1. Define the following terms:

a. Standard enthalpy of formation.

b Standard enthalpy of combustion.

c. Hess's law

2. Write an equation to show the standard enthalpy of formation of propane (C_3H_8).

a. Draw a Hess's law energy cycle to calculate the standard enthapy of formation of propane using the information in the table below.

b. What is the standard enthalpy change of combustion of propane per gram?

Substance	Standard enthalpy of combustion (Δ_cH°)/kJmol^{-1}
Carbon (graphite)	-393
Hydrogen (H_2)	-286
Propane (C_3H_8).	-2220

3. Many unwanted reactions can occur when fuels are burned inside car engines. One such reaction is the conversion of NO(g) to $NO_2(g)$ as shown below:

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$$

a. By defintion what is the standard enthalpy of formation ($\Delta_f H^o$) of an element?

b. Use the information in the table opposite to calculate the enthalpy change for the reaction above.

Substance	Standard enthalpy of formation ($\Delta_f H^o$)/kJmol^{-1}
NO	91
NO_2	35

3. Ethanol (C_2H_5OH) is a biofuel which is added to petrol to reduce the amount of carbon dioxide being added to the atmosphere.

a. Write an equation to show the standard enthalpy of formation of ethanol.

c. Calculate the standard enthalpy of formation of ethanol using the information in the table opposite.

Substance	Standard enthalpy of combustion ($\Delta_c H^o$)/kJmol^{-1}
C_2H_5OH	-1367
C	-393
H_2	-286

4. A blast furnace can reduce iron oxide (Fe_2O_3) to iron according to the equation below.

$$Fe_2O_{3(s)} + 3CO_{(g)} \longrightarrow 2Fe_{(s)} + 3CO_{2\,(g)}$$

a. Calculate the enthalpy change for this reaction using the information in the table opposite.

Substance	Standard enthalpy of formation ($\Delta_f H^o$)/kJmol^{-1}
Fe_2O_3	-824
CO_2	-393
CO	-99

Answers

1. Define the following terms:

a. Standard enthalpy of formation.

Enthalpy change under standard conditions when 1 mole of a substance is formed from its elements, with all reactants and products in their standard states.

b Standard enthalpy of combustion.

Enthalpy change under standard conditions when 1 mole of substance is completely burned in oxygen, with all reactants and products in their standard states.

c. Hess's law

The enthalpy change for a reaction only depends on the initial and final states of the reaction and is independent of the route taken by the reaction.

2. Write an equation to show the standard enthalpy of formation of propane (C_3H_8).

$$3C_{(s)} + 4H_{2(g)} \longrightarrow C_3H_{8\,(g)}$$

Step 1 – Write the equation for which you have to calculate the enthalpy change

$$3C_{(s)} + 4H_{2(g)} \xrightarrow{\Delta H_{rxn}} C_3H_{8\,(g)}$$

$\Delta H_1 = 3\Delta_c H$ carbon $= -1179\,kJ$

$\Delta H_2 = 4\Delta_c H$ hydrogen $= -1144\,kJ$

$\Delta H_3 = \Delta_c$ propane $= -2220\,kJ$

$$3CO_{2(g)} + 4H_2O_{(l)}$$

$$\Delta H_{rxn} = (\Delta H_1 + \Delta H_2) - \Delta H_3$$
$$= (-2323) - (-2220)$$
$$= -103\,kJ\,mol^{-1}$$

b. What is the standard enthalpy change of combustion of propane per gram?

1 mole of propane = 44g, this releases 2220kJ of heat per mole when burned.

So 1g will produce 2220/44 = 50.45kJ of heat energy.

3. Many unwanted reactions can occur when fuels are burned inside car engines. One such reaction is the conversion of NO(g) to $NO_2(g)$ as shown below:

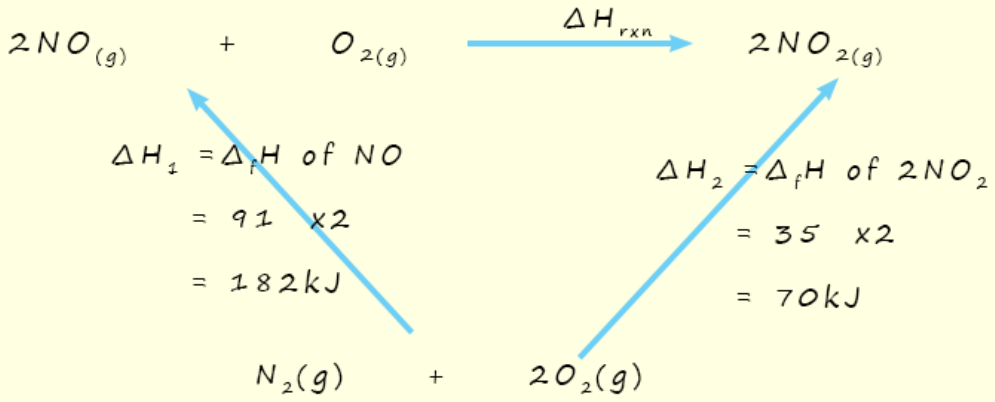
$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$$

a. By defintion what is the standard enthalpy of formation ($\Delta_f H^o$) of an element?

It is zero

b. Use the information in the table opposite to calcualte the enthalpy change for the reaction above.

Step 1 - Write the equation for which you have to calculate the enthalpy change



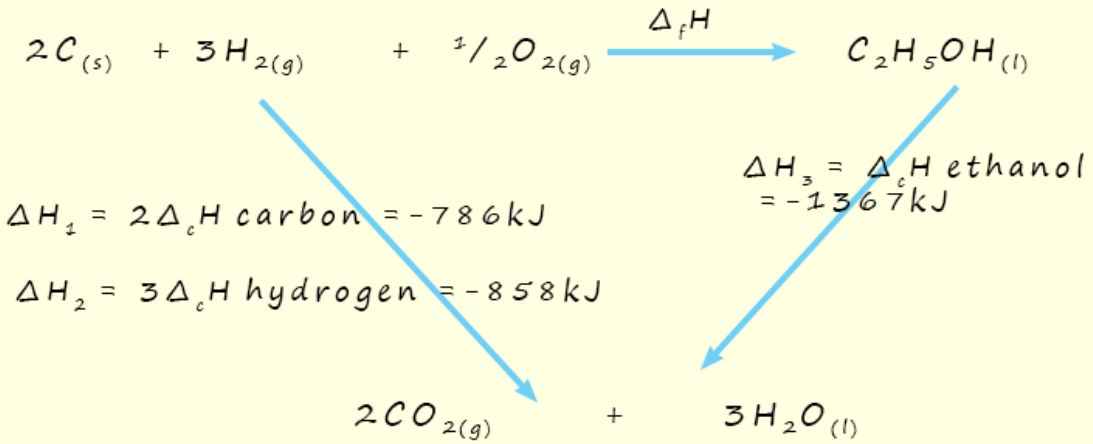
$$\Delta H_{rxn} = \Delta H_2 - \Delta H_1$$
$$= (70) - (182)$$
$$= -112kJ$$

3. Ethanol (C_2H_5OH) is a biofuel which is added to petrol to reduce the amount of carbon dioxide being added to the atmosphere.

a. Write an equation to show the standard enthalpy of formation of ethanol.

$$2C_{(s)} + 3H_{2(g)} + 1/_2O2_{(g)} \longrightarrow C_2H_5OH_{(l)}$$

c. Calculate the standard enthalpy of formation of ethanol using the information in the table opposite.



$$\Delta_fH = (\Delta H_1 + \Delta H_2) - \Delta H_3$$
$$= (-1644) - (-1367)$$
$$= -277 kJ mol^{-1}$$

4. A blast furnace can reduce iron oxide (Fe_2O_3) to iron according to the equation below.

$$Fe_2O_{3(s)} + 3CO_{(g)} \longrightarrow 2Fe_{(s)} + 3CO_{2\,(g)}$$

a. Calculate the enthalpy change for this reaction using the information in the table opposite.

Step 1 - Write the equation for which you have to calculate the enthalpy change

$Fe_2O_{3(s)} + 3CO_{(g)} \xrightarrow{\Delta H_{rxn}} 2Fe_{(s)} + 3CO_{2(g)}$

$\Delta H_1 = \Delta_f H$ of $Fe_2O_{3(s)}$
$= -824\,kJ$

$\Delta H_2 = 3\Delta_f H$ of $CO_{(g)}$
$= -297\,kJ$

$\Delta H_3 = \Delta_f H$ of $3CO_2$
$= -1179\,kJ$
$=$

$2Fe_{(s)} + 2O_{2(g)} + 3C_{(s)}$

$\Delta H_{rxn} = \Delta H_3 - (\Delta H_1 + \Delta H_1)$
$= (-1179) - (-1121)$
$= -58\,kJ$