**ANSWERS: The synthesis of methanol**

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| **2019** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (i)  (ii) | Methane is reacted with steam and a nickel catalyst to produce carbon monoxide and  hydrogen.  CH4 + H2O --> CO + 3H2  The carbon monoxide is reacted with hydrogen gas at a high temperature and a copper and  zinc catalyst to produce methanol.  CO + 2H2 --> CH3OH | • Both structures correct.  • One correct process described. | • One correct process and condition with one unbalanced equation. | • Full explanation of both processes with conditions and balanced equations. |

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| **2016** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | Methanol is made from methane in a two (or three) step process.  The first reaction is done at high temperatures (over 800oC) using a nickel catalyst, while the last reaction is done using a Cu-Zn / Cu / Pt catalyst.  ass90932q2d  OR  CH4 + H2O → CO + 3H2 (Ni catalyst)  CO + H2O → CO2 + H2  2H2 + CO → CH3OH (Cu-Zn, Cu, or Pt catalyst)  OR  2CH4 + 3H2O → CO + CO2 + 7H2 (Ni catalyst)  CO + 2H2 → CH3OH (Cu-Zn, Cu, or Pt catalyst)  CO2 + 3H2 → CH3OH + H2O (Cu-Zn, Cu, or Pt catalyst)  Ethanol is made by a process of fermentation, which involves the conversion of a solution of sugar molecules (in water) into ethanol and carbon dioxide in warm, anaerobic conditions using yeast as a catalyst. Yeast is a living organism and requires warmth and moisture to carry out fermentation. Yeast metabolises / converts the sugars into alcohol when there is a lack of oxygen.  C6H12O6 → 2C2H5OH + 2CO2  How do they differ?  The production of ethanol is a one-step process, whereas the production of methanol involves more than one step.  They both involve the use of catalysts, but to produce ethanol it is yeast, a living organism. To produce methanol, a metal (non-living) catalysts is used.  The production of methanol requires high temperatures, but for ethanol it requires warm and anaerobic conditions. | * States heat and Ni and Cu-Zn   OR  yeast and anaerobic / warmth.   * Describes methane converted into methanol   OR  glucose converted into ethanol. | * Explains the conditions required for either process, i.e. both achieved points (yeast and anaerobic, and warmth). * Correct equations for either fermentation or industrial production, but no or incorrect balancing. | * Both processes explained correctly including conditions with 1 statement of difference. * Correctly balanced equations for the production of methanol.      * Correctly balanced equation for the production of ethanol. |

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| **2014** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (i)  (ii) | CH4 + H2O → CO + 3H2  Ni  (*Catalysts and heat are not required in the equations*).  CO + 2H2 → CH3OH  250°C   Cu–Zn | * Most formulae correct in (i) and (ii), i.e. one incorrect formula allowed in each of (i) and (ii). | * All formulae correct but equations not balanced. | * Both equations correct in (b).   (*States, catalysts and heat are not required in balanced equations*). |

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