**Bond enthalpy**

**2022**

Freon-11, CCl3F(*g*), is produced in the lab by the reaction of carbon tetrachloride, CCl4(*g*), with

hydrogen fluoride, HF(*g*), as shown in the reaction below.



Use the change in enthalpy (Δr*H*°) for the reaction above and the bond energies listed in the table below to calculate the average bond energy of the C–Cl bond.



**2021**

Another fuel that can be used in rocket engines is methane, CH4(g).It reacts with oxygen, 02(g),as

shown by the reaction below.



Use the change in enthalpy (8.rH°) for the combustion of methane and the bond energies listed

in the table below to calculate the average bond energy of the C-H bond in methane.





**2020**

The chlorination of ethene can be shown by the following equation.



Calculate the bond enthalpy of the C – Cl bond using the data below.



**2019**

When propane, C3H8(*g*), is burned, it reacts with oxygen, O2(*g*), in the air to form water, H2O(*g*), and carbon dioxide, CO2(*g*).



Calculate the average bond enthalpy of the C = O bond using the data below.



**2018**

Nitrogen gas, N2(*g*), reacts with hydrogen gas, H2(*g*), to produce ammonia gas, NH3(*g*), as shown by the

following equation



Calculate the average bond enthalpy of the **N–H** bond in NH3, using the average bond enthalpies in the table below.



**2017**

Hydrazine, N2H4, is used as rocket fuel.

Use calculations to determine which of **Reaction 1** or **Reaction 2** releases more energy.

**Reaction 1:** N2H4(*g*) + O2(*g*) → N2(*g*) + 2H2O(*g*)

**Reaction 2:** N2H4(*g*) + 2F2(*g*) → N2(*g*) + 4HF(*g*)

The structure of each chemical species is shown in the box below.



Use the average bond enthalpies given in the table below.

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Show your working and include appropriate units in your answer.

**2016**

Calculate the enthalpy change, Δr*H*°, for the reaction of but-1-ene gas, C4H8(*g*), with hydrogen gas, H2(*g*),

to form butane gas, C4H10(*g*).

Use the average bond enthalpies given in the table below.

Show your working and include appropriate units in your answer.





**2015**

Ethene gas, C2H4(*g*), reacts with bromine gas, Br2(*g*), as shown in the equation below.



Calculate the enthalpy change, Δr*H*°, for the reaction between ethene and bromine gases, given the average

bond enthalpies in the table below.

Show your working and include appropriate units in your answer.



**2014**

Hydrogen gas, H2(*g*), reacts with oxygen gas, O2(*g*), as shown by the following equation

H2(*g*) + ½ O2(*g*) → H2O(*g*) Δr *H*° = –242 kJ mol–1

Given the average bond enthalpies in the table below, calculate the average bond enthalpy of the **O – H** bond in H2O.



**2013**

Chlorine reacts with methane to form chloromethane and hydrogen chloride, as shown in the equation

below.

CH4(*g*) + Cl2(*g*) → CH3Cl(*g*) + HCl(*g*)

Use the following bond enthalpies to calculate Δr *H*° for this reaction.



**2012**

(i) The equation for the combustion of propan-1-ol is:

CH3CH2CH2OH(*g*) + 4½O2(*g*) → 3CO2(*g*) + 4H2O(*g*) Δr*H* = –2 010 kJ mol–1

Calculate the bond enthalpy for the C=O bond, using the enthalpy of the reaction above and the bond enthalpy data in the table.

####

#### (ii) Define bond enthalpy and explain why the bond enthalpy value calculated for C=O is higher than the C–O bond enthalpy.

#### 2011

Complete combustion of methanol can be represented by the following chemical equation:

2CH3OH(*g*) + 3O2(*g*) → 2CO2(*g*) + 4H2O(*g*)

#### Use the following bond enthalpies to calculate Δr*H* for this reaction.

####

### 2010

The equation for the combustion of ethanol is:

CH3CH2OH(*g*) + 3O2(*g*) → 2CO2(*g*) + 3H2O(*g*) Δr*H*° = –1379 kJ mol–1

### Calculate the bond enthalpy for the O–H bond using the enthalpy of the reaction above and the bond enthalpy data in the table.

###

### 2009

Calculate the enthalpy change for the reaction below using the bond enthalpy data in the table.

### CH3Cl(*g*) + NH3(*g*) → CH3NH2(*g*) + HCl(*g*)

###

### 2008

### Methylhydrazine, N2H3CH3, can be used as a fuel.

###

### (i) Define the term bond enthalpy.

### (ii) Use the bond enthalpies given in the table below to calculate the energy released when one mole of methylhydrazine vapour is burned.

### N2H3CH3(*g*) + 2½O2(*g*) → CO2(*g*) + N2(*g*) + 3H2O(*g*)

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