**Exhaust gases**

1. A car contains 40kg of petrol.

It is driven until the petrol runs out.

What is the total mass of the exhaust gases produced during the journey?

A greater than 40kg.

B equal to 40kg.

C less than 40kg.

*Chemistry > Big idea CCR: Chemical reactions > Topic CCR2: Understanding reactions> Key concept CCR2.2: Combustion*

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| **Diagnostic question** |
| **Exhaust gases** |

**Overview**

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| Learning focus: | During combustion new products are formed from the combination of oxygen with the fuel, resulting in an increase in measured mass. |
| Observable learning outcome: | Predict that the products of combustion will have a greater mass than the original fuel due to combination with oxygen. |
| Question type: | simple multiple choice |
| Key words: | mass |

**What does the research say?**

Research (Kind, 2014)into pre-service teachers’ understanding found that 41% answered a question about the mass of exhaust gases compared to the starting mass of petrol correctly. About 26% applied conservation of mass to the question and thought that the mass of the of the exhaust gases would equal that of the petrol. These individuals had omitted to consider the oxygen with which the petrol reacted.

Some gave the explanation that the petrol was ‘used up’. The exhaust gases were then considered to have less mass. Others thought that the mass of the exhaust gases would be less because mass had changed into energy to move the car.

If this question proved challenging for trainee teachers then it is to be anticipated that students may also have difficulty with the question.

**Ways to use this question**

Students should complete the question individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

It may help some students to be shown a simple diagram of a car at the start, middle and end. This could show the petrol tank being full and then empty as well as exhaust gases being emitted.

**Expected answers**

A

**How to respond - what next?**

A student who selects option B may have correctly recalled ideas about conservation of mass but has forgotten that only the mass of the petrol is given in the question, not the mass of the other reactant oxygen.

Selection of option C may indicate more than one type of misunderstanding so further questioning may be helpful. In the research, explanations linked to loss of mass included the petrol being ‘used up’ and ‘changed into the energy’ to move the car.

If students have misunderstandings about the mass of reactants and products it may help to support students in thinking about the process at the sub-microscopic level. By understanding which atoms combine it may become more evident that the products of combustion have greater mass than the initial fuel, due to the combination with oxygen (which is not included in the initial mass). It is important that students understand that overall conservation of mass still applies.

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

* Burning carbon

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**References**

Kind, V. (2014). A degree is not enough: A qualitative study of aspects of pre-service science teachers' chemistry content knowledge. *International Journal of Science Education,* 36(8)**,** 1313-1345.