**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 andhydrogen.CH4 + H2O --> CO + 3H2The carbon monoxide is reacted with hydrogen gas at a high temperature and a copper andzinc 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.ass90932q2dORCH4 + H2O → CO + 3H2 (Ni catalyst)CO + H2O → CO2 + H22H2 + CO → CH3OH (Cu-Zn, Cu, or Pt catalyst)OR2CH4 + 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 + 2CO2How 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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