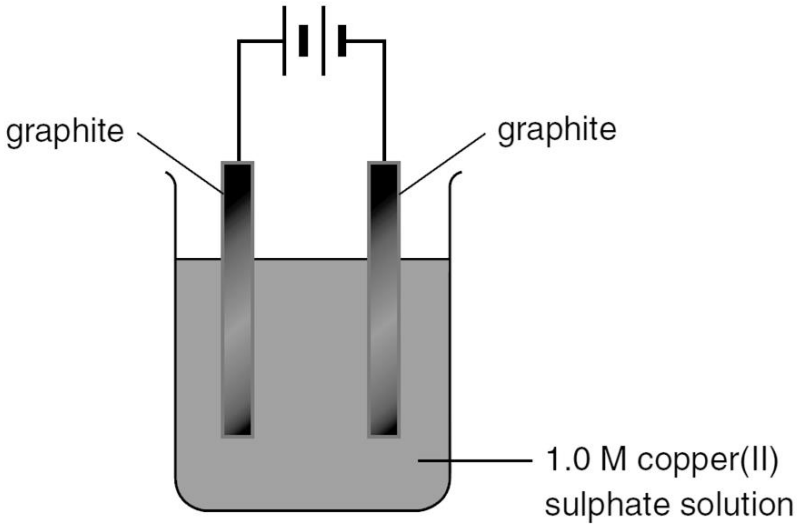
Quiz (Electrolysis – Further Exercise)

1. The diagram on the right shows the electrolysis of a 1.0 M copper(II) sulphate solution using graphite electrodes.



   (a) Write the half equations for reactions taking place at the anode and the cathode respectively.

   (b) When electrolysis is completed, a few drops of universal indicator are added to the solution. State the colour of the resultant solution.

   (c) The electrolyte is replaced by 5.0 M copper(II) sulphate solution. State the product formed at each electrode. Explain your answer.

2. The diagram below shows a set-up for the electrolysis of concentrated sodium bromide solution. After passing electricity for some time, gas bubbles were observed at electrode *P*.

   (a) Which of the electrodes, *P* or *Q*, is the cathode?

   (b) Name the gas produced at electrode *P* during electrolysis, and write a half equation for the reaction that occurred.

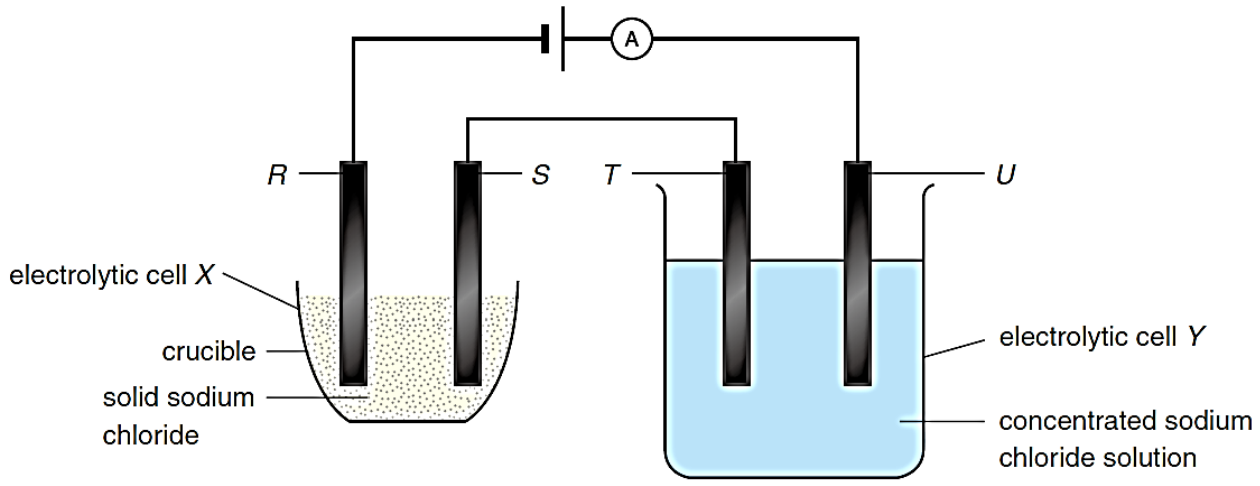
   (c) What ion(s) would migrate towards electrode Q during electrolysis?

   (d) A yellowish brown colour appeared around electrode Q during electrolysis. Write a half equation for the reaction that occurred.

   (e) The yellowish brown colour gradually extended from electrode Q to the bottom of the U-tube. Explain briefly.

   (f) Suggest TWO ways to speed up the electrolysis, using the same set-up and chemicals.

3. An electric circuit is set up as shown in the figure below. All the electrodes are made of graphite.



(a) No current flows while the sodium chloride is in the solid state. The ammeter shows a reading when the solid sodium chloride is heated and melted. Explain why this happens.

(b) State the anodes and the cathodes in the electrolytic cells *X* and *Y* respectively.

(c) What are the ions present in electrolytic cells *X* and *Y* respectively?

(d) (i) After a current is passed through the circuit for some time, what would be observed at electrodes *R*, *S*, *T* and *U* respectively? Explain.

(ii) Write the half equations for the changes that occur.

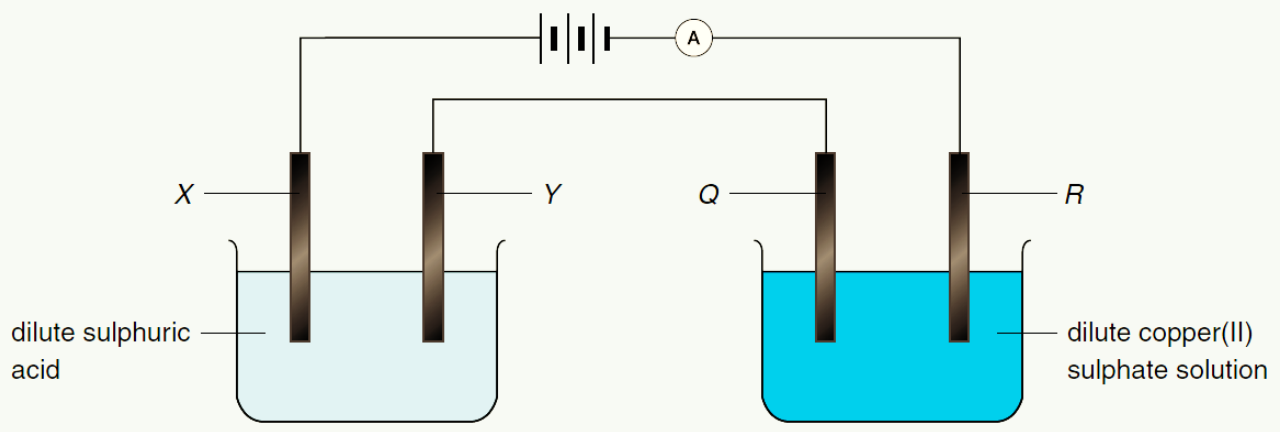
4. Predict the product formed at each electrode in each of the following cases:

(a) Electrolysis of lead(II) nitrate solution with a copper cathode and a platinum anode.

(b) Electrolysis of concentrated potassium iodide solution with graphite electrodes.

(c) Electrolysis of concentrated copper(II) chloride solution with graphite electrodes.

5. An electric circuit is set up as shown below. Electrodes *X*, *Y*, *Q* and *R* are made of graphite.



(a) Explain why sulphuric acid can be used as an electrolyte.

(b) (i) In the above set-up, which electrodes are positive electrodes?

(ii) Write the half equations for the reactions taking place at the positive electrodes in the electrolytic cells. State the expected observable changes at the positive electrodes.

(c) (i) In the above set-up, which electrodes are negative electrodes?

(ii) Write the half equations for the reactions taking place at the negative electrodes. State the expected observable changes at the negative electrodes.

Suggested Answer

1. (a) At the anode: $4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$
   At the cathode: $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$

   (b) The colour of the resultant solution is red.

   (c) The respective products formed at the anode and at the cathode are the same as that formed when 1.0 M copper(II) sulphate solution is electrolysed.

   This is because $Cu^{2+}(aq)$ is lower than $H^+(aq)$ in the Electrochemical Series.

   $Cu^{2+}(aq)$ ions are preferentially discharged at the cathode.

   Although the concentration of $SO_4^{2-}(aq)$ has been increased much, the $OH^-(aq)$ is much higher than $SO_4^{2-}(aq)$ in the Electrochemical Series.

   $OH^-(aq)$ ions are preferentially discharged at the anode.

2. (a) Electrode *P*

   (b) Hydrogen
   $2H^+(aq) + 2e^- \longrightarrow H_2(g)$

   (c) Hydroxide ions and bromide ions

   (d) $2Br^-(aq) \longrightarrow Br_2(aq) + 2e^-$

   (e) Bromine is slightly soluble in water and is denser than the solution, so it sinks to the bottom of the U-tube.

   (f) 1. Increase the current by adjusting the variable resistor to a lower resistance.

   2. Immerse the electrodes deeper into the electrolyte solution.

3. (a) Solid sodium chloride does not conduct electricity because its ions are not mobile. However, when sodium chloride is melted, the ions become mobile and can conduct electricity.

   (b) Electrolytic cell *X*: anode – *S*; cathode – *R*.
   Electrolytic cell *Y*: anode – *U*; cathode – *T*.

   (c) Electrolytic cell *X*: $Na^+(l)$ and $Cl^-(l)$
   Electrolytic cell *Y*: $Na^+(aq)$, $H^+(aq)$, $Cl^-(aq)$ and $OH^-(aq)$

   (d) (i) At *R*, silvery metal forms. $Na^+(l)$ is discharged to form sodium metal.

   At *S*, greenish yellow gas evolves. $Cl^-(l)$ is discharged to form chlorine gas.

   At *T*, colourless gas evolves. $H^+(aq)$ is preferentially discharged to form hydrogen gas since it is lower than $Na^+(aq)$ in the E.C.S.

   At *U*, greenish yellow gas evolves. The concentration of $Cl^-(aq)$ is much higher than that of $OH^-(aq)$ while the positions of $Cl^-(aq)$ and $OH^-(aq)$ in the E.C.S. are not too far apart. $Cl^-(aq)$ is preferentially discharged to form chlorine gas.

   (ii) At *R*: $Na^+(l) + e^- \longrightarrow Na(l)$ At *T*: $2H^+(aq) + 2e^- \longrightarrow H_2(g)$
   At *S*: $2Cl^-(l) \longrightarrow Cl_2(g) + 2e^-$ At *U*: $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$

4. (a) At the anode: Oxygen
   At the cathode: Hydrogen

   (b) At the anode: Iodine
   At the cathode: Hydrogen

   (c) At the anode: Chlorine
   At the cathode: Copper

5. (a) Sulphuric acid ionizes in water to give mobile $H^+(aq)$ and $SO_4^{2-}(aq)$ ions.

   (b) (i) Electrodes X and Q

   (ii) At both electrodes X and Q, colourless gas bubbles evolve.
   $4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$

   (c) (i) Electrodes Y and R

   (ii) Colourless gas bubbles evolve at electrode Y.
   $2H^+(aq) + 2e^- \longrightarrow H_2(g)$

   Reddish brown solid deposits on the surface of electrode R.
   $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$