Electrolyser worksheet – green hydrogen

1. Consider the electrolysis of water using a PEM electrolyser.
   a. Write the half-equations for both the oxidation and reduction reactions that occur at the electrodes labelled A and B in the box provided in fig 1. State required.
   b. In the red box, identify the species moving through the semipermeable membrane and draw an arrow to indicate the direction of flow.
   c. Give the polarity of electrodes:
      A ____
      B ____

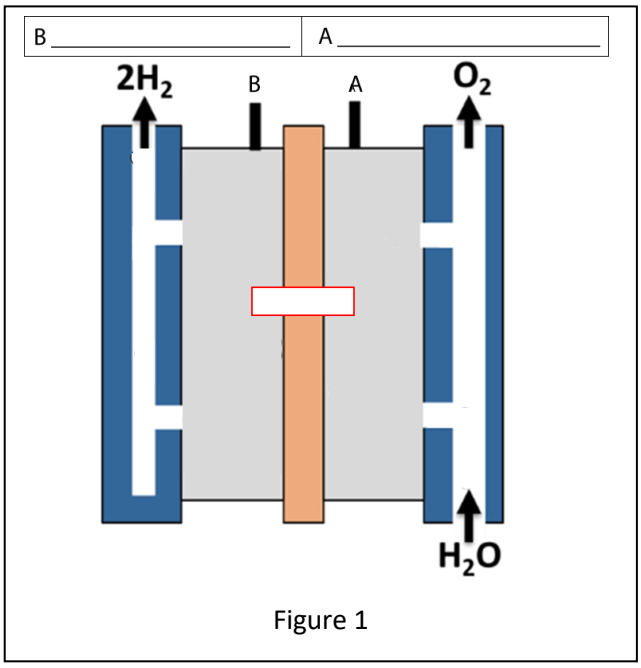

Figure 1

   d. A current of 5.0 A is applied for 2.0 hours.

      i. Calculate the total charge passed through the electrolyser.

      ii. Calculate the mass, in grams, of hydrogen produced, assuming 80% efficiency. Express the answer to the right number of significant figures.

2. Consider the design of an AEM electrolyser shown in fig. 2. It operates at a current of 20 amps.

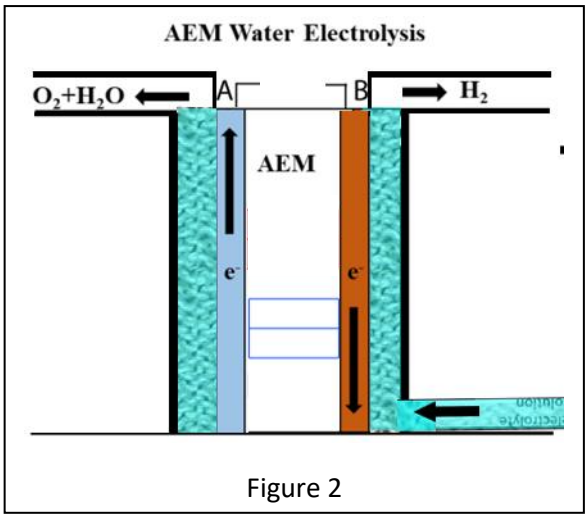

Figure 2

   a. In the blue give the ion species moving through the membrane and draw the arrow to indicate the direction of travel.
   b. Identify electrodes A and B as either the cathode or anode.

      A _____

      B _____

   c. Write the balanced half equations, states included, for the reactions taking place at the:

      Anode _____

      Cathode _____

   d. Identify an appropriate electrolyte solution

      _____

   e. Calculate the time, in hours, required to produce 2.000 kg of green hydrogen. Assume 100% efficiency in the electrolytic process.

3. Compare two scenarios of water electrolysis using a PEM electrolyser. In Scenario A, a current of 15 amps is applied for 3 hours, and in Scenario B, a current of 10 A is applied for 5 hours.
   a. Determine which scenario produces more hydrogen gas and discuss the factors influencing the comparison.

   b. Calculate the mass, in grams, of hydrogen gas produced using your answer to a. above. Give the answer to the right number of significant figures.

   c. Under what conditions is the hydrogen produced by an electrolyser considered green-hydrogen?

      i. Give three examples of green hydrogen production

      ii. Give three examples of the production of non-green hydrogen production.

   d. Bioethanol is used as a fuel in an ethanol/oxygen fuel cell to generate power to drive an PEM electrolyser. Ethanol is produced via fermentation of corn starch and then purified via distillation. The process of distillation, in this case, requires heat generated from the burning of natural gas.
      i. Is the hydrogen gas produced via this method considered “Green hydrogen”?

      ii. Is the hydrogen gas produced via this method “sustainable” and “renewable”?

iii. Ethanol can also be used directly in a decomposition reaction to produce hydrogen gas according to the equation below.

$$C_2H_5OH \rightarrow H_2 + CO + CH_4 \qquad \Delta H = 51.3kJ/mol$$

Is the hydrogen gas produced by this decomposition reaction sustainable and renewable if the heat energy required comes from wind turbines? Explain.

4. A green hydrogen production facility utilizes a AEM electrolyzer that operates with a current of 30.0 A for 8.0 hours. The overall water electrolysis reaction is given below

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

Calculate the:

i. Total charge passed through the electrolyser.

ii. Mol of electrons that pass through the electrolyser.

iii. Give the balanced half equation occurring at the cathode.

iv. The theoretical yield of green hydrogen in grams.

v. The percentage yield given that the hydrogen gas produced occupied a volume of 99.2 litres at SLC.

vi. What conditions must apply for the hydrogen produced in the electrolyser to be considered green hydrogen?

5. Compare and contrast a PEM electrolyser with a hydrogen fuel cell by discussing two similarities and two differences between the two.