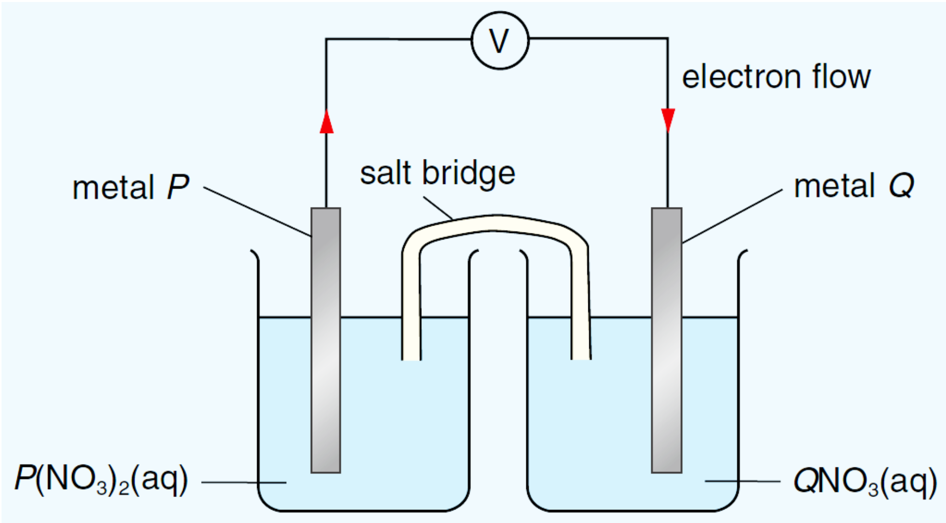
Quiz (Two Half Cells System with Inert Electrodes)

1. A simple chemical cell is shown below:

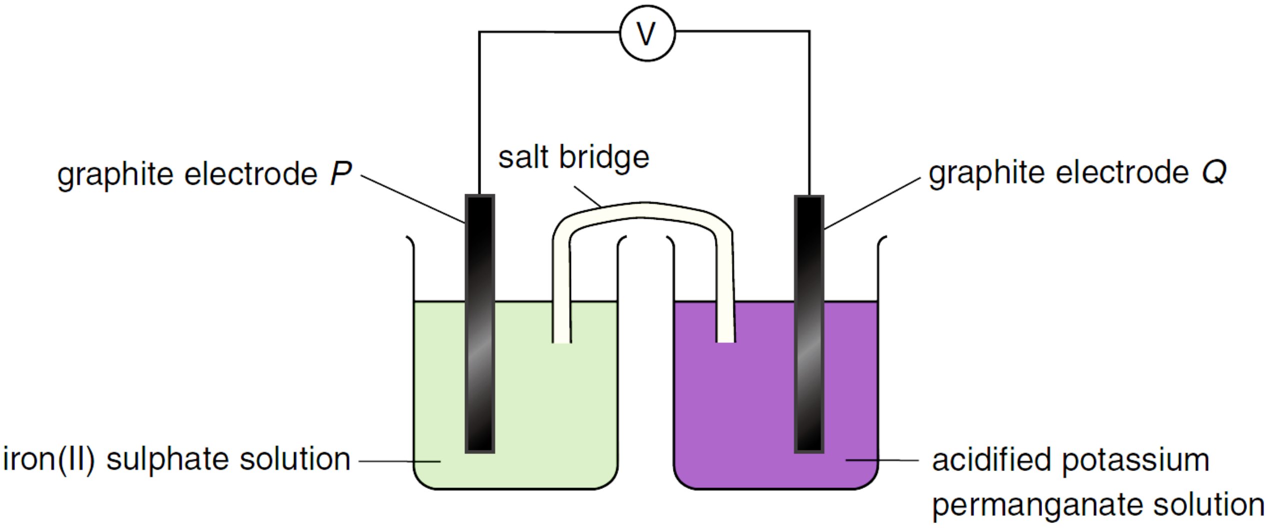


(a) Write a half equation for the change that occurs at each of the following electrodes.
   (i) Metal *P* electrode
   (ii) Metal *Q* electrode

(b) Write the ionic equation for the overall cell reaction.

(c) Identify the anode and the cathode of the above chemical cell.

2. Refer to the simple chemical cell shown below:



(a) What would be observed in each half cell?

(b) Write half equations for the reactions taking place in each half cell.

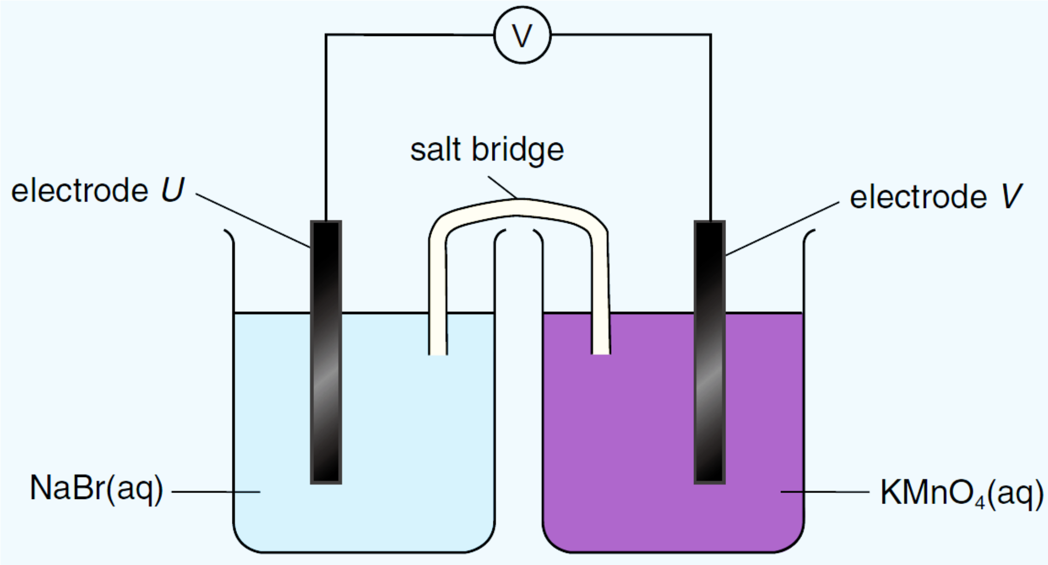
(c) Decide and explain which electrode is the anode.
(d) Decide and explain which electrode is the cathode.

(e) Write the overall ionic equation for the reaction taking place in the chemical cell.

(f) What is the direction of electron flow in the external circuit?

(g) Would the reaction occur if the salt bridge is removed? Explain briefly.

3. A simple chemical cell is set up as shown in the figure below:



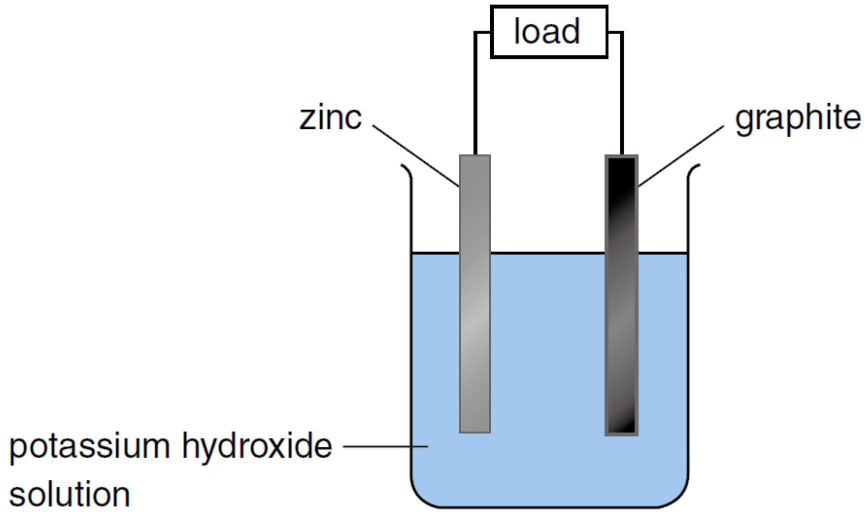
(a) Write half equations for reactions taking place at electrodes *U* and *V* respectively.

(b) What would be observed at electrodes *U* and *V* respectively?

(c) Write the overall ionic equation for the reaction in the chemical cell.

(d) In which direction will the electrons flow in the external circuit? Hence, decide and explain which electrode is the negative electrode.

4. The following diagram shows a simplified structure of the chemical cell used in an electric car. During discharge, zinc undergoes oxidation to give zincate ions, ZnO_2^{2-}(aq). The electrolyte is potassium hydroxide solution. At the graphite electrode, oxygen and water react to produce hydroxide ions.



(a) Write balanced equations for the reactions occurring at
    (i) the zinc electrode;
    (ii) the graphite electrode.

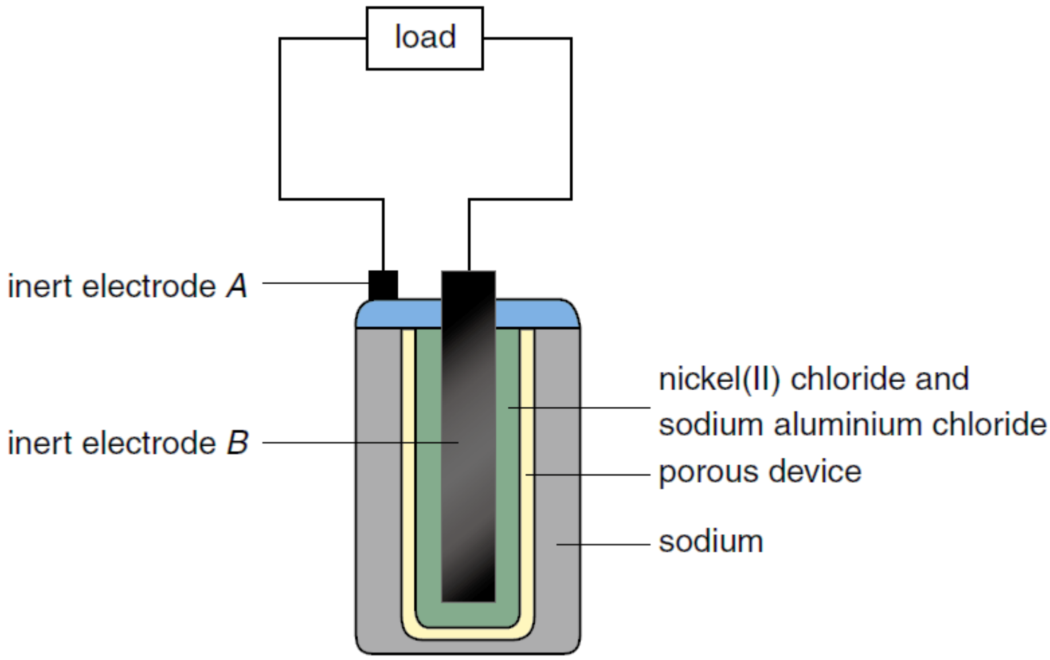
(b) Identify the anode and the cathode of the chemical cell.

(c) Write the overall equation for the reaction occurring in the above chemical cell.

(d) What is the direction of electron flow in the external circuit?

5. The following diagram shows a sodium-nickel(II) chloride cell connected to a load. The electrodes are inert and the electrolyte consists of nickel(II) chloride and sodium aluminium chloride. The cell operates at about 300°C. The overall reaction of the chemical cell is:

$$2Na(l) + NiCl_2(l) \longrightarrow Ni(l) + 2NaCl(l)$$



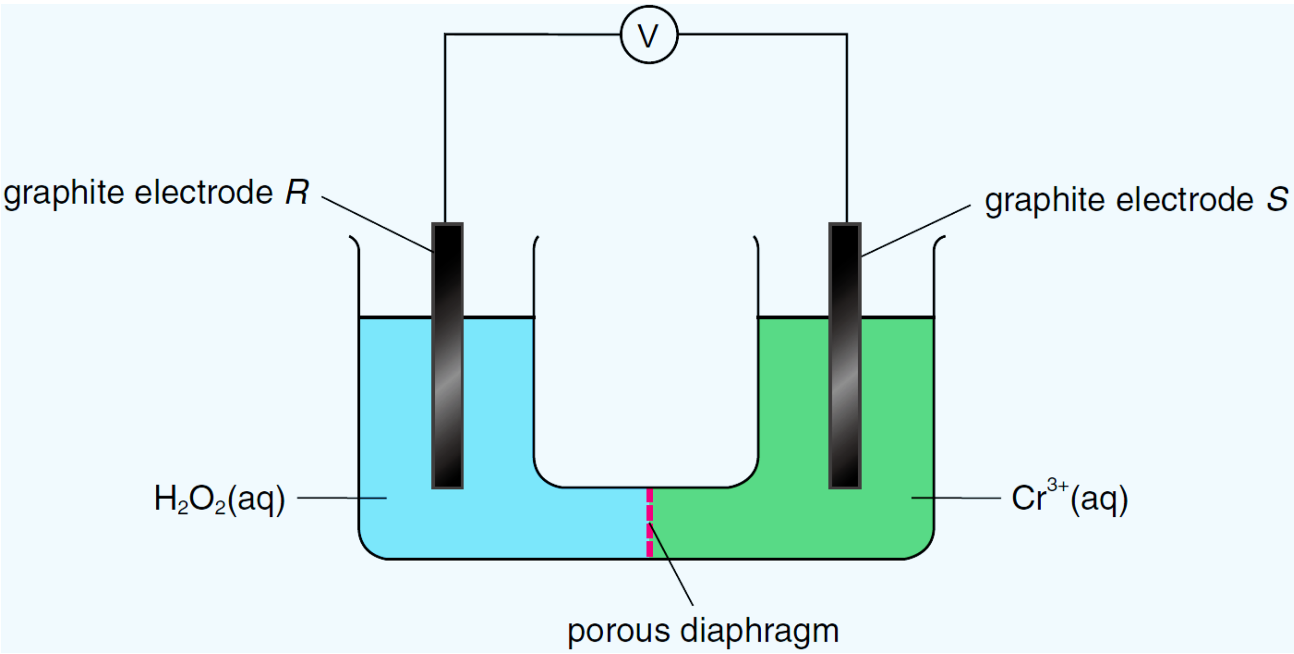
(a) What is the direction of electron flow in the external circuit when the cell is discharged? Explain briefly.

(b) Write half equations for the reactions that occur at electrodes *A* and *B* respectively.

(c) Suggest why a high temperature is needed for the cell to operate.

(d) Sodium-nickel(II) chloride cell is rechargeable and can be used in electric vehicles. State ONE advantage of using this cell as power source.

6. The following diagram shows a chemical cell with a porous diaphragm separating the anode and cathode compartments. During discharge, hydrogen peroxide undergoes reduction to give hydroxide ions while chromium(III) ions undergo oxidation in alkaline medium to give chromate(VI) ions (CrO_4^{2-}(aq)).



(a) (i) Write a half equation for the reaction occurring at electrode *R*.
(ii) Explain why the reaction occurring at electrode *R* is a reduction reaction in terms of change in oxidation number.

(b) (i) Write a half equation for the reaction occurring at electrode *S*.
(ii) Explain why the reaction occurring at electrode *S* is an oxidation reaction in terms of change in oxidation number.

(c) Write the overall equation for the reaction occurring in the above chemical cell.

(d) Suggest what would happen if the porous diaphragm is removed from the above chemical cell.

Suggested Answer

1. (a) (i) $P(s) \longrightarrow P^{2+}(aq) + 2e^-$
   (ii) $Q^+(aq) + e^- \longrightarrow Q(s)$

   (b) $P(s) + 2Q^+(aq) \longrightarrow P^{2+}(aq) + 2Q(s)$

   (c) Anode: metal P electrode
   Cathode: metal Q electrode

2. (a) In the left half cell, the solution changes from pale green to yellow gradually. In the right half cell, the purple solution fades gradually.

   (b) In the left half cell: $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$
   In the right half cell: $MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$

   (c) Electrode *P* is the anode because oxidation takes place at this electrode.

   (d) Electrode Q is the cathode because reduction takes place at this electrode.

   (e) $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \longrightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

   (f) Electrons flow from *P* to *Q* in the external circuit.

   (g) No. This is because there will be no electrical connection between the two half cells.

3. (a) Reaction at electrode U:
   $2Br^-(aq) \longrightarrow Br_2(aq) + 2e^-$

   Reaction at electrode V:
   $MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$

   (b) The solution around electrode U turns orange / brown.
   The purple solution around electrode V fades / becomes colourless.

   (c) $2MnO_4^-(aq) + 10Br^-(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5Br_2(aq) + 8H_2O(l)$

   (d) Electrons flow from electrode U to electrode V in the external circuit. $Br^-(aq)$ ions lose electrons at electrode U and are oxidized to $Br_2(aq)$. Thus, electrons move into the external circuit from U to V. Hence, U is the negative electrode.

4. (a) (i) $Zn(s) + 4OH^-(aq) \longrightarrow ZnO_2^{2-}(aq) + 2H_2O(l) + 2e^-$
(ii) $O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$

(b) Zinc electrode is the anode while graphite electrode is the cathode.

(c) $2Zn(s) + 4OH^-(aq) + O_2(g) \longrightarrow 2ZnO_2^{2-}(aq) + 2H_2O(l)$

(d) Electrons flow from the zinc electrode to the graphite electrode.

5. (a) Electrons flow from electrode *A* to electrode *B* because sodium atoms lose electrons when the cell is discharged.

(b) At electrode *A*: $Na(l) \longrightarrow Na^+(l) + e^-$
At electrode *B*: $Ni^{2+}(l) + 2e^- \longrightarrow Ni(l)$

(c) To keep sodium and the electrolyte in molten state.

(d) No exhaust gas is produced.

6. (a) (i) $H_2O_2(aq) + 2e^- \longrightarrow 2OH^-(aq)$
(ii) The oxidation number of oxygen decreases from -1 to -2 in the reaction. Thus, the reaction is a reduction.

(b) (i) $Cr^{3+}(aq) + 8OH^-(aq) \longrightarrow CrO_4^{2-}(aq) + 4H_2O(l) + 3e^-$
(ii) The oxidation number of chromium increases from +3 to +6 in the reaction. Thus, the reaction is an oxidation.

(c) $2Cr^{3+}(aq) + 10OH^-(aq) + 3H_2O_2(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

(d) The two electrolytes mix together and react. No electrons flow in the external circuit. As a result, the voltage of the cell drops to zero.