**ANSWERS: Combustion**

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| **2019** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (a)  (b) | Complete combustion occurs when there is a plentiful supply of oxygen; incomplete combustion occurs when there is limited oxygen.  Water is always produced as a combustion product.  During complete combustion, carbon dioxide is produced. During incomplete combustion, the following products could be produced: carbon dioxide, carbon monoxide, carbon and water.  Blue flame for complete combustion, yellow flame for incomplete combustion which is due to soot particles being heated.  Carbon dioxide gas and water vapour both are greenhouse gases, so they contribute to the greenhouse effect, which leads to global warming due to increased trapping of infra-red radiation / heat and this affects the environment with rising sea levels / melting of polar ice  (example). CO2 is absorbed by the ocean / reacts with water in clouds to form (carbonic) acid and this decreases the pH of the ocean, affecting marine ecosystem causes acid rain which can erode buildings, etc.  **Carbon particles can produce visual pollution in the environment**, e.g. blackening of limestone walls and monuments as carbon particles are deposited on them, or **slow down photosynthesis** due to carbon particles coating leaves, which prevents entry / exit of gases and water, or carbon particles in waterways affecting fish and plants, etc.  Allow for other valid effects.  pentane + oxygen 🡪 carbon dioxide + water  C2H4 + 3O2 🡪 2H2O + 2CO2  C3H8 + 4O2 🡪 4H2O + CO2 + 2CO  2C4H10 + 9O2 🡪 10H2O + 8CO  OR C4H10 + 9/2O2 🡪 5H2O + 4CO | • Names products of complete or incomplete combustion.  • Describes flame of complete or incomplete combustion.  • One valid effect of a combustion product on the environment. | • Explains what causes  complete and incomplete  combustion.  • Links yellow flame to soot  OR blue flame to no soot.  • Explains effects of one  combustion products on  the environment. | • Fully compares and contrasts complete and incomplete combustion of  butane, and explains effects of two combustion products on the environment. |

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| **2018** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (a) (i)  (ii)  (b) | When butane reacts with a plentiful supply of air, complete combustion occurs since there is enough oxygen for the alkane to react fully with it. When the butane burns completely, all the carbon reacts to produce carbon dioxide and the hydrogens form water.  C4H10 + 13 / 2 O2 → 4 CO2 + 5 H2O  When butane reacts with a limited supply of air or oxygen, water is still produced, but carbon monoxide and / or carbon (soot) are produced instead of carbon dioxide since there is not enough oxygen for all of the carbon to react to produce carbon dioxide.    Ethanol has a higher flashpoint than petrol, which means that a higher temperature is required to ignite it, which is a disadvantage. Also, ethanol releases less energy per litre of fuel than petrol – another disadvantage since more of it is required.  Ethanol is produced by fermentation (yeast converts sugar into ethanol) and so is a renewable energy source – won’t run out. In contrast, petrol is made from crude oil and so is non-renewable and will run out at some stage.  Ethanol undergoes complete combustion in plentiful oxygen, producing CO2 and H2O. CO2 is a greenhouse gas and contributes to climate change; however ethanol is carbon neutral since corn and sugarcane (which ethanol is produced from) absorb CO2 as they grow and therefore offset the CO2 produced when the ethanol is made and burned.  Petrol is made up of hydrocarbons, which do not burn as cleanly – they are more likely to undergo incomplete production producing C (soot) and CO which are harmful to human health. Petrol contains locked up carbon so is not carbon neutral. The hydrocarbons in petrol contain more C atoms than ethanol and so produce more greenhouse gas emissions (CO2), which contribute to climate change. | Structure correct  Complete combustion occurs when oxygen plentiful.  OR  Incomplete combustion occurs when reduced % oxygen.  Carbon dioxide produced during complete combustion.  OR  Carbon and / or carbon monoxide produced during incomplete combustion.  Identifies one disadvantage of using ethanol as a fuel.  Identifies one advantage of using ethanol as a fuel.  Identifies one effect of a fuel on human health.  Identifies one effect of a fuel on the environment. | Links complete combustion to amount of O2 and the production of CO2 and incomplete combustion to the amount of O2 production of CO and / or C (soot).  Explains disadvantages of a fuel in terms of flashpoint and energy  released.  Explains one advantage of using ethanol as a fuel.  Explains one effect of a fuel on human health and the environment. | Links complete and incomplete combustion to the amount of oxygen and products produced.  AND  One balanced symbol equation.  Evaluates the feasibility of ethanol as a fuel compared to petrol – including reference to both the information given in the table and  knowledge of the effects both fuels on human health and the  environment. |

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| **2017** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | C7H16 + 11O2 → 7CO2 + 8H2O  2CH3OH + 3O2 → 2CO2 + 4H2O or CH3OH + 1.5O2 → CO2 + 2H2O  Complete combustion would burn with a blue / colourless flame while incomplete combustion burns with an orange flame and produces soot.  The C (soot) and CO produced during incomplete combustion are harmful to  humans. C (soot) can be inhaled and cause respiratory problems and damage the  heart; it is also a carcinogen. CO is a poisonous gas as it binds to red blood cells  (preventing oxygen binding) and may cause death.  Advantages of using methanol  Methanol produces less CO2 so has less of an effect on the environment  Methanol has only 1 carbon, so it is easy to ignite and will burn with an almost  colourless flame. | • Describes observations for both complete and  incomplete combustion.  • States a valid effect on incomplete combustion of  human health.  • Gives one advantage of using methanol as a fuel. | • One correct, but incorrectly  balanced equation.  • Links incomplete combustion product to an impact on human health.  • Links an advantage of burning methanol to a reason. | • ONE balanced symbol  equation.  • Compares the advantages of using methanol over heptane  as a fuel. |

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| **2016** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | Effects on the environment of two combustion products:  **Carbon dioxide gas and water vapour** both are **greenhouse gases**, so they contribute to the greenhouse effect, which leads to global warming due to increased trapping of infra-red radiation / heat and this effects the environment with rising sea levels / melting of polar ice (example). CO2 is absorbed by the ocean / reacts with water in clouds to form (carbonic) acid and this decreases the pH of the ocean affecting marine ecosystems / causes acid rain which can erode buildings, etc.  **Carbon particles can produce** **visual pollution in the environment**, e.g. blackening of limestone walls and monuments as carbon particles are deposited on them, or **slow down photosynthesis** due to carbon particles coating leaves which prevents entry / exit of gases and water, or carbon particles in waterways affecting fish and plants, etc.  Equation for complete combustion:  C4H10 + 6½O2 → 4CO2 + 5H2O  Equation for incomplete combustion:  C4H10 + 5O2 → 2CO2 + CO + C +5H2O  (or any appropriate variation of incomplete combustion, which must include C OR CO AND H2O). | • States a valid effect on the **environment** for one product. | * Links a product to an effect on the environment   OR  compares availability of oxygen and energy production in incomplete and complete combustion.  One correct equation with  one minor error in balancing. | * Explains effects on the environment from **two products.**   Correctly balanced equation for complete combustion.  Correctly balanced equation for  incomplete combustion. |

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| **2015** | **Evidence** | **Achievement** | Merit | Excellence |
|  | When there is a shortage of oxygen, **incomplete combustion** will occur.  propane + oxygen → carbon + carbon monoxide + water  C3H8 + 3O2 → 2CO + C + 4H2O  (accept balanced alternatives with different amounts of CO & C)  Equations may have C and/or CO.  If there was a lack of oxygen: the flame would be more yellow – due to specks of C glowing  black smoke produced – black C  a black solid (soot) may be seen on the cooking pot – black C  less heat would be produced (slower cooking) – since there is less oxygen available for complete combustion.  The C (soot) and CO produced during incomplete combustion are harmful to humans. C (soot) can be inhaled and cause respiratory problems and damage the heart; it is also a carcinogen. CO is a poisonous gas as it binds to red blood cells (preventing oxygen binding) and may cause death. | Incomplete combustion.  States a product of incomplete combustion.  Describes one observation during incomplete combustion.  States a valid effect of incomplete combustion on human health. | Gives a word equation for incomplete combustion / writes unbalanced symbol equation.  Links one observation to a reaction occurring during incomplete combustion.  • Links a product of incomplete combustion to an effect on human health. | Correct balanced equation for incomplete combustion.  Explains TWO effects of incomplete combustion products on **human health**. |

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