

Worksheet: HESS LAW

Questions will be solved by the help of HESS LAW formulas

For Formation:

$$\Delta H_r = \sum \Delta H_f (\text{Products}) - \sum \Delta H_f (\text{Reactants})$$

For Combustion:

$$\Delta H_r = \sum \Delta H_c (\text{Reactants}) - \sum \Delta H_c (\text{Products})$$

- 3 Ethanol is increasingly being used as a fuel for cars.

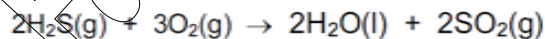
The standard enthalpy change of formation of carbon dioxide is -393 kJ mol^{-1} .
 The standard enthalpy change of formation of water is -286 kJ mol^{-1} .
 The standard enthalpy change of formation of ethanol is -277 kJ mol^{-1} .

What is the standard enthalpy change of combustion of ethanol?

- A $-1921 \text{ kJ mol}^{-1}$
- B $-1367 \text{ kJ mol}^{-1}$
- C -956 kJ mol^{-1}
- D -402 kJ mol^{-1}

w/14/qp11

- 5 Hydrogen sulfide, H_2S , is released from volcanoes. It reacts with oxygen in the air to form sulfur dioxide.



$$\Delta H_f^\ominus [\text{H}_2\text{S}(\text{g})] = -21 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [\text{H}_2\text{O}(\text{l})] = -286 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [\text{SO}_2(\text{g})] = -297 \text{ kJ mol}^{-1}$$

What is the standard enthalpy change of this reaction?

- A $-1208 \text{ kJ mol}^{-1}$
- B $-1124 \text{ kJ mol}^{-1}$
- C -562 kJ mol^{-1}
- D -541 kJ mol^{-1}

w/14/qp13

- 3 The enthalpy change of formation of carbon dioxide is -394 kJ mol^{-1} .
The enthalpy change of formation of water is -286 kJ mol^{-1} .
The enthalpy change of formation of methane is -74 kJ mol^{-1} .

What is the enthalpy change of combustion of methane?

- A -892 kJ mol^{-1}
- B -606 kJ mol^{-1}
- C $+606 \text{ kJ mol}^{-1}$
- D $+892 \text{ kJ mol}^{-1}$

s/14/qp12

- 9 The enthalpy change of formation of $\text{Mn}(\text{NO}_3)_2(\text{s})$ is -696 kJ mol^{-1} .
The enthalpy change of formation of $\text{MnO}_2(\text{s})$ is -520 kJ mol^{-1} .
The enthalpy change of formation of $\text{NO}_2(\text{g})$ is $+33 \text{ kJ mol}^{-1}$.

On heating, $\text{Mn}(\text{NO}_3)_2$ decomposes into MnO_2 and NO_2 .



What is the value of the standard enthalpy change of this reaction?

- A -242 kJ mol^{-1}
- B -209 kJ mol^{-1}
- C $+209 \text{ kJ mol}^{-1}$
- D $+242 \text{ kJ mol}^{-1}$

s/14/qp13

- 12 Propanone has molecular formula $\text{C}_3\text{H}_6\text{O}$.

The enthalpy change of combustion of hydrogen is -286 kJ mol^{-1} .

The enthalpy change of combustion of carbon is -394 kJ mol^{-1} .

The enthalpy change of formation of propanone is -254 kJ mol^{-1} .

Using this information, what is the enthalpy change of combustion of propanone?

- A $-2644 \text{ kJ mol}^{-1}$
- B $-2294 \text{ kJ mol}^{-1}$
- C $-1786 \text{ kJ mol}^{-1}$
- D -426 kJ mol^{-1}

s/13/qp12

- 10 A student calculated the standard enthalpy change of formation of ethane, C_2H_6 , using a method based on standard enthalpy changes of combustion.

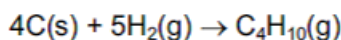
He used correct values for the standard enthalpy change of combustion of ethane ($-1560 \text{ kJ mol}^{-1}$) and hydrogen (-286 kJ mol^{-1}) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was -158 kJ mol^{-1} .

What did he use for the standard enthalpy change of combustion of carbon?

- A $-1432 \text{ kJ mol}^{-1}$
- B -860 kJ mol^{-1}
- C -430 kJ mol^{-1}
- D -272 kJ mol^{-1}

w/12/qp11

- 8 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.



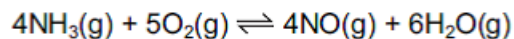
By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, ΔH_f° , for this reaction?

compound	$\Delta H_c^\circ / \text{kJ mol}^{-1}$
carbon	-394
hydrogen	-286
butane	-2877

- A $-5883 \text{ kJ mol}^{-1}$
- B -129 kJ mol^{-1}
- C $+129 \text{ kJ mol}^{-1}$
- D $+2197 \text{ kJ mol}^{-1}$

w/10/qp11

- 6 The first stage in the industrial production of nitric acid from ammonia can be represented by the following equation.



Using the following standard enthalpy change of formation data, what is the value of the standard enthalpy change, ΔH^\ominus , for this reaction?

compound	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{NH}_3(\text{g})$	-46.1
$\text{NO}(\text{g})$	+90.3
$\text{H}_2\text{O}(\text{g})$	-241.8

- A +905.2 kJ mol⁻¹
 B -105.4 kJ mol⁻¹
 C -905.2 kJ mol⁻¹
 D -1274.0 kJ mol⁻¹

w/09/qp11

- 6 Given $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$ $\Delta H_f^\ominus = -297 \text{ kJ mol}^{-1}$
 and $\text{S}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$ $\Delta H_f^\ominus = -395 \text{ kJ mol}^{-1}$

what is the enthalpy change of reaction, ΔH^\ominus , of $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$?

- A -196 kJ mol⁻¹ B -98 kJ mol⁻¹ C +98 kJ mol⁻¹ D +196 kJ mol⁻¹

w/05/qp1

- 11 The 'flash' produced by nineteenth century photographers to take indoor photographs was obtained from the following reaction.



The standard enthalpy changes of formation are given below.

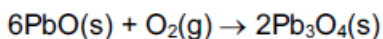
	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
MgO	-602
KCl	-437
KClO ₃	-391

What is the standard enthalpy change of the 'flash' reaction?

- A $-3(-602) + (-437) - (-391)$
 B $(-602) + (-437) - (-391)$
 C $3(-602) + (-437) - (-391)$
 D $(-602) + 3(-437) - 3(-391)$

w/03/qp1

- 12 Red lead oxide, Pb₃O₄, is used in metal priming paints. It can be made by heating PbO in air.



Which two values are needed to calculate the enthalpy change for this reaction?

- A enthalpy change of atomisation of O₂ and enthalpy change of formation of Pb₃O₄
 B enthalpy change of formation of O₂ and enthalpy change of formation of Pb₃O₄
 C enthalpy change of formation of PbO and enthalpy change of atomisation of O₂
 D enthalpy change of formation of PbO and enthalpy change of formation of Pb₃O₄

s/12/qp12

- 7 Propanone has the molecular formula C_3H_6O .

The enthalpy change of combustion of hydrogen is -286 kJ mol^{-1} .

The enthalpy change of combustion of carbon is -394 kJ mol^{-1} .

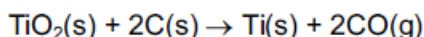
The enthalpy change of combustion of propanone is $-1786 \text{ kJ mol}^{-1}$.

Using this information, what is the enthalpy change of formation of propanone?

- A $-1106 \text{ kJ mol}^{-1}$
- B -540 kJ mol^{-1}
- C -254 kJ mol^{-1}
- D $+1106 \text{ kJ mol}^{-1}$

s/12/qp11

- 7 Titanium occurs naturally as the mineral rutile, TiO_2 . One possible method of extraction of titanium is to reduce the rutile by heating with carbon.



The standard enthalpy changes of formation of $TiO_2(s)$ and $CO(g)$ are -940 kJ mol^{-1} and -110 kJ mol^{-1} respectively.

What is the standard enthalpy change of this reaction?

- A -830 kJ mol^{-1}
- B -720 kJ mol^{-1}
- C $+720 \text{ kJ mol}^{-1}$
- D $+830 \text{ kJ mol}^{-1}$

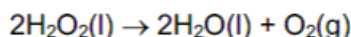
s/11/qp12

- 8 Hydrogen peroxide slowly decomposes into water and oxygen. The enthalpy change of reaction can be calculated using standard enthalpies of formation.

$$\Delta H_f^\ominus(\text{hydrogen peroxide(l)}) = -187.8 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{water(l)}) = -285.8 \text{ kJ mol}^{-1}$$

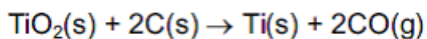
Using a Hess cycle, what is the enthalpy change of reaction for this decomposition?



- A $+98 \text{ kJ mol}^{-1}$
- B -98 kJ mol^{-1}
- C -196 kJ mol^{-1}
- D $-947.2 \text{ kJ mol}^{-1}$

s/09/qp1

- 10 Titanium occurs naturally as the mineral rutile, TiO_2 . One possible method of extraction of titanium is to reduce the rutile by heating with carbon.



The standard enthalpy changes of formation of $\text{TiO}_2(\text{s})$ and $\text{CO}(\text{g})$ are -940 kJ mol^{-1} and -110 kJ mol^{-1} respectively.

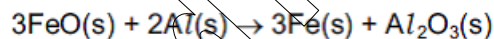
What is the standard enthalpy change of this reaction?

- A -830 kJ mol^{-1}
- B -720 kJ mol^{-1}
- C $+720 \text{ kJ mol}^{-1}$
- D $+830 \text{ kJ mol}^{-1}$

s/08/qp1

- 8 The standard enthalpy changes of formation of iron(II) oxide, $\text{FeO}(\text{s})$, and aluminium oxide, $\text{Al}_2\text{O}_3(\text{s})$, are -266 kJ mol^{-1} and $-1676 \text{ kJ mol}^{-1}$ respectively.

What is the enthalpy change under standard conditions for the following reaction?



- A $+878 \text{ kJ}$ B -878 kJ C -1942 kJ D -2474 kJ

s/04/qp1
