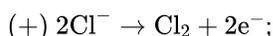


HL Paper 3

Discuss the production of chlorine and sodium hydroxide from brine using a membrane cell. Include in your answer the materials used for the electrodes, the equations taking place at each electrode and why this method has replaced the mercury cell.

Markscheme

(+) electrode made of titanium and (–) electrode made of steel;



environmental as poisonous mercury leaks from mercury cell / *OWTTE* / membrane cell is much cheaper to run;

Examiners report

Like C1, this was a question that demanded knowledge of basic chemistry, but it was poorly done. Vague answers were given as to “toxic mercury”.

A fuel cell is an energy conversion device that generates electricity from a spontaneous redox reaction.

- a. The *Geobacter* species of bacteria can be used in microbial fuel cells to oxidise aqueous ethanoate ions, CH_3COO^- (aq), to carbon dioxide gas. [2]

State the half-equations for the reactions at both electrodes.

Negative electrode (anode):

.....

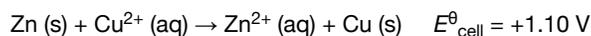
Positive electrode (cathode):

.....

- b. A concentration cell is an example of an electrochemical cell. [3]

(i) State the difference between a concentration cell and a standard voltaic cell.

(ii) The overall redox equation and the standard cell potential for a voltaic cell are:



Determine the cell potential E at 298 K to three significant figures given the following concentrations in mol dm^{-3} :



Use sections 1 and 2 of the data booklet.

(iii) Deduce, giving your reason, whether the reaction in (b) (ii) is more or less spontaneous than in the standard cell.

c. Dye-sensitized solar cells (DSSC) convert solar energy into electrical energy.

[4]

(i) Describe how a DSSC converts sunlight into electrical energy.

(ii) Explain the role of the electrolyte solution containing iodide ions, I^- , and triiodide ions, I_3^- , in the DSSC.

Markscheme

a. *Negative electrode (anode):* $CH_3COO^-(aq) + 2H_2O(l) \rightarrow 2CO_2(g) + 7H^+(aq) + 8e^-$

Positive electrode (cathode): $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

Accept equilibrium signs in equations.

Award [1 max] if correct equations are given at wrong electrodes.

b. i

concentration cell has different concentrations of electrolyte «solutions» «but same electrodes and electrolytes»

OR

standard voltaic cell has different electrodes/electrolytes «but same concentration of electrolytes»

Accept “both half-cells in concentration cell made from same materials”.

ii

$$E = 1.10 - \left(\frac{RT}{nF} \right) \ln \frac{[Zn^{2+}]}{[Cu^{2+}]} = 1.10 - \left(\frac{8.31 \times 298}{2 \times 96500} \right) \ln \frac{10^{-4}}{10^{-1}} = 1.10 + 0.0886 \Rightarrow$$

(+) 1.19 «V»

3 significant figures needed for mark.

iii

more spontaneous because $E > E_{cell}^{\theta}$

c. i

photon/«sun»light absorbed by the dye/photosensitizer/«transition» metal complex

OR

dye/photosensitizer/«transition» metal complex excited by photon/«sun»light

electron«s» move«s» to conduction band

OR

electron«s» transferred to semiconductor/ TiO_2

ii



OR

triiodide ions/ I_3^- reduced into/produce iodide ions/ I^- «at cathode»

iodide ions/ I^- reduce dye/act as reducing agent **AND** oxidized into/produce triiodide ions/ I_3^-

OR



Examiners report

[N/A]

- b. [N/A]
 - c. [N/A]
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