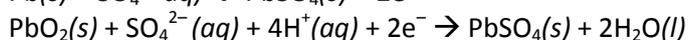
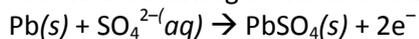


Revision of galvanic and fuel cells

Question 1

A lead-acid battery is made up of six cells connected in series. When the battery is providing energy, the reactions occurring at the electrodes of a single cell are:



a.

i. Give an equation for the net reaction that occurs while a lead-acid battery is providing energy.

ii. Give the formula of the oxidant and the formula of the reductant in the above reaction.

oxidant -----

reductant -----

b. What happens to the pH when the battery is being recharged? Explain

c. Write the equation occurring at the negative terminal when the battery is being recharged

d. NiCad batteries are secondary cells. The chemical reaction that occurs when a NiCad cell is being recharged can be represented by the chemical equation

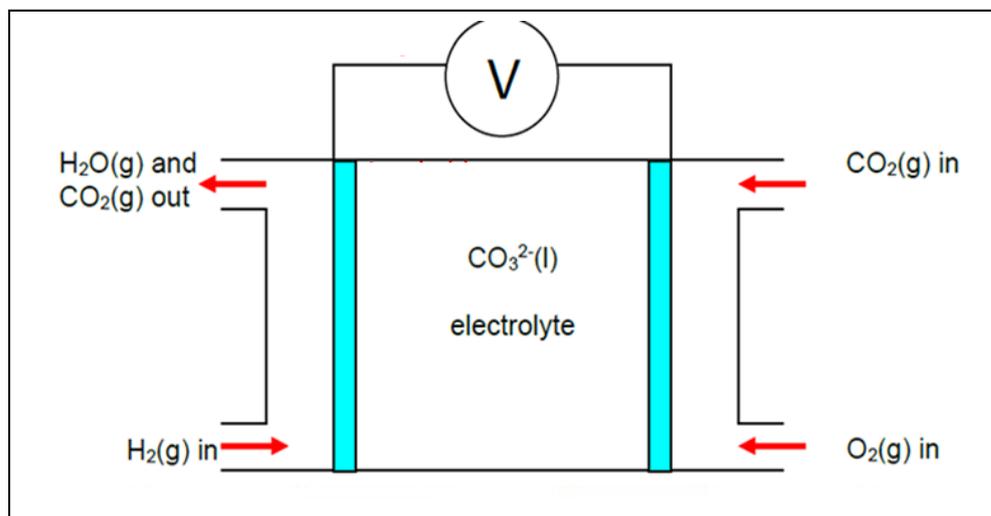


i. What is the reductant when the NiCad cell is discharging?

ii. When a NiCad cell is being recharged what terminal of the external power supply must be attached to the cadmium electrode.

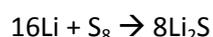
iii. Write a balanced chemical reaction, *with states*, that occurs at the cathode during recharge

2) A molten carbonate fuel cell (MCFC) uses a molten mixture of lithium carbonate, Li_2CO_3 and sodium carbonate, Na_2CO_3 as the electrolyte. Hydrogen gas is passed over one electrode and a combination of oxygen gas and carbon dioxide gas is passed over the other electrode, as shown in the diagram below. The net overall reaction is $\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$. There is no net gain or loss of the electrolyte.



- Write a half equation for the overall cell reaction at the anode.
- Write a half equation for the overall cell reaction at the cathode.
- On the diagram above, label
 - the anode and its polarity.
 - the direction of electron flow.
 - the direction of molten carbonate flow.
- What is the net overall effect on the molten carbonate electrolyte as the cell produces energy?

3) An experimental galvanic cell is being trialled that uses lithium metal and sulphur as reactants. The overall equation, states not shown, for this cell while discharging is given below.



The light weight and relatively cheap cell uses a polymer electrolyte rather than an aqueous solution to produce a voltage of 2.4 volts.

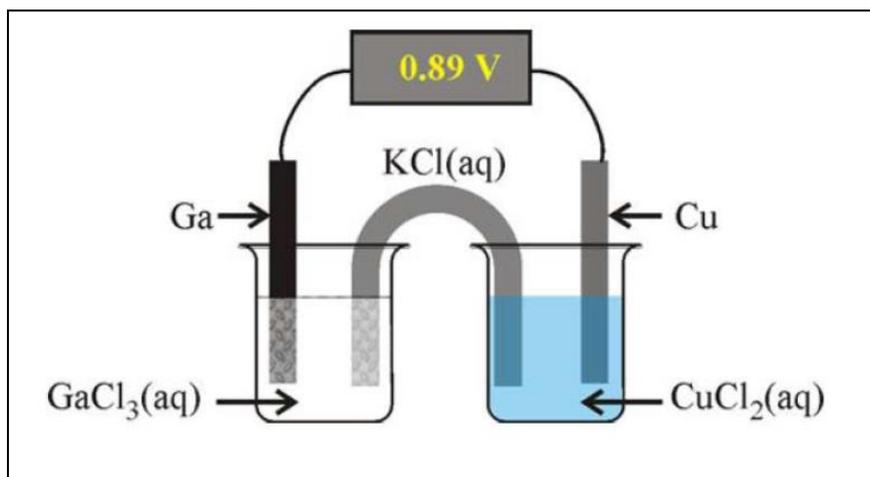
- Explain why an aqueous solution is not used in this cell. Justify your answer with a balanced equation.
- Write a balanced half-equation of the reactions occurring at the anode and the cathode.

anode –

cathode –
- This cell is rechargeable. Write a balanced equation for the reaction taking place at the cathode when the cell is recharging.

Question 4

a. A galvanic cell was assembled by combining the $\text{Cu}^{2+}(\text{aq})/\text{Cu}(\text{s})$ and $\text{Ga}^{3+}(\text{aq})/\text{Ga}(\text{s})$ standard half-cells as shown in the diagram below.



The cell potential was measured at 0.89 V, with the copper electrode gaining mass when the cell was discharging.

i. Write an appropriate half-equation for the process that would be occurring at the gallium electrode.

ii. Write an appropriate chemical equation for the overall reaction that would occur in this cell when it is discharging.

iii. Determine the standard electrode potential (E^\ominus) for the $\text{Ga}^{3+}(\text{aq})/\text{Ga}(\text{s})$ standard half-cell.

iv. What voltage would be produced by a $\text{Ga}^{+3}/\text{Ga} // \text{Zn}/\text{Zn}^{2+}$ galvanic cell at SLC?

iv. On the diagram **above** clearly label the direction of flow of the potassium ions in the salt bridge

v. With reference to any half equations, explain why potassium ions flow in this direction.

Question 5

A hydrogen-oxygen proton exchange membrane fuel cell operates at 65% efficiency.

a. Write appropriate chemical half-equations for the reaction occurring at the cathode

b. Calculate the volume of hydrogen gas, at SLC, that would be required for the fuel cell to produce 300 MJ of electrical energy. *Be sure your answer is to the correct number of significant figures.*

b. Explain one major issue associated with the use of hydrogen as a fuel.

c. Write a balanced equation for the reaction that takes place at the anode of a propane / oxygen fuel cell that uses $\text{KOH}(\text{aq})$ as the electrolyte.