CHEMISTRY 12 EXTENDED RESPONSE ASSESSMENT

FUEL CELLS & INTERNAL COMBUSTION ENGINES

MARKING KEY

1. Compare the traditional internal combustion engine to the fuel cell. Include in your answer advantages and disadvantages of both systems. [5]

Comparison based on energy conversions

or

types of fuel

or any other reasonable basis [1]

Advantages of fuel cells - any 2 [1/2 mark each]

Disadvantages of fuel cells - any 2 [1/2 mark each]

Advantages of internal combustion engines - any 2 [1/2 mark each]

Disadvantages of internal combustion engines - any 2 [1/2 mark each]

2. Identify the half reactions and overall equations (include states of matter) occurring at each electrode in a hydrogen fuel cell and in the methanol fuel cell. [5]

Hydrogen fuel cell

Anode: 2H2 (g) 🡪 4H+ (aq) + 4e- [1]

Cathode: O2 (g) + 4H+(aq) + 4e- 🡪 2H2O (l) O2 (g) 🡪 2 O (adsorbed)

O (ads) + H+ (aq) + e- 🡪 OH (ads)

OH (ads) + H+ (aq) + e- 🡪 H2O (l) [1]

Overall: 2H2 (g) + O2 (g) 🡪 2H2O (l) [1/2]

Methanol fuel cell

Anode: CH3OH (l) + H2O (l) 🡪 6H+(aq) + 6e- + CO2 (g) x2 [1]

Cathode: O2 (g) + 4H+(aq) + 4e- 🡪 2H2O (l) x3 [1/2]

Overall: 2CH3OH (l) + 3O2 (g) 🡪 2CO2 (g) + 4H2O (l) [1]

NB: states of matter not included -1/2

methanol equation given without half-equations zero

3. Methanol fuel cells have been put forward as a possible carbon neutral solution and a better option than the internal combustion engine. Discuss. [5]

METHANOL INTERNAL COMBUSTION ENGINE

CO2 made but no other pollutants CO2 plus other pollutants + particulates [1]

Fuel cells can be used to convert CO2

into CH3OH

but

- energy needed to do this

- use of renewables to do this

limited [1]

- drawing CO2 from atmosphere slow

(CO2 only 1% of atmosphere) [1]

CH3OH highly toxic [1]

Initial production of CH3OH uses energy Not C-neutral

- only C-neutral if renewable source - petrol production requires energy [1]

of energy used - use of petrol as fuel

ICE's not yet suited to CH3OH use [1]

CH3OH able to cross through the

electrolyte, react at cathode without [1]

electrons released to produce current.

NB: Any FIVE aspects to be included in explanation.

4. In your opinion discuss whether the use of hydrogen fuel cells will be a viable option on a commercial scale in the near future. Consider environmental, economic and logistical issues to justify your answer. [10]

Students are expected to proffer an opinion, and include some of the following points… [1]

plus any nine of the following

Transport/logistical issues associated with H2 (trucks can only transport a small volume of pressurized hydrogen gas) [1]

Supply of hydrogen gas in its elemental form (low natural occurrence of H2)

Energy intensive process to extract or produce H2 (steam reforming process…etc) [1]

H2 may be carbon-neutral, it is usually derived from hydrocarbons, non-renewable resource [1]

Flammability / leakage / explosion danger [1]

Cost of H2 and Pt (electrode) and fuel cell structure [1]

Clean (water is the only product) [1]

More efficient due to few moving parts (less wear and tear due to less friction) [1]

No burning is required – electrochemical process only therefor no pollutants [1]

High energy density [1]

Lightweight and long-lasting [1]

Quiet [1]