13 Energy cycles in reactions

Teaching plan

Sub-chapter	Approximate number of learning hours	Learning content	Resources
13.1 Bond enthalpies	1–2	Bond breaking absorbs energy and bond forming releases energy. Calculation of the enthalpy change of a reaction from given average bond enthalpy data. Explanation of why bond enthalpy data are average values and may give rise to different values from those measured experimentally.	**Coursebook** Section 13.1 Test your understanding questions 1–5 **Workbook** Exercise 13.1 **Teacher's resource** PowerPoint 13, slides 3–4 Worksheet 13.1 End of Chapter 13 test
13.2 Hess's law 13.3 Using standard enthalpy change of combustion data 13.4 Standard enthalpy changes of formation	2–3	Hess's law states that the enthalpy change for a reaction is independent of the pathway between the initial and final states. Application of Hess's law to calculate enthalpy changes in multi-step reactions. Standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$, and formation, $\Delta H_f^{\ominus}$, data are used in thermodynamic calculations. Construction of equations and solution of problems involving these terms. An application of Hess's law uses enthalpy of formation data to calculate the enthalpy change of a reaction. Calculation of enthalpy changes of a reaction using ΔH_f data: $\Delta H = \Sigma(\Delta H_f \text{ products}) - \Sigma(\Delta H_f \text{ reactants})$	**Coursebook** Sections 13.1–13.4 Test your understanding Questions 6–23 **Workbook** Exercises 13.2–13.4 **Teacher's resource** PowerPoint 13, slides 5–7

Sub-chapter	Approximate number of learning hours	Learning content	Resources
13.5 Energy cycles for ionic compounds	1–2	A Born–Haber cycle is an application of Hess's law used to show energy changes in the formation of an ionic compound. Interpretation and determination of values from a Born–Haber cycle for compounds composed of univalent and divalent ions.	**Coursebook** Section 13.5 Test your understanding questions **Workbook** Exercise 13.5 **Teacher's resource** PowerPoint 13, slide 8

BACKGROUND KNOWLEDGE

- Students should understand bonding from Unit 2, to draw out the molecules and count the bonds, as this will be required for this chapter. They will need to have a good understanding of the previous chapter, as this knowledge will be built on.

Syllabus overview

- Students will understand the definition of average bond enthalpies and use these to calculate the enthalpy change of a reaction. They will then build on this with an understanding of Hess's law, using what they have learned to calculate enthalpy changes for different multi-step reactions.
- At Higher Level, students will use enthalpy change of combustion and enthalpy change of formation data to work out the overall enthalpy change for certain reactions. They will then recap the definitions of different stages of the Born–Haber cycle and link these to Hess's law, and they will be able to construct a Born–Haber cycle for the formation of ionic compounds.

13.1 Bond enthalpies

LEARNING PLAN

Learning objectives	Success criteria
Understand the term average bond enthalpy	Students can explain the term average bond enthalpy.
Calculate enthalpy changes using bond enthalpies	Students can calculate enthalpy changes using bond enthalpies.

Common misconceptions

Misconception	How to identify	How to overcome
Students use the wrong bond enthalpies to calculate enthalpy changes.	Through calculation work during the lesson.	Students should always draw out the molecules, so they can see all the different bonds, which will help then use the correct bond enthalpy data.

Starter ideas

1 Recap of bonding – drawing out some simple organic molecules (20 minutes)

Resources: Mini-whiteboards.

Description and purpose: On the board, there should be some different organic molecules for the students to draw on the mini-whiteboards. This will help the students to revisit the bonding topic and help them cement their understanding of bonding. Knowledge of bonding is required as they move through the topic. The teacher can also assess the students' understanding of this and help those who need it.

What to do next: The students could be given different molecules of easier to harder structures to draw, so the students could give themselves the challenge of going for the harder ones. All students should be able to draw the easier molecules, which should build confidence.

2 Ice packs (15 minutes)

Resources: Ice packs.

Description and purpose: Students are asked what is happening when an ice pack is used. The teacher can then talk about the energetics of a reaction.

What to do next: The students can link this to exothermic and endothermic reactions and look at the energy needed to break bonds versus the energy released making bonds.

Main teaching ideas

1 Average bond enthalpies (25 minutes)

Resources: Data on some average bond enthalpies compared with combustion data.

Description and purpose: The students are asked to think about why there is a difference between bond enthalpy data and combustion data for different molecules.

Differentiation ideas:

Support: The teacher can facilitate discussion by adding in ideas to help the students understand some of the differences between data.

Challenge: Students could try and work out an enthalpy change using bond enthalpies and combustion data to see what the difference is.

2 Example calculations (45 minutes)

Resources: Data booklet containing bond enthalpies, molecular modelling kits.

Description and purpose: The teacher will explain what an average bond enthalpy is and show the class the data booklet with the average bond enthalpies in it. The students need to know the definition, so this should also be highlighted. The teacher will go through a worked example, calculating an enthalpy change using bond enthalpies. Students should always draw out the molecules to make sure they have the right number of bonds. Doing this will mean they are less likely to make a mistake.

Differentiation ideas:

Support: The teacher could group the students by ability and then spend more time with the groups that needs more support. They will be able to pick up and highlight any mistakes that the students are making. Students could be given molecular modelling kits to build the molecules, so they can see all of the bonds if they are struggling with this.

Challenge: Students can be given harder calculations, containing multiple bonds and trickier molecules, to work out.

Plenary ideas

1 Exit tickets (10 minutes)

Resources: Pieces of card or sticky notes.

Description and purpose: Students can write what they have learned on the ticket and what they are unsure of, and either hand it into the teacher or stick it on the board. The teacher can assess their understanding of the content of the lesson and use this to plan future lessons.

13.2 Hess's law; 13.3 Using standard enthalpy change of combustion data and 13.4 Standard enthalpy changes of formation

LEARNING PLAN

Learning objectives	Success criteria
Uses Hess's law to calculate enthalpy changes • Calculate enthalpy changes using standard enthalpy changes of combustion • Understand the term standard enthalpy changes of formation • Calculate enthalpy changes using standard enthalpy changes of formation	Students can use Hess's law to calculate enthalpy changes. Students can calculate enthalpy changes using standard enthalpy changes of combustion. Students can explain the term standard enthalpy changes of formation. Students can calculate enthalpy changes using standard enthalpy changes of formation.

Common misconceptions

Misconceptions	How to identify	How to overcome
Students put the arrows the wrong way round on their Hess's cycle.	Through the questions set in lessons and the teacher going around supporting the students.	The students should always look at the data they are given, and this tells them which way the arrows should go. Get them to highlight the data to help reinforce this.

Misconceptions	How to identify	How to overcome
Students get confused with whether to use combustion or formation calculations.	Through the questions set during the lessons.	Always make sure that the students look at the data given to them in the question. The students should highlight this, and this will help them understand which calculation to use.

Starter ideas

1 Bingo (15 minutes)

Resources: Nine answers on the board.

Description and purpose: The student pick six answers from the board. The teacher then asks the nine questions (these can be tailored to the previous lesson based on the assessment for learning that the teacher has done, or they could be more general revision on bond enthalpies, bonding, etc.). This revision should help create a scaffolded approach to learning, which will cement the students' understanding on the topic.

Main teaching ideas

1 Enthalpy calculations using Hess cycles (40 minutes)

Resources: Questions using Hess's law to work out enthalpy changes.

Description and purpose: The teacher will give examples for working out enthalpy calculations using Hess's law. The teacher should show the students two different methods for these calculations. Examples of this are in the Coursebook. The students will then be given some questions to do using Hess's law, and they can choose which method they would like to use.

Differentiation ideas:

Support: Three tiers of questions can be used (easy, medium, hard). Students could pick the questions they would like to challenge themselves with. The teacher can go around the classroom to assess and support those students who require more help.

Stretch and challenge: The students can challenge themselves with the harder questions.

2 Calculate enthalpy changes using standard enthalpy changes of combustion and formation (40 minutes)

Resources: Questions on enthalpy changes using enthalpy of combustion and formation data.

Description and purpose: The teacher will explain and give examples for working out enthalpy changes using standard enthalpy changes of combustion and formation. The students will then be given some questions to answer. The teacher should highlight the data used in each question and get the student to highlight the data as well, to make sure they are doing the calculation correctly.

Differentiation ideas:

Support: Three tiers of questions can be used (easy, medium, hard). Students could pick the questions they would like to challenge themselves with. The teacher can go around the classroom to assess and support those students who require more help.

Stretch and challenge: The students can challenge themselves with the harder questions.

Plenary ideas

1 Corrections (15 minutes)

Resources: Answers to the questions set.

Description and purpose: The teacher goes through the answers to the questions set in the lesson.

Assessment ideas: The students can either mark their own work or this can be peer assessed. The students can then correct their own work and pick up on any mistakes they have made. The teacher will be able to assess the students' knowledge in this area.

2 Hess cycles (15 minutes)

Resources: Different sections of some Hess cycles.

Description and purpose: The students are given different parts of a Hess cycle and are asked to put them in the correct order. This will help them to understand how to use Hess cycles and help them with their calculations.

13.5 Energy cycles for ionic compounds

LEARNING PLAN

Learning objectives	Success criteria
Use a Born–Haber cycle to calculate enthalpy changes for ionic compounds	Students can use a Born–Haber cycle to calculate enthalpy changes for ionic compounds.

Common misconceptions

Misconception	How to identify	How to overcome
Students get confused by the different stages of the Born–Haber cycle and which ones are exothermic and which ones are endothermic.	Throughout the lesson, homework questions and end of unit tests.	Practice questions will help students to recognise their mistakes. The teacher should spend time highlighting these misconceptions during the lesson, so students have a better understanding and can answer the questions correctly.

Starter ideas

1 Definitions for each stage of the Born–Haber cycle (10 minutes)

Resources: Mix and match definitions and stages on the board.

Description and purpose: Students try and match the right definition to the correct stage. The teacher then goes through these with the students.

Language focus: Keyword definitions and correct use of terms.

What to do next: Students should write down the correct definitions to the stage and spend time making sure they understand all these definitions.

Main teaching ideas

1 Born–Haber cycle examples (40 minutes)

Resources: Diagram of a Born–Haber cycle on the board.

Description and purpose: The teacher goes through an example of a Born–Haber cycle on the board and labels each stage, to give the students a solid understanding of the cycle. The teacher should also mention divalent ions and how this affects the Born–Haber cycle. An example calculation should be done on the board, and then the students should be given some questions to do. The teacher can then support the students while they are working on these.

› **Differentiation ideas:**

Support: Students can be given cut-out sections of the Born–Haber cycle and put them together in the right place to complete the cycle.

Stretch and challenge: Students can be given more difficult compounds (MgO, $CaCl_2$), and the data required, to try to draw out the Born–Haber cycle correctly for each one and answer the questions for it.

2 Born–Haber cycle mix and match (25 minutes)

Resources: Different sections of a Born–Haber cycle.

Description and purpose: The students are given different sections of a Born–Haber cycle and are asked to put them in the right order.

Support: The teacher can move around the classroom observing the students and help those that are struggling.

Stretch and challenge: The students can then calculate one bit of the Born–Haber cycle given other data required.

Plenary ideas

1 Exam-style questions – work out the enthalpy changes for the reaction (25 minutes)

Resources: Different exam-style questions based on the unit covered.

Description and purpose: Students will need to work out which method to use to calculate the enthalpy changes for each question. This should help them with their understanding of the chapter. It will also show the teacher how much the students have understood from the lessons, and they can use this to build in some revision, if required.

Assessment ideas

- Past-paper questions on the topic would help students with their exam technique.

› **Language focus:** Students can see how questions are worded and the format data comes in.

Homework ideas

- Students could watch YouTube videos on bond enthalpy calculations and Born–Haber cycles to help with their understanding of the content. The teacher can search for relevant videos for the students to watch (current IB ones are for the old syllabus, although very similar).
- Students could make their own video explaining the chapter. This could be split up into different groups and then posted together, so the whole class has revision material they can use. The students can then watch the videos and make notes from them.

Links to digital resources

- Revision resource that explains bond enthalpy
- Revision resource that explains lattice enthalpy