REVISION: CHEMISTRY 17 SEPTEMBER 2013

Lesson Description

In this lesson, we:

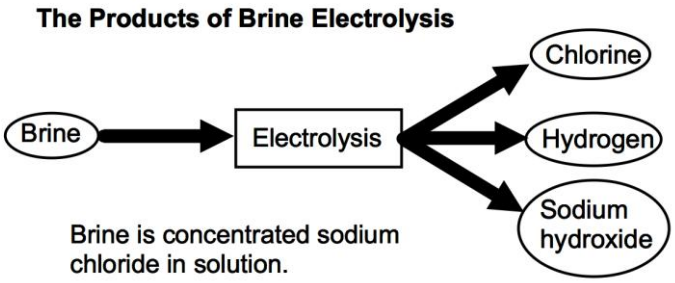
- Revise chemical industries, batteries and electrochemical cells.

Key Concepts

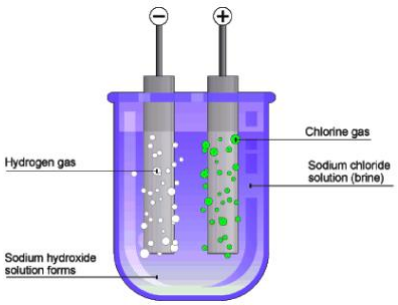
Terminology

Brine	Concentrated salt water.
Anode	Electrode where oxidation takes place.
Cathode	Electrode where reduction takes place.
Asbestos	Fibrous material used in the diaphragm cell – lung irritant.
Electrolysis	Process using electricity to create chemicals.
Primary Cell	A cell which can only be used once.
Secondary Cell	A cell which can be recharged.

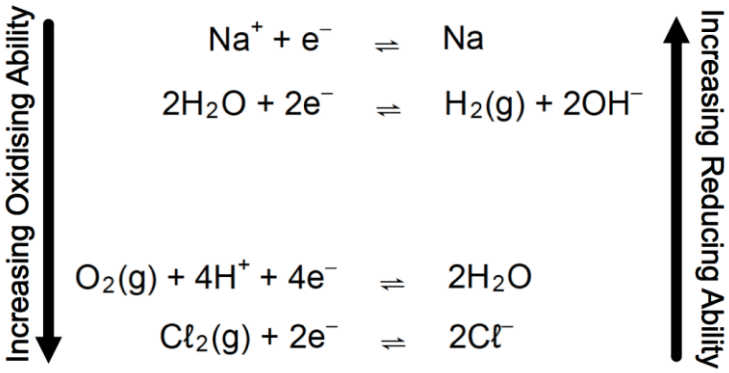
Brine Electrolysis



When NaCl(s) dissolves in water, it separates into two ions:



$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$



H_2O is the best oxidising agent in place of Na^+, so hydrogen and not sodium metal is made at the cathode.

The Cl^- is more attracted to the positive electrode and oxidises in place of the water at the anode. This is the reason concentrated NaCl is used – to prevent H_2O from forming oxygen.

Nitrogen containing Fertilizers

Nitrogen containing fertilisers are ammonium salts. These salts are mainly ammonium nitrates and ammonium sulphate. Plants absorb nitrogen containing fertilizers as nitrate or ammonium ions through the roots. The production of these salts is done through a number of processes:

1. Nitrogen is harvested from air which is 78% nitrogen per volume through fractional distillation. The air is liquefied and then heat up to allow gases to evaporate at different boiling points.

2. Nitrogen is the allowed to react with hydrogen through the Haber process to produce ammonia.

   $N_2(g) + 3H_2(g) \rightarrow 2NH_3$

3. Ammonia is reacted with oxygen to produce to produce nitrogen monoxide which is necessary for the production of Nitric Acid through the Ostwald process.

   Step I: $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

   Step II: $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

   Step III: $3NO_2(g) + H_2O(\ell) \rightarrow 2HNO_3(aq) + NO(g)$

4. Ammonium nitrate is then produced by the reaction of ammonia and nitric acid as follows:

   $NH_3(g) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$.

5. The production of ammonium sulphate involves the contact process where sulphuric acid is produced.

   Step I: Sulphur burns in oxygen to form Sulphur Dioxide:

   $S(s) + O_2(g) \rightarrow SO_2(g)$

Step II: Sulphur dioxide reacts with oxygen in the presence of a contact catalyst being V_2O_5 or platinum. This is a reversible reaction so it can reach a state of chemical equilibrium if it is conducted in a closed system.

$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$

Step III: Sulphur trioxide is dissolved in sulphuric acid to form a highly concentrated form of the acid called oleum.

$SO_3(g) + H_2SO_4(\ell) \rightarrow H_2S_2O_7(\ell)$

Step IV: The oleum is dissolved in water to produce sulphuric acid.

$H_2S_2O_7(\ell) + H_2O(\ell) \rightarrow 2H_2SO_4(aq)$

6. Ammonium sulphate is then produced as follows:

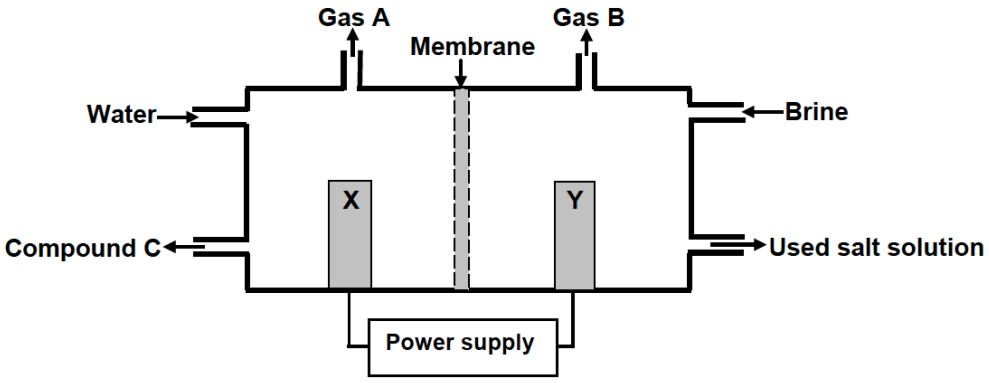
$\mathbf{2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4}$

Questions

Question 1

(DOE Nov 2011, Question 10)

The simplified diagram of a membrane cell used in the chlor-alkali industry is shown below. Gas A, gas B and compound C are the three major products formed during this process. X and Y represent the two electrodes.



1.1 Write down the function of the membrane in this cell. (1)

1.2 Which electrode, X or Y, is connected to the positive terminal of the power supply? Briefly explain how you arrived at the answer. (2)

1.3 Write down the NAME or FORMULA of:

1.3.1 Gas A (1)

1.3.2 Gas B (1)

1.3.3 Compound C (1)

1.4 Write down the balanced net (overall) cell reaction taking place in this cell. (3)

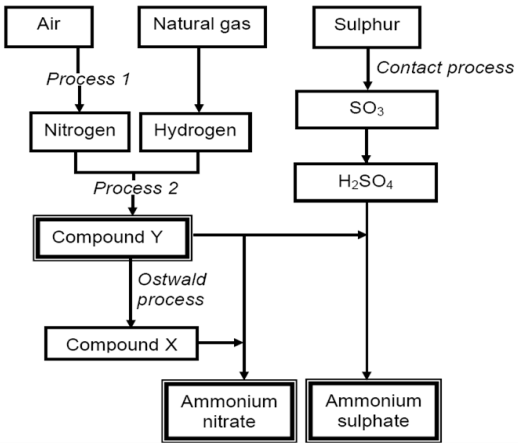
Question 2

What are the processes used to produce the following substances called?

a.) Nitrogen
b.) Ammonia
c.) Nitric acid
d.) Sulphuric acid

Question 3

Ammonia, ammonium nitrate and **ammonium sulphate** are three important nitrogen-containing fertilisers. The flow diagram below shows how these fertilisers are produced in industry.



Use the information in the flow diagram above and write down the following:

a.) Name of Process 1
b.) Balanced equation for Process 2
c.) NAME or FORMULA of compound X
d.) Balanced equation for the preparation of ammonium sulphate using sulphuric acid and compound Y
e.) NAME or SYMBOL of the primary nutrient in ammonium sulphate
f.) Write down ONE positive impact of fertilisers on humans.
g.) Write down TWO negative impacts of the use of ammonium nitrate, as fertiliser, on humans.

Question 4

(Adapted from Sep 2012, EC, Paper 2, Question 9)

The common lead-acid battery, used to start motor vehicles, is composed of a number of galvanic cells, each having an emf of about 2 V. These are connected in series so that their voltages are additive. Most motor vehicle batteries contain six such cells and give about 12 V, but 6 V, 24 V and 32 V batteries are also available.

a.) Is the lead acid battery an example of a primary or secondary cell? Explain.

b.) What type of energy transformation takes place in the cell whilst it is discharging?

c.) 98% of a lead-acid battery can be recycled.
Name THREE components of the battery that can be recycled and explain, in your own words, how they are recycled.

Question 5

(DOE Nov 2012, Question 10)

The following half-reactions take place when a non-rechargeable alkaline cell is in use:

$$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(\ell) + 2e^- \text{……..……(1)}$$

$$MnO_2(s) + 2H_2O(\ell) + 2e^- \rightarrow Mn(OH)_2(s) + 2OH^-(aq) \text{ …….(2)}$$

a.) Write down the general name used for non-rechargeable cells. (1)
b.) Which ONE of the above equations (1 or 2) represents the half-reaction that takes place at the cathode? Give a reason for your answer. (2)
c.) Give a reason why the cell 'dies' after delivering current for a while. (1)
d.) The emf of the alkaline cell is 1,5 V. The maximum electrical work that can be done by this cell is 3×10^4J.

Calculate the:

i. Cell capacity of this cell in A·h (4)
ii. Maximum constant current that this cell can deliver for 20 hours (3)