**EXTENDED RESPONSE #1: INDUSTRIAL APPLICATIONS OF EQUILIBRIUM Name:**

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| --- | --- | --- |
| **Equations** | **Marks available** | **Marks awarded** |
| CH4(g) + H2O(ℓ) ⇌ CO(g) + 3 H2(g); ΔH = +ve | 1 |  |
| N2(g) + 3 H2(g) ⇌ 2 NH3(g); ΔH = -ve | 1 |  |
| CO(g) + 2 H2(g) ⇌ CH3OH(g); ΔH = -ve | 1 |  |
| **Steam reforming conditions** |  |  |
| To get the best reaction rate: |  |  |
| * High pressure | 1 |  |
| * High temperature | 1 |  |
| * Catalyst | 1 |  |
| To get the best yield: |  |  |
| * Low pressure | 1 |  |
| * High temperature | 1 |  |
| **Haber process & Methanol synthesis conditions** |  |  |
| Recall of Haber process conditions: |  |  |
| * Temperature 400-500 oC | 1 |  |
| * Pressure ~200 atm | 1 |  |
| * Catalyst: iron-based | 1 |  |
| To get the best reaction rate for both reactions: *(may be described jointly)* |  |  |
| * High pressure | 1 |  |
| * High temperature | 1 |  |
| * Addition of catalyst | 1 |  |
| To get the best yield for both reactions: (*may be described jointly)* |  |  |
| * High pressure | 1 |  |
| * Low temperature | 1 |  |
| **Links to relevant theories** |  |  |
| Explains using collision theory how temperature affects rates | 2 |  |
| Explains using collision theory how pressure affects rates | 2 |  |
| Explains using collision theory how catalysts affect rates | 2 |  |
| Explains using Le Chatelier’s Principle how temperature affects yield | 2 |  |
| Explains using Le Chatelier’s Principle how pressure affects yield | 2 |  |
| States that catalysts do not affect equilibrium yield | 1 |  |
| **Understanding of industrial needs & compromise** |  |  |
| Identifies and explains compromises in temperature and pressure | 2 |  |
| Identifies and explains economic considerations | 2 |  |
| **‘Compare & contrast’ format for Haber & Methanol Synthesis** |  |  |
| Explicitly identifies **similarities** and discusses reasons for similarities | 2 |  |
| Identifies (minor) **differences** and proposes reasons for differences | 2 |  |
| **Quality of writing** |  |  |
| **Characteristics of excellent answer:**   * Well organized ideas that flow easily * Excellent use of vocabulary, including relevant scientific terms * Use of subheadings and paragraphs to effectively order ideas * Concise language – lack of needless repetition * Legible writing with minimal spelling errors | 5 |  |
|  | TOTAL: | / 40 |

**Comments:**