**Energy and rearranging atoms**

Coal is made up of carbon atoms that are joined together in one giant molecule.

Oxygen is made up of oxygen atoms that are joined in pairs to make small molecules.

When coal burns in oxygen the atoms must separate. They then rearrange and are combined in a different way to make carbon dioxide (CO2) and water (H2O).

Some students are discussing the energy changes that take place when this happens.

Who do you agree with?

**Ben:** The energy stored in the coal will be let out when the atoms separate.

**Grace:** Energy is needed to stick the atoms together again.

**Yeasmin:** Energy is needed to pull the atoms apart from each other.

**Aryan:** Energy is released when the atoms are attracted to each other.

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| Cards for  **Energy and rearranging atoms** |  |
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*Chemistry > Big idea CCR: Chemical reactions > Topic CCR3: Energy and reactions > Key concept CCR3.1: Exothermic and endothermic reactions*

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| **Diagnostic question** |
| **Energy and rearranging atoms** |

**Overview**

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| Learning focus: | During a chemical reaction energy may be transferred to or from the surroundings. |
| Observable learning outcome: | Describe the energy changes needed for the rearrangement of atoms during a chemical reaction. |
| Question type: | Diagnostic, talking heads |
| Key words: | atom, energy |

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| **B** | **BRIDGING**  This diagnostic question probes understanding of ideas that are usually taught at age 14-16, to build a bridge to later stages of learning. |

**What does the research say?**

Research into chemistry misconceptions by Kind (2004) found that the phrase ‘fuels contain energy’ can lead some students to think that energy is stored in a fuel and released when it burns. This may then be extrapolated to conclude that this energy is stored in the chemical bonds and is released when these bonds break.

Research (Galley, 2004) asked 600 undergraduate biochemistry and physiology students to complete the sentence “ The release of energy during the combustion of ethylene is due to….” The chemical equation was provided. Over 80% of students selected bond breaking of the reactants as the origin of the energy released.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as the scribe. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

Yeasmin and Aryan’s answers are consistent with the correct direction of energy transfer when atoms separate and combine.

**How to respond - what next?**

If a student agrees with Ben that energy will be “let out” when the atoms separate, they may hold similar misconceptions to those described in the research. Their everyday understanding of fuels as providing energy may have led them to think that this energy is stored somewhere in the fuel. Although students are unlikely to have been introduced to chemical bonding specifically it is a not an illogical step for a student to infer that if energy is stored in a fuel it will be let out when the atoms of the fuel are separated during a chemical reaction.

A student who agrees with Grace that energy is needed to stick the atoms together again may be thinking of a physical model in which the “atoms” need to be pushed together to connect.

If students have misunderstandings about energy being released when the atoms separate it may help to reinforce that a fuel is not a store of energy and that the transfer of energy to the surroundings is due to the chemical reaction with oxygen. If students have a physical model in mind to explain the energy change when atoms are separated and combined it may help to critique how good this model is for the purpose.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Molecule models

**Acknowledgments**

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Images: None

**References**

Galley, W. C. (2004). Exothermic bond breaking: A persistent misconception. *Journal of Chemical Education,* 81(4)**,** 523-525.

Kind, V. (2004). Beyond appearances: Students' misconceptions about basic chemical ideas. [Online]. Available at: <http://www.rsc.org/learn-chemistry/resource/res00002202/beyond-appearances?cmpid=CMP00007478>.