

# ELECTROLYSIS-MIXED BAG

## 5.8.1

The results of experiments on electrolysis using inert electrodes are given in the table.

Complete the table; the first line has been completed as an example.

electrolyte	change at negative electrode	change at positive electrode	change to electrolyte
molten lead(II) bromide	lead formed	bromine formed	used up
..... .....	potassium formed	iodine formed	used up
dilute aqueous sodium chloride	.....	.....	..... .....
aqueous copper(II) sulfate	.....	.....	..... .....
..... .....	hydrogen formed	bromine formed	potassium hydroxide formed

[Total: 8]

-----Marking Scheme-----

molten potassium iodide      **NOT** aqueous      [1]

hydrogen      [1]

oxygen      [1]

water used up **or** solution becomes more concentrated **or** sodium chloride remains  
**NOT** no change      [1]

If products are given as hydrogen, chlorine and sodium hydroxide then 2/3

copper      [1]

oxygen (and water)      [1]

sulfuric acid      accept hydrogen sulfate      [1]

aqueous **or** dilute **or** concentrated potassium bromide      [1]

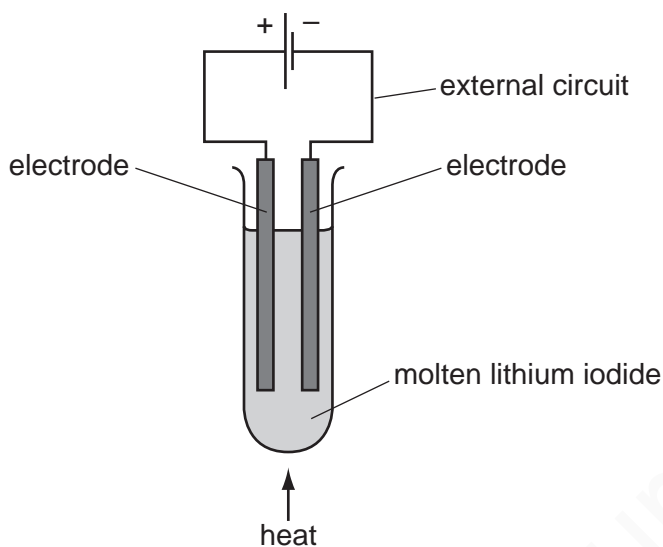
**accept** correct formulae

**[Total: 8]**

### 5.8.2

During electrolysis, ions move in the electrolyte and electrons move in the external circuit. Reactions occur at the electrodes.

(a) The diagram shows the electrolysis of molten lithium iodide.



(i) Draw an arrow on the diagram to show the direction of the electron flow in the external circuit. [1]

(ii) Electrons are supplied to the external circuit. How and where is this done?

.....  
 ..... [2]

(iii) Explain why solid lithium iodide does not conduct electricity but when molten it is a good conductor.

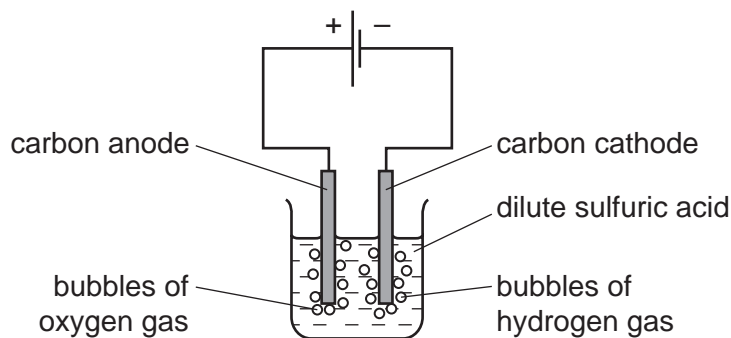
.....  
 ..... [1]

(b) The results of experiments on electrolysis are shown in the following table. Complete the table. The first line has been done as an example.

electrolyte	electrodes	product at cathode	product at anode	change to electrolyte
molten lithium iodide	carbon	lithium	iodine	used up
aqueous copper(II) sulfate	platinum		oxygen	
concentrated aqueous potassium chloride	carbon		chlorine	

[4]

- (c) The diagram below shows the electrolysis of dilute sulfuric acid. Hydrogen is formed at the negative electrode (cathode) and oxygen at the positive electrode (anode) and the concentration of sulfuric acid increases.



The ions present in the dilute acid are  $\text{H}^+(\text{aq})$ ,  $\text{OH}^-(\text{aq})$  and  $\text{SO}_4^{2-}(\text{aq})$ .

- (i) Write an equation for the reaction at the negative electrode (cathode).

..... [2]

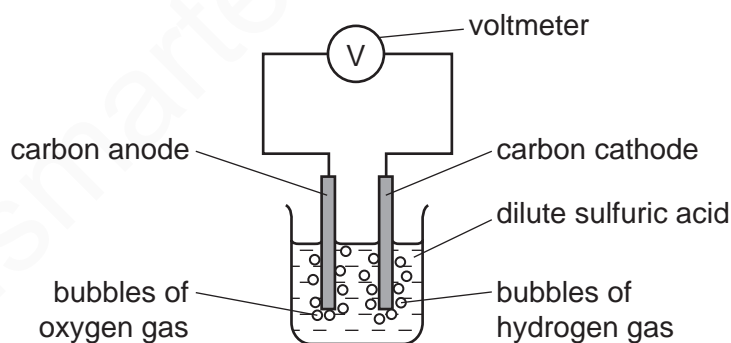
- (ii) Complete the equation for the reaction at the positive electrode (anode).



- (iii) Suggest an explanation of why the concentration of the sulfuric acid increases.

..... [1]

- (d) In the apparatus used in (c), the power supply is removed and immediately replaced by a voltmeter.



A reading on the voltmeter shows that electrical energy is being produced. Suggest an explanation for how this energy is produced.

.....  
 .....  
 ..... [3]

[Total: 15]

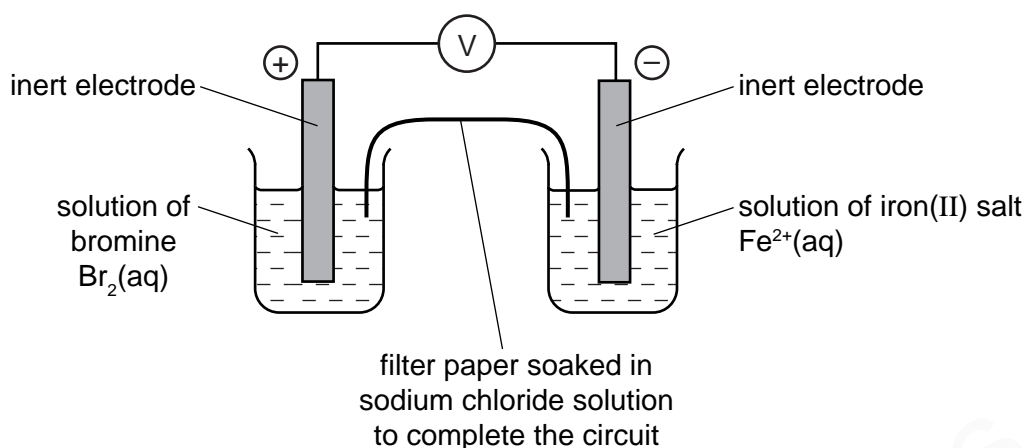
-----Marking Scheme-----

- (a) (i) correct arrow from negative terminal of battery or from anode; [1]
- (ii) from battery / power supply / cell; [1]  
from negative electrode of battery to external circuit; [1]  
**or** from anode;  
from iodide ion losing electron **or** oxidation of anion;
- (iii) ions cannot move in solid / ions can move in liquid; [1]
- (b) copper; [1]  
(changes to) sulfuric acid; [1]
- hydrogen; [1]  
(changes to) potassium hydroxide; [1]
- (c) (i)  $2\text{H}^+ + 2\text{e} \rightarrow \text{H}_2$  [2]  
not balanced = [1]
- (ii)  $4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}$  [1]
- (iii) water used up; [1]
- (d) it is a cell; [1]  
hydrogen reacts with oxygen; [1]  
this reaction produces energy / is exothermic / produces flow of electrons /  
changes chemical energy to electrical energy; [1]

**[Total: 15]**

### 5.8.3

The diagram shows a cell. This is a device which produces electrical energy. The reaction in a cell is a redox reaction and involves electron transfer.

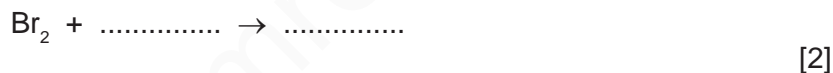


(i) Complete the sentence.

A cell will change ..... energy into electrical energy. [1]

(ii) Draw an arrow on the diagram to show the direction of the electron flow. [1]

(iii) In the left hand beaker, the colour changes from brown to colourless. Complete the equation for the reaction.



(iv) Is the change in (iii) oxidation or reduction? Give a reason for your choice.

.....  
 ..... [1]

(v) Complete the following description of the reaction in the right hand beaker.

$\text{Fe}^{2+}$  changes into ..... [1]

(vi) When a solution of bromine is replaced by a solution of chlorine, the voltage increases. When a solution of bromine is replaced by a solution of iodine, the voltage decreases.

Suggest an explanation for this difference.

.....  
 ..... [1]

[Total: 7]

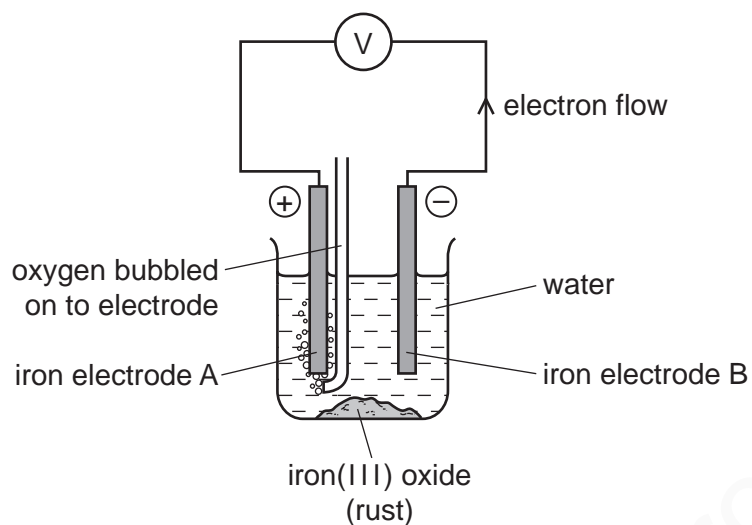
- (i) chemical [1]
- (ii) from right to left [1]  
**not** through salt bridge
- (iii)  $\text{Br}_2 + 2\text{e} \rightarrow 2\text{Br}^-$  [2]  
for  $\text{Br}^-$  as product [1]
- (iv) reduction because electron gain [1]  
/ because oxidation number decreases  
need both points
- (v)  $\text{Fe}^{3+}$  [1]
- (vi) any correct discussion of the reactivity of the halogens [1]  
e.g. the more reactive the halogen the higher the voltage  
**not** better conductor

**[Total: 7]**

### 5.8.4

Iron and steel rust when exposed to water and oxygen. Rust is hydrated iron(III) oxide.

(a) The following cell can be used to investigate rusting.



(i) What is a cell?

.....

..... [2]



- (i) device which changes chemical energy; [1]  
into electrical energy; [1]  
**OR**  
produces a voltage / potential difference / electricity; [1]  
due to difference in reactivity of two metals; [1]  
**OR**  
produces a voltage / potential difference / electricity; [1]  
by redox reactions; [1]

### 5.8.5

Describe how zinc metal can be obtained from zinc sulfate solution by electrolysis.

A labelled diagram is acceptable. Include all the products of this electrolysis. The electrolysis is similar to that of copper(II) sulfate solution with inert electrodes.

[4]

-----Marking Scheme-----

cathode labelled carbon / zinc / platinum;	[1]
zinc deposited at cathode;	[1]
oxygen formed (at anode);	[1]
(electrolyte becomes) sulfuric acid / remaining solution contains $H^+$ and $SO_4^{2-}$ ;	[1]

**5.8.6**

The solution of zinc sulfate is electrolysed using inert electrodes.

This electrolysis is similar to that of copper(II) sulfate with inert electrodes.

(i) Write the equation for the reaction at the negative electrode (cathode).

..... [1]

(ii) Complete the equation for the reaction at the positive electrode (anode).



(iii) The electrolyte changes from zinc sulfate to

..... [1]

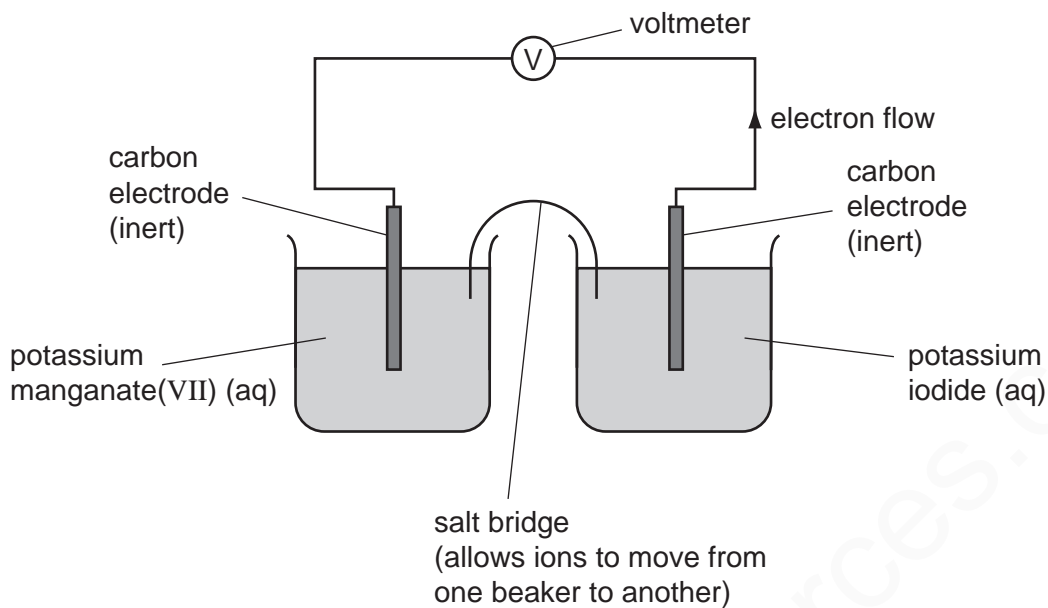
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-----Marking Scheme-----

- (i)  $\text{Zn}^{2+} + 2\text{e} \rightarrow \text{Zn}$  [1]
- (ii)  $\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + \dots\text{e}$  (1) only [2]  
 $4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}$
- (iii) sulfuric acid / hydrogen sulfate [1]  
**ACCEPT:** sulfuric acid

### 5.8.7

Cells can be set up with inert electrodes and the electrolytes as oxidant and reductant.



The potassium manganate(VII) is the oxidant and the potassium iodide is the reductant.

(i) Describe the colour change that would be observed in the left hand beaker.

..... [2]

(ii) Write an ionic equation for the reaction in the right hand beaker.

..... [2]

- (i) pink or purple [1]  
to colourless or decolourised [1]  
**NOT** red **NOT** clear
- (ii)  $2\text{I}^- - 2\text{e} = \text{I}_2$  [2]  
unbalanced **ONLY** [1]