

5.1.3 Balance fuel-cell equations and compare whole pathways

Name: _____ Class: _____ Date: _____ Total: 15 marks

KEY WORDS evidence • conditions

Objective

Balance fuel-cell equations and compare whole pathways. All questions and marking guidance are original.

1 Key knowledge and worked examples

Fuel and oxidant are supplied continuously. Acidic and alkaline hydrogen cells use different half-equations but the same overall reaction, $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. Check atoms and charge separately, then cancel electrons and any H^+/OH^- present on both sides.

■ Worked method

Alkaline oxidation is $2\text{H}_2 + 4\text{OH}^- \rightarrow 4\text{H}_2\text{O} + 4\text{e}^-$. Reduction is $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$. Adding and cancelling gives $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. Methanol oxidation produces CO_2 as well as water. Production and storage of fuels matter when comparing environmental impact.

2 Practice

2.1 Write the acidic hydrogen oxidation half-equation for two H_2 molecules. [2]

2.2 Write oxygen reduction to water in acidic conditions. [2]

2.3 Explain why describing a fuel cell as having a finite sealed supply of reactants misses its usual operation. [1]

3 Exam-style questions

3.1 Balance alkaline oxygen reduction using O_2 , H_2O , electrons and OH^- . Combine it with the worked oxidation equation. [4]

3.2 Balance complete methanol oxidation in an oxygen fuel cell. Give one operational advantage and one direct emission disadvantage relative to hydrogen. [3]

3.3 A hydrogen supplier uses electricity from fossil fuel generation. Evaluate the claim that a water-only cell exhaust proves zero environmental impact. [3]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$. Atoms and charge/electrons.

2.2 $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$. Atoms and charge/electrons.

2.3 Fuel and oxidant continue to enter from outside while the cell operates.

3.1 $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$. Cancel 4e^- and 4OH^- and two waters; overall $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$.

3.2 $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$. Liquid methanol is easier to store/transport; operation emits CO_2 .

3.3 The cell itself produces water, but making hydrogen consumes energy with possible upstream CO_2 emissions. Storage/transport also require energy, so compare complete production pathways.