Reaction profiles and bond energies

Pearson Edexcel 1CH0 Separate Chemistry · Foundation and Higher

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. A cooler mixture

A reaction mixture cools from 20 °C to 16 °C. Is the reaction exothermic or endothermic? Describe where energy is transferred.

2. Compare temperature rises

In two runs, mixture A warms from 18.6 °C to 27.2 °C and mixture B warms from 21.0 °C to 28.1 °C. A student says B warmed more because it finished hotter. Use the data to check the claim.

3. Observe dissolving an ionic solid

An ionic solid is stirred into water and dissolves. The solution temperature falls from 19.5 °C to 15.0 °C. Calculate the temperature decrease. Explain what the fall shows about the direction of energy transfer during dissolving.

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4. Draw a reaction profile

On a reaction profile the reactants are at 30 kJ mol^{-1}, the peak is at 85 kJ mol^{-1} and the products are at 10 kJ mol^{-1}. Sketch and label the profile. Give the forward activation energy.

5. Use bond energies (Higher)

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$. Bond energies in kJ mol^{-1} are H-H 436, Cl-Cl 242 and H-Cl 431. Calculate the overall energy change for the equation as written.

6. Count bonds in combustion (Higher)

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. Bond energies in kJ mol^{-1} are C-H 413, O=O 498, C=O in CO_2 805 and O-H 463. Calculate the energy change when 1 mol of methane reacts. Treat all substances as gases.

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7. Add a catalyst

An exothermic reaction goes through a different pathway when a catalyst is added. Sketch both reaction profiles on one set of axes. Explain the change in activation energy and any effect on the overall energy change.

8. Find a missing bond energy (Higher)

$H_2(g) + I_2(g) \rightarrow 2HI(g)$. Breaking H-H takes 436 kJ mol^{-1} and breaking I-I takes 151 kJ mol^{-1}. The change is −11 kJ for the amounts in the equation. Calculate the H-I bond energy.

9. Extra challenge · Interpret an energy profile

In a reaction profile, reactants are at 184 kJ mol^{-1}, products at 116 kJ mol^{-1} and the peak is at 251 kJ mol^{-1}. When a catalyst is added the peak is at 221 kJ mol^{-1}. Find the two forward activation energies and the overall energy change. Explain whether the catalysed reaction is also exothermic.

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Worked answers

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1. A cooler mixture

Endothermic. Energy is transferred from the surroundings to the reacting substances, so the measured temperature falls.

2. Compare temperature rises

A rises by 27.2 − 18.6 = 8.6 °C. B rises by 28.1 − 21.0 = 7.1 °C. A warmed 1.5 °C more than B.

3. Observe dissolving an ionic solid

The temperature decreases by 19.5 − 15.0 = 4.5 °C. Dissolving absorbs energy from the water and its surroundings, so this is an endothermic change.

4. Draw a reaction profile

Label the vertical axis energy and the horizontal axis progress of reaction. Draw a curve from the reactant level up to the peak, then down to a product level below the reactants.

The forward activation energy is 85 − 30 = 55 kJ mol^{-1}. Its arrow starts at the reactant level and reaches the peak.

5. Use bond energies (Higher)

Breaking the bonds takes 436 + 242 = 678 kJ. Forming two H-Cl bonds releases 2 × 431 = 862 kJ. Energy change = 678 − 862 = −184 kJ for the amounts in the equation.

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Worked answers

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6. Count bonds in combustion (Higher)

Bonds broken take 4 × 413 + 2 × 498 = 2,648 kJ. Bonds formed release 2 × 805 + 4 × 463 = 3,462 kJ.

The energy change is 2,648 − 3,462 = −814 kJ for 1 mol of methane.

7. Add a catalyst

On the energy versus reaction progress graph, both curves start at the same reactant energy and end at the same lower product energy. The catalysed pathway has a lower peak and hence a lower activation energy. The difference between the starting and finishing levels is unchanged.

8. Find a missing bond energy (Higher)

Breaking takes 436 + 151 = 587 kJ. A net release of 11 kJ means that forming the two H-I bonds releases 587 + 11 = 598 kJ. The H-I bond energy is 598 ÷ 2 = 299 kJ mol^{-1}.

9. Extra challenge · Interpret an energy profile

Forward activation energy = peak − reactants. It is 251 − 184 = 67 kJ mol^{-1} without the catalyst and 221 − 184 = 37 kJ mol^{-1} with it.

Overall energy change = products − reactants = 116 − 184 = −68 kJ mol^{-1} for both paths. The products are lower in energy in both cases, so both are exothermic. The catalyst changes the pathway and the peak.

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