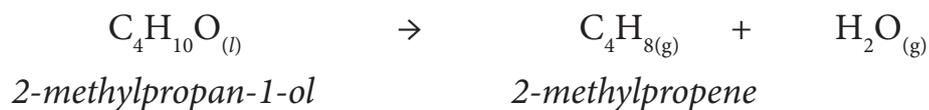


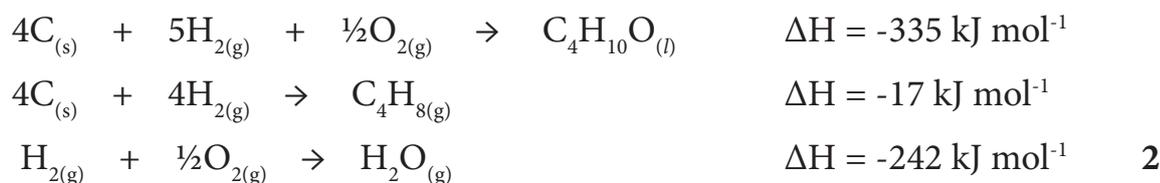
Hess's Law Problems

Q1 2-Methylpropan-1-ol can also be converted to produce diesel and jet fuel.

The first step in the process is the production of 2-methylpropene.

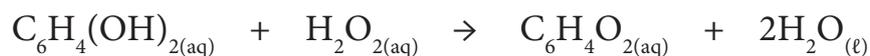


Using the data below, calculate the enthalpy change, in kJ mol^{-1} , for the production of 2-methylpropene from 2-methylpropan-1-ol.

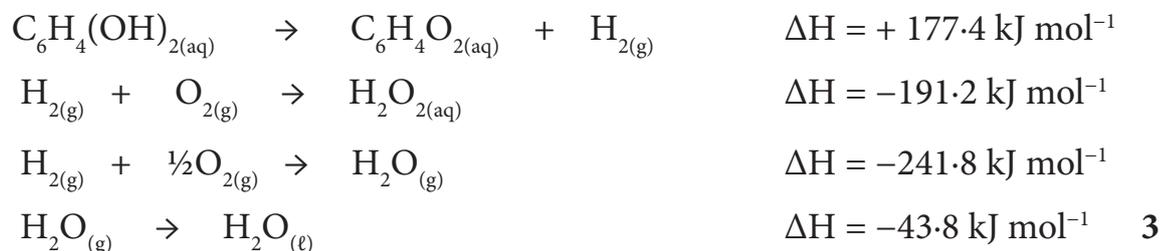


Q2 When in danger, bombardier beetles can fire a hot, toxic mixture of chemicals at their attacker. This mixture contains quinone, $\text{C}_6\text{H}_4\text{O}_2$, a compound that is formed by the reaction of hydroquinone, $\text{C}_6\text{H}_4(\text{OH})_2$, with hydrogen peroxide, H_2O_2 .

The equation for the overall reaction is:



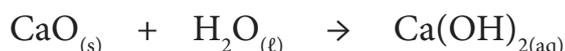
Use the following data to calculate the enthalpy change, in kJ mol^{-1} , for the above reaction.



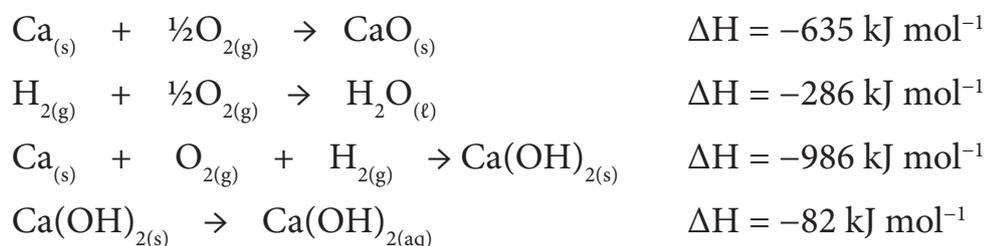
Q3 Self-heating cans may be used to warm drinks such as coffee. When the button on the can is pushed, a seal is broken, allowing water and calcium oxide to mix and react.

The reaction produces solid calcium hydroxide and releases heat. If more water is used the calcium hydroxide is produced as a solution instead of as a solid.

The equation for the reaction is:

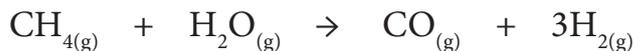


Using the following data, calculate the enthalpy change, in kJ mol^{-1} , for this reaction.

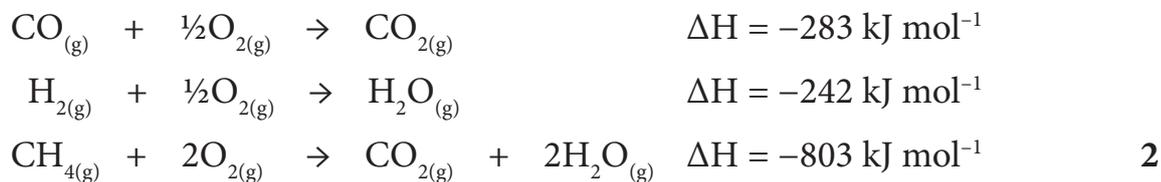


- Q4** Mobile phones are being developed that can be powered by methanol. Methanol can be made by a two-stage process.

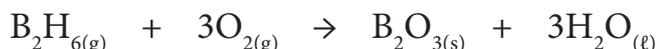
In the first stage, methane is reacted with steam to produce a mixture of carbon monoxide and hydrogen.



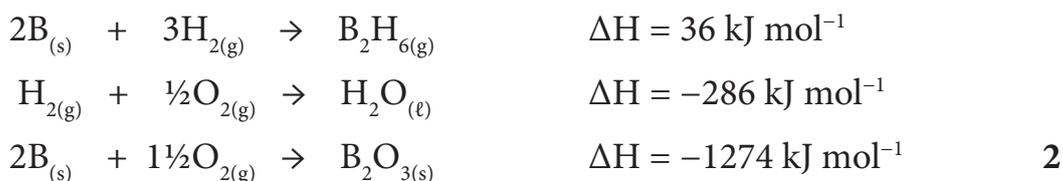
Use the data below to calculate the enthalpy change, in kJ mol^{-1} , for the forward reaction.



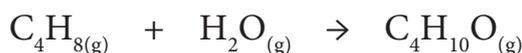
- Q5** The compound diborane (B_2H_6) is used as a rocket fuel. The equation for the combustion of diborane is shown below.



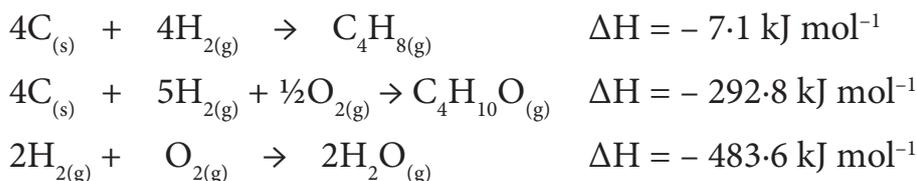
Calculate the enthalpy of combustion of diborane (B_2H_6) in kJ mol^{-1} , using the following data.



- Q6** The industrial method currently used to produce butan-2-ol is the hydration of but-2-ene.

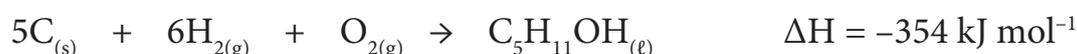


The enthalpy values for the following reactions are:



Using the data above, calculate the enthalpy change, in kJ mol^{-1} , for the production of butan-2-ol by hydration of but-2-ene. **2**

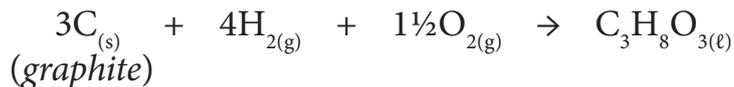
- Q7** Enthalpy changes can also be calculated using Hess's Law. The enthalpy of formation for pentan-1-ol is shown below.



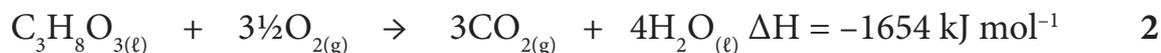
Using this value, and the enthalpies of combustion of carbon and hydrogen from the data booklet, calculate the enthalpy of combustion of pentan-1-ol, in kJ mol^{-1} . **2**

Q8 Glycerol, $C_3H_8O_3$, is widely used as an ingredient in toothpaste and cosmetics.

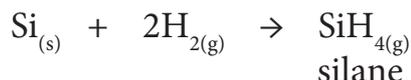
The enthalpy of formation of glycerol is the enthalpy change for the reaction:



Calculate the enthalpy of formation of glycerol, in kJ mol^{-1} , using information from the data booklet and the following data.



Q9 Silane, silicon hydride, is formed in the reaction of silicon with hydrogen.



The enthalpy change for this reaction is called the enthalpy of formation of silane.

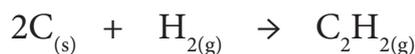
The combustion of silane gives silicon dioxide and water.



The enthalpy of combustion of silicon is -911 kJ mol^{-1} .

Use this information and the enthalpy of combustion of hydrogen in the data booklet to calculate the enthalpy of formation of silane, in kJ mol^{-1} . 2

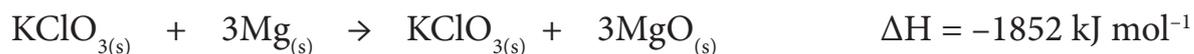
Q10 The equation for the enthalpy of formation of ethyne is:



Use the enthalpies of combustion of carbon, hydrogen and ethyne given in the data booklet to calculate the enthalpy of formation of ethyne, in kJ mol^{-1} . 2

Q11 Hess's Law can be used to obtain enthalpy changes for reactions that cannot be measured directly.

Use the following enthalpy changes



to calculate the enthalpy change in kJ mol^{-1} , for the reaction:



Q1 $\Delta H = [+335 + (-17) + (-242)]$ (1 mark) = (+) 76 (kJ mol⁻¹) (1 mark)

Sign and units need not be given in answer but if given must be correct

Q2 -202.6 kJ mol⁻¹ (ignore units) (3 marks) 177.4 + 191.2 + 2(-241.8) + 2(-43.8)

- reversing peroxide equation (1 mark).
- doubling water formation and condensation equations (1 mark).
- correct additions (1 mark).

Q3 -147 kJ mol⁻¹ (2 marks) 1 mark is awarded for 2 out of the four following numbers
+635 +286 -986 -82

Q4 +206 kJ mol⁻¹ (2 marks) 1 mark is awarded for 2 out of the three following numbers
-803 +726 +283

Q5 -2168 (kJ mol⁻¹) (2 marks) 1 mark for 2 from the three correct enthalpy change values:
-36 kJ -1274 kJ 3 x -286 (= -858) kJ

Q6 -43.9 (2 marks) 1 mark for 2 values from this list +7.1 +241.8 -292.8

Q7 -3332 (2 marks) 1 mark for 2 from the three correct enthalpy change values:
+354 -5 x 394 or -1970 -6 x 286 or -1716

Q8 -672 kJ mol⁻¹ (2 marks) 1 mark for 2 from the three correct enthalpy change values:
3C + 3O₂ → 3CO₂ -394 x 3 = -1182 kJ
4H₂ + 2O₂ → 4H₂O -286 x 4 = -1144 kJ
3CO₂ + 4H₂O → C₃H₈O₃ + 7/2 O₂ = +1654 kJ

Q9 34 kJ mol⁻¹ (2 marks) 1 mark for 2 from the three correct enthalpy change values:
SiO_{2(s)} + 2H₂O_(l) → SiH_{4(g)} + 2O_{2(g)} +1517 kJ
Si_(s) + O_{2(g)} → SiO_{2(s)} -911 kJ
2H_{2(g)} + O_{2(g)} → 2H₂O_(g) -572 kJ

Q10 +226 kJ mol⁻¹ (2 marks) 1 mark for 2 from the three correct enthalpy change values:
 ΔH_c carbon x 2 = -394 kJ x 2 = -788 kJ
 ΔH_c hydrogen -286 kJ
reverse ΔH_c ethyne = +1300 kJ

Q11 -391 kJ mol⁻¹ (2 marks) 1 mark for 2 from the three correct enthalpy change values:
rev ① 1852 kJ unchanged ② -437 kJ 3 x ③ -1806 kJ