3H_{8(g)} \Longrightarrow C_{3(s)} + H_{8(g)}$	ΔH = +104 kJ

Question 3

The standard heat of formation of $CCl_{4(l)}$ is -135 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$C_{(s)} + 2\ Cl_{2(g)} \Longrightarrow CCl_{4(g)}$	ΔH = -135 kJ
$CCl_{4(l)} \Longrightarrow C_{(s)} + 2\ Cl_{2(g)}$	ΔH = +135 kJ
$C_{(s)} + Cl_{4(g)} \Longrightarrow CCl_{4(g)}$	ΔH = -135 kJ
$CCl_{4(g)} \Longrightarrow CCl_{4(l)}$	ΔH = -135 kJ
$C_{(g)} + 4\ Cl_{(g)} \Longrightarrow CCl_{4(l)}$	ΔH = -135 kJ
$CCl_{4(l)} \Longrightarrow C_{(s)} + 4\ Cl_{(g)}$	ΔH = +135 kJ

Question Group 2

Question 4

The standard heat of formation of $H_2O_{(g)}$ is -242 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$H_{2(g)} + ½\ O_{2(g)} \Longrightarrow H_2O_{(g)}$	ΔH = -242 kJ
$2\ H_{2(g)} + O_{2(g)} \Longrightarrow 2\ H_2O_{(g)}$	ΔH = -484 kJ
$2\ H_2O_{(g)} \Longrightarrow 2\ H_{2(g)} + O_{2(g)}$	ΔH = +484 kJ
$2\ H_{2(g)} + O_{2(g)} \Longrightarrow 2\ H_2O_{(g)}$	ΔH = -242 kJ
$H_{2(g)} + O_{(g)} \Longrightarrow H_2O_{(g)}$	ΔH = -242 kJ
$2\ H_{(g)} + O_{(g)} \Longrightarrow H_2O_{(g)}$	ΔH = -242 kJ

Question 5

The standard heat of formation of $C_2H_{6(g)}$ is -84.7 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$2\ C_{(s)} + 3\ H_{2(g)} \Longrightarrow C_2H_{6(g)}$	ΔH = -84.7 kJ/mol
$C_{2(g)} + 3\ H_{2(g)} \Longrightarrow C_2H_{6(g)}$	ΔH = -84.7 kJ/mol
$2\ C_{(s)} + 6\ H_{(g)} \Longrightarrow C_2H_{6(g)}$	ΔH = -84.7 kJ/mol
$C_{2(g)} + H_{6(g)} \Longrightarrow C_2H_{6(g)}$	ΔH = -84.7 kJ/mol
$C_2H_{6(g)} \Longrightarrow C_{2(g)} + H_{6(g)}$	ΔH = +84.7 kJ/mol
$C_2H_{6(g)} \Longrightarrow 2\ C_{(s)} + 6\ H_{(g)}$	ΔH = +84.7 kJ/mol

Question 6

The standard heat of formation of $Al_2O_{3(s)}$ is -1676 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$2\ Al_{(s)} + 3/2\ O_{2(g)} \Longrightarrow Al_2O_{3(s)}$	ΔH = -1676 kJ
$4\ Al_{(s)} + 3\ O_{2(g)} \Longrightarrow 2\ Al_2O_{3(s)}$	ΔH = -3352 kJ
$2\ Al_2O_{3(s)} \Longrightarrow 4\ Al_{(s)} + 3\ O_{2(g)}$	ΔH = +3352 kJ
$Al_{2(s)} + O_{3(g)} \Longrightarrow Al_2O_{3(s)}$	ΔH = -1676 kJ
$Al_2O_{3(s)} \Longrightarrow Al_{2(s)} + O_{3(g)}$	ΔH = +1676 kJ
$2\ Al_{2(s)} + 2\ O_{3(g)} \Longrightarrow 2\ Al_2O_{3(s)}$	ΔH = -3352 kJ

Question Group 3

Question 7

The standard heat of formation of $BaCO_{3(s)}$ is -1216 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$Ba_{(s)} + C_{(s)} + 3/2\ O_{2(g)} \Longrightarrow BaCO_{3(s)}$	ΔH = -1216 kJ
$2\ Ba_{(s)} + 2\ C_{(s)} + 3\ O_{2(g)} \Longrightarrow 2\ BaCO_{3(s)}$	ΔH = -2432 kJ
$BaCO_{3(s)} \Longrightarrow Ba_{(s)} + C_{(s)} + 3/2\ O_{2(g)}$	ΔH = +1216 kJ
$Ba_{(s)} + C_{(s)} + O_{3(g)} \Longrightarrow BaCO_{3(s)}$	ΔH = -1216 kJ
$2\ BaCO_{3(s)} \Longrightarrow Ba_{2(s)} + C_{2(s)} + 3/2\ O_{2(g)}$	ΔH = +2432 kJ
$BaCO_{3(s)} \Longrightarrow 1/3\ Ba_{3(s)} + 1/3\ C_{3(s)} + O_{3(g)}$	ΔH = +1216 kJ

Question 8

The standard heat of formation of $CaCO_{3(s)}$ is -1207 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$Ca_{(s)} + C_{(s)} + 3/2\ O_{2(g)} \Longrightarrow CaCO_{3(s)}$	ΔH = -1207 kJ
$2\ Ca_{(s)} + 2\ C_{(s)} + 3\ O_{2(g)} \Longrightarrow 2\ CaCO_{3(s)}$	ΔH = -2414 kJ
$CaCO_{3(s)} \Longrightarrow Ca_{(s)} + C_{(s)} + 3/2\ O_{2(g)}$	ΔH = +1207 kJ
$Ca_{(s)} + C_{(s)} + O_{3(g)} \Longrightarrow CaCO_{3(s)}$	ΔH = -1207 kJ
$2\ CaCO_{3(s)} \Longrightarrow Ca_{2(s)} + C_{2(s)} + 3/2\ O_{2(g)}$	ΔH = +2414 kJ
$CaCO_{3(s)} \Longrightarrow 1/3\ Ca_{3(s)} + 1/3\ C_{3(s)} + O_{3(g)}$	ΔH = +1207 kJ

Question 9

The standard heat of formation of $MgCO_{3(s)}$ is -1096 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$Mg_{(s)} + C_{(s)} + 3/2\ O_{2(g)} \Longrightarrow MgCO_{3(s)}$	ΔH = -1096 kJ
$2\ Mg_{(s)} + 2\ C_{(s)} + 3\ O_{2(g)} \Longrightarrow 2\ MgCO_{3(s)}$	ΔH = -2192 kJ
$MgCO_{3(s)} \Longrightarrow Mg_{(s)} + C_{(s)} + 3/2\ O_{2(g)}$	ΔH = +1096 kJ
$Mg_{(s)} + C_{(s)} + O_{3(g)} \Longrightarrow MgCO_{3(s)}$	ΔH = -1096 kJ
$2\ MgCO_{3(s)} \Longrightarrow Mg_{2(s)} + C_{2(s)} + 3/2\ O_{2(g)}$	ΔH = +2192 kJ
$MgCO_{3(s)} \Longrightarrow 1/3\ Mg_{3(s)} + 1/3\ C_{3(s)} + O_{3(g)}$	ΔH = +1096 kJ

Question Group 4

Question 10

The standard heat of formation of $KClO_{4(s)}$ is -433 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$K_{(s)} + ½\ Cl_{2(g)} + 2\ O_{2(g)} \Longrightarrow KClO_{4(s)}$	ΔH = -433 kJ
$2\ K_{(s)} + Cl_{2(g)} + 4\ O_{2(g)} \Longrightarrow 2\ KClO_{4(s)}$	ΔH = -866 kJ
$K_{(s)} + Cl_{(g)} + 2\ O_{2(g)} \Longrightarrow KClO_{4(s)}$	ΔH = -433 kJ
$K_{(s)} + Cl_{(g)} + O_{4(g)} \Longrightarrow KClO_{4(s)}$	ΔH = -433 kJ
$KClO_{4(s)} \Longrightarrow K_{(s)} + Cl_{(g)} + O_{4(g)}$	ΔH = +433 kJ
$2\ KClO_{4(s)} \Longrightarrow 2\ K_{(s)} + 2\ Cl_{(g)} + 4\ O_{2(g)}$	ΔH = +866 kJ

Question 11

The standard heat of formation of $KNO_{3(s)}$ is -495 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$K_{(s)} + ½\ N_{2(g)} + 3/2\ O_{2(g)} \Longrightarrow KNO_{3(s)}$	ΔH = -495 kJ
$2\ K_{(s)} + N_{2(g)} + 3\ O_{2(g)} \Longrightarrow 2\ KNO_{3(s)}$	ΔH = -990 kJ
$K_{(s)} + N_{(g)} + O_{3(g)} \Longrightarrow KNO_{3(s)}$	ΔH = -495 kJ
$KNO_{3(s)} \Longrightarrow K_{(s)} + N_{(g)} + 3\ O_{(g)}$	ΔH =+495 kJ
$KNO_{3(s)} \Longrightarrow K_{(s)} + N_{(g)} + O_{3(g)}$	ΔH = +495 kJ
$2\ KNO_{3(s)} \Longrightarrow 2\ K_{(s)} + 2\ N_{(g)} + 6\ O_{(g)}$	ΔH = +990 kJ

Question 12

The standard heat of formation of $HNO_{3(l)}$ is -174 kJ/mol. Which of the following chemical equations and corresponding ΔH values are consistent with this fact? Identify all that apply.

$½\ H_{2(g)} + ½\ N_{2(g)} + 3/2\ O_{2(g)} \Longrightarrow HNO_{3(l)}$	ΔH = -174 kJ
$H_{2(g)} + N_{2(g)} + 3\ O_{2(g)} \Longrightarrow 2\ HNO_{3(l)}$	ΔH = -348 kJ
$H_{2(g)} + 2\ N_{(g)} + 2\ O_{3(g)} \Longrightarrow HNO_{3(l)}$	ΔH = -348 kJ
$HNO_{3(l)} \Longrightarrow H_{(g)} + N_{(g)} + 3\ O_{(g)}$	ΔH =+174 kJ
$HNO_{3(l)} \Longrightarrow H_{(g)} + N_{(g)} + O_{3(g)}$	ΔH = +174 kJ
$2\ HNO_{3(l)} \Longrightarrow 2\ H_{(g)} + 2\ N_{(g)} + 6\ O_{(g)}$	ΔH = +348 kJ

Activity 2: Heat of Reaction 1

Activity 2 questions involve multi-part exercises that guide students from knowledge of the heat of formation values to the determination of the heat of reaction. The basic idea of the questions are presented below. However, the actual activity is significantly more sophisticated than a static question on a page.

Question Group 5

Question 13

Determine the enthalpy change of the reaction:

$2\ CO_{(g)} + O_{2(g)} \Longrightarrow 2\ CO_{2(g)}$

ΔH_f Values

$CO_{(g)}$: -110.5 kJ/mol

$CO_{2(g)}$: -393.5 kJ/mol

Question 14

Determine the enthalpy change of the reaction:

$2\ H_2O_{2(l)} \Longrightarrow 2\ H_2O_{(l)} + O_{2(g)}$

ΔH_f Values

$H_2O_{2(l)}$: -187.8 kJ/mol

$H_2O_{(l)}$: -285.8 kJ/mol

Question Group 6

Question 15

Determine the enthalpy change of the reaction:

$N_2H_{4(l)} + O_{2(g)} \Longrightarrow N_{2(g)} + 2\ H_2O_{(g)}$

ΔH_f Values

$N_2H_{4(l)}$ +50.6 kJ/mol

$H_2O_{(g)}$: -241.8 kJ/mol

Question 16

Determine the enthalpy change of the reaction:

$Fe_3O_{4(s)} + 4\ H_{2(g)} \Longrightarrow 3\ Fe_{(s)} + 4\ H_2O_{(g)}$

ΔH_f Values

$Fe_3O_{4(s)}$ -1118.4 kJ/mol

$H_2O_{(g)}$ -241.8 kJ/mol

Question Group 7
Question 17
Determine the enthalpy change of the reaction:
$2\ KClO_{3(s)} \Longrightarrow 2\ KCl_{(s)} + 3\ O_{2(g)}$

ΔH_f Values

$KClO_{3(s)}$	-391.4 kJ/mol
$KCl_{(s)}$	-436.68 kJ/mol

Question 18
Determine the enthalpy change of the reaction:
$KClO_{4(s)} \Longrightarrow KCl_{(s)} + 2\ O_{2(g)}$

ΔH_f Values

$KClO_{4(s)}$	-430.12 kJ/mol
$KCl_{(s)}$	-436.68 kJ/mol

Activity 3: Heat of Reaction 2

Activity 3 questions involve multi-part exercises that guide students from knowledge of the heat of formation values to the determination of the heat of reaction. The basic idea of the questions are presented below. However, the actual activity is significantly more sophisticated than a static question on a page.

Question Group 8

Question 19

Determine the enthalpy change of the reaction:

$CH_{4(g)} + 2\ O_{2(g)} \Longrightarrow CO_{2(g).} + 2\ H_2O_{(l)}$

ΔH_f Values

$CH_{4(g)}$: -74.8 kJ/mol

$CO_{2(g)}$: -393.5 kJ/mol

$H_2O_{(l)}$: -285.8 kJ/mol

Question 20

Determine the enthalpy change of the reaction:

$C_3H_{8(g)} + 5\ O_{2(g)} \Longrightarrow 3\ CO_{2(g).} + 4\ H_2O_{(g)}$

ΔH_f Values

$C_3H_{8(g)}$: -74.8 kJ/mol

$CO_{2(g)}$: -393.5 kJ/mol

$H_2O_{(g)}$: -241.8 kJ/mol

Question 21

Determine the enthalpy change of the reaction:

$2\ C_2H_5OH_{(l)} + 7\ O_{2(g)} \Longrightarrow 4\ CO_{2(g).} + 6\ H_2O_{(g)}$

ΔH_f Values

$C_2H_5OH_{(l)}$: -277.7 kJ/mol

$CO_{2(g)}$: -393.5 kJ/mol

$H_2O_{(g)}$: -241.8 kJ/mol

Question Group 9

Question 22

Determine the enthalpy change of the reaction:

$HNO_{3(g)} + 4\ H_{2(g)} \Longrightarrow NH_{3(g)} + 3\ H_2O_{(g)}$

ΔH_f Values

$HNO_{3(g)}$: -134.3 kJ/mol

$NH_{3(g)}$: -46.1 kJ/mol

$H_2O_{(g)}$: -241.8 kJ/mol

Question 23
Determine the enthalpy change of the reaction:
$2\ CH_3OH_{(l)} + 3\ O_{2(g)} \Longrightarrow 2\ CO_{2(g)} + 4\ H_2O_{(g)}$

ΔH_f Values
$CH_3OH_{(l)}$ -238.7 kJ/mol
$CO_{2(g)}$ -393.5 kJ/mol
$H_2O_{(g)}$ -241.8 kJ/mol

Question 24
Determine the enthalpy change of the reaction:
$2\ C_2H_{2(g)} + 5\ O_{2(g)} \Longrightarrow 4\ CO_{2(g).} + 2\ H_2O_{(g)}$

ΔH_f Values
$C_2H_{2(g)}$ +226.7 kJ/mol
$CO_{2(g)}$ -393.5 kJ/mol
$H_2O_{(g)}$ -241.8 kJ/mol

Question Group 10
Question 25
Determine the enthalpy change of the reaction:
$Al_2O_{3(s)} + 3\ H_2O_{(g)} \Longrightarrow 2\ Al(OH)_{3(s)}$

ΔH_f Values
$Al_2O_{3(s)}$ -1675.5 kJ/mol
$H_2O_{(g)}$ -241.8 kJ/mol
$Al(OH)_{3(s)}$ -1277 kJ/mol

Question 26
Determine the enthalpy change of the reaction:
$Fe_2O_{3(s)} + 3\ CO_{(g)} \rightarrow 2\ Fe_{(s)} + 3\ CO_{2(g)}$

ΔH_f Values
$Fe_2O_{3(s)}$ -824.2 kJ/mol
$CO_{(g)}$ -110.5 kJ/mol
$CO_{2(g)}$ -393.5 kJ/mol

Question 27

Determine the enthalpy change of the reaction:

$SiC_{(s)} + 2\ CO_{(g)} \rightarrow SiO_{2(s)} + 3\ C_{(s)}$

ΔH_f Values

$SiC_{(s)}$	-71.5 kJ/mol
$CO_{(g)}$	-110.5 kJ/mol
$SiO_{2(s)}$	-910.86 kJ/mol