

Combined Science - Chemistry - Key Stage 4

Energy Changes

# Calculating bond energies - Higher

Mrs. Begum



# Independent task 1



$$\text{H-H} = 432 \text{ kJ}$$

$$\text{Cl-Cl} = 242 \text{ kJ}$$

$$\text{H-Cl} = 431 \text{ kJ}$$

1. Calculate the overall energy change.
2. Is the reaction exothermic or endothermic?
3. Explain why.



# Independent task 1 answers



Energy required for bond breaking:

$$\text{H-H} = 432 \text{ kJ}$$

$$\text{Cl-Cl} = 242 \text{ kJ}$$

**Total energy taken in = 674 kJ**

Energy released when bonds are made:

$$\text{H-Cl} = 431 \text{ kJ}$$

**Total energy released = 862 kJ**

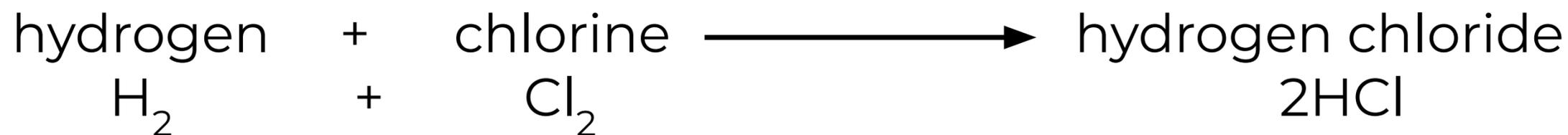
**Overall energy = 674 - 862**

**Overall = -188 kJ**

**The reaction is  
exothermic by 188 kJ  
per mole**



# Independent task 1 answers



$$\text{H-H} = 432 \text{ kJ}$$

$$\text{H-Cl} = 431 \text{ kJ}$$

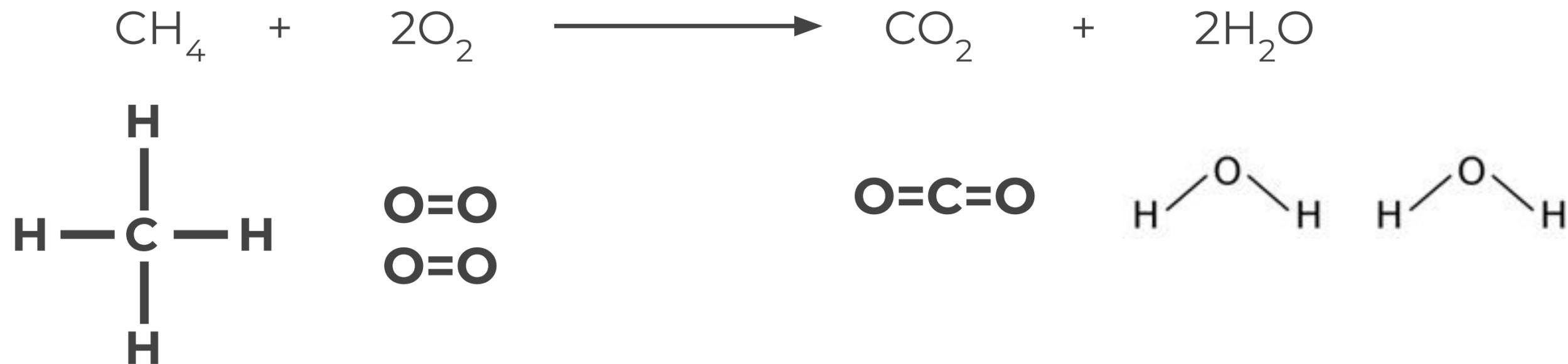
$$\text{Cl-Cl} = 242 \text{ kJ}$$

1. Calculate the overall energy change. **Overall energy = 674 – 862  
= –188 kJ**
2. Is the reaction exothermic or endothermic? **Exothermic**
3. Explain why. **The reaction is exothermic because more energy is released when the bonds between H and Cl are formed than is needed to break bonds in the reactants.**



## Independent task 2

Calculate the overall energy change for this reaction.



Bond energies

C-H = 412 kJ/mol

O=O = 498 kJ/mol

Bond energies

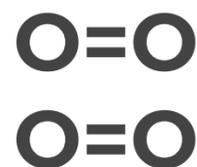
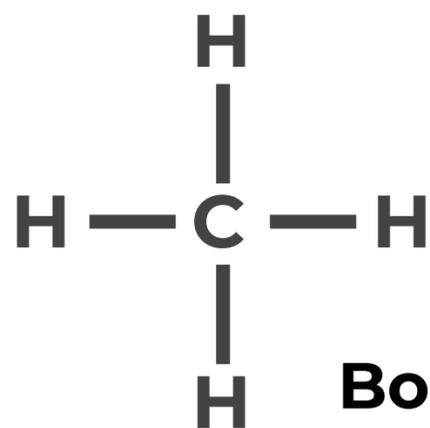
C=O = 805 kJ/mol

H-O = 463 kJ/mol



# Independent task 2 answers

Calculate the overall energy change for this reaction.



**Bond breaking**  
 $(413 \times 4) + (498 \times 2)$   
 $= 1648 + 996$   
 $= 2644 \text{ kJ/mol}$

**Bond making**  
 $(805 \times 2) + (463 \times 4)$   
 $= 1610 + 1852$   
 $= 3462 \text{ kJ/mol}$

**Overall energy = 2644 - 3462**  
**Overall = -818 kJ**

**The reaction is exothermic  
by 818 kJ per mole**



# Exam style question

Hydrazine ( $\text{N}_2\text{H}_4$ ) reacts with oxygen to produce nitrogen gas and water.



## Bond energies

(kJ/mol)

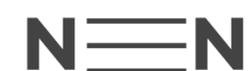
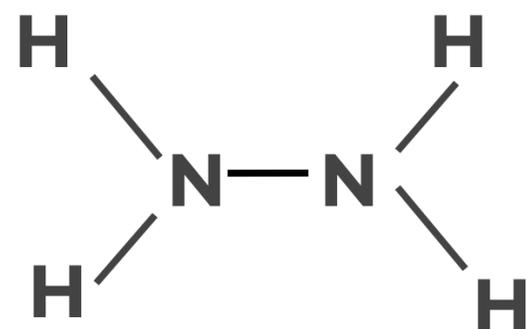
$\text{N}-\text{N} = 163$

$\text{N}\equiv\text{N} = 945$

$\text{N}-\text{H} = 391$

$\text{O}=\text{O} = 498$

$\text{O}-\text{H} = 463$



## Questions

1. Calculate the overall energy change in this reaction, using the bond energy values given.
2. Explain why this reaction is exothermic, in terms of bonds broken and bonds formed.



# Exam style question answers

Hydrazine ( $\text{N}_2\text{H}_4$ ) reacts with oxygen to produce nitrogen gas and water.



Energy required for bond breaking:

$$163 + (4 \times 391) + 498$$

$$= 2,225$$

Energy released when bonds are made:

$$945 + (4 \times 463)$$

**Total energy taken in = 2225 kJ/mol**

**Total energy released = 2797 kJ/mol**

**Overall energy = 2225 - 2797**

**Overall = -572 kJ**

**The reaction is exothermic by 572 kJ per mole**



# Exam style question answers

Hydrazine ( $\text{N}_2\text{H}_4$ ) reacts with oxygen to produce nitrogen gas and water.



**2. Explain why this reaction is exothermic, in terms of bonds broken and bonds formed.**

**This reaction is exothermic because more energy is released when the bonds are made than is needed to break the bonds.**

