

## Chapter 9B. Nitric acid

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### Solution 1:

Nitric acid is formed in atmosphere during lightning discharge. Nitrogen in atmosphere combine with oxygen to form nitric acid.

### Solution 2:

- (i) Gas produced in air during lightning is Nitric Oxide.
- (ii) Hydrogen gas is obtained by treating manganese with 1% nitric acid.
- (iii) Salt referred to as Chile saltpeter is  $\text{NaNO}_3$ .
- (iv) Salt used in laboratory to prepare nitric acid is  $\text{KNO}_3/\text{NaNO}_3$ .
- (v) Products obtained by catalytic oxidation of ammonia are  $\text{NO}$ , water & heat.
- (vi) Products obtained by heating concentrated nitric acid are  $\text{NO}_2$ , water &  $\text{O}_2$ .
- (vii) Copper nitrate is blue coloured, cobalt nitrate is coloured.

### Solution 3:

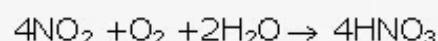
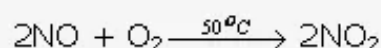
- (a) Aqua fortis: It is the other name for nitric acid, it is also known as 'strong water'. It was called so because earlier this was the only liquid which could dissolve many metals including silver.
- (b) Aqua Regia: It is a mixture of concentrated nitric acid and concentrated hydrochloric acid in proportion of 1:3 (by volume).
- (c) Fuming nitric acid: It contains  $\text{NO}_2$  dissolved in concentrated  $\text{HNO}_3$ . It is obtained by distilling concentrated  $\text{HNO}_3$  with little starch.
- (d) Decrepitation: It is the breaking of a substance usually accompanied by the emission of a crackling sound. An example for a substance which decrepitates on heating is lead nitrate ( $\text{Pb}(\text{NO}_3)_2$ ).

**Solution 4:**

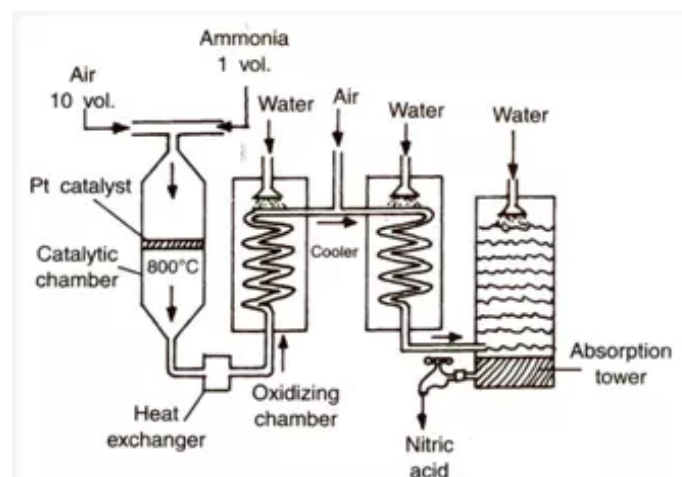
- (a) In laboratory, nitric acid is prepared by heating a mixture of concentrated sulphuric acid and potassium or sodium nitrate with conc.  $\text{H}_2\text{SO}_4$  at  $200^\circ\text{C}$ .
- $$\text{KNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{KHSO}_4 + \text{HNO}_3$$
- (b) Concentrated sulphuric acid is non-volatile and produce volatile nitric acid.
- (c) The temperature is maintained at  $200^\circ\text{C}$  in the above reaction to avoid following problems:
- Nitric acid would decompose at high temperature.
  - Potassium or sodium sulphate is formed which will stick to the walls of glass and cannot be removed easily.
  - The glass apparatus may break at high temperature.
- (d) No, concentrated  $\text{HCl}$  cannot be used in the place of concentrated  $\text{H}_2\text{SO}_4$  because  $\text{HCl}$  is more volatile than  $\text{HNO}_3$  and hence nitric acid vapours will carry  $\text{HCl}$  vapours.

**Solution 5:**

- (a). **Ostwald process** is used for used for the manufacture of nitric acid.
- (b). Reactants required for Ostwald process are ammonia and oxygen of air.
- (c). In ostwald process ammonia gas and air are taken in 1:10 ratio.
- (d). Pt gauge is used as a catalyst in ostwald process.
- (e). Oxygen is the oxidizing agent which converts ammonia to nitric acid.
- (f).  $4\text{NH}_3 + 5\text{O}_2 \xrightarrow[800^\circ\text{C}]{\text{Platinum gauge}} 4\text{NO} + 6\text{H}_2\text{O} + \text{Heat}$



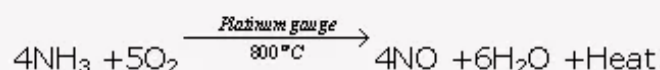
### Solution 6:



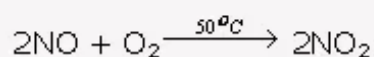
Ostwald process-

The nitric acid is manufactured by Ostwald process. In ostwald process ammonia gas and air are taken in 1:10 ratio. Pt gauge is used as a catalyst in ostwald process. Following steps are involved in Ostwald's process for the manufacture of nitric acid.

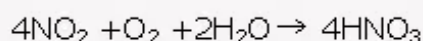
1. Oxidation of ammonia in catalytic chamber.



2. Oxidation of nitric acid in oxidation chamber.



3. Absorption of nitrogen dioxide in water.



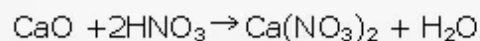
### Solution 7:

- (a) Nitric acid cannot be concentrated beyond 68% by the distillation of a dilute solution of  $\text{HNO}_3$  because it forms an azeotropic mixture i.e. at  $121^\circ\text{C}$  it boils without any change in its concentration of the mixture with water.
- (b) 98 % nitric acid is obtained by distilling 68% nitric acid with conc.  $\text{H}_2\text{SO}_4$  under reduced pressure. The function of  $\text{H}_2\text{SO}_4$  is to absorb water.

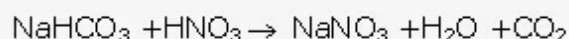
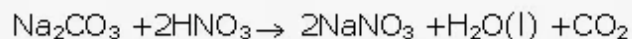
### Solution 8:

Three equations to prove acidic nature of nitric acid are-

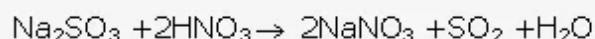
- (a) Reaction with basic oxide-



- (b) Reaction with carbonates and hydrogen carbonates-



- (c) Reaction with metallic sulphites-



### Solution 9:

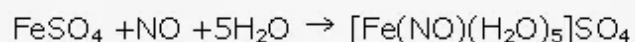
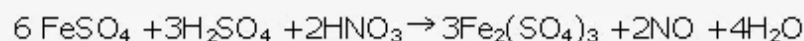
Uses of nitric acid are-

- (i) Nitric acid is used in the purification of silver, gold, platinum etc. because impurities of other metals are dissolved in it.
- (ii) Nitric acid is used as an oxidiser in rocket fuel because it can supply large amount of oxygen.
- (iii) Nitric acid is used in the manufacture of dyes, perfumes, drugs etc. from coal tar products since nitrobenzene is one of the raw materials of it which is manufactured from nitric acid.

### Solution 10:

- (a) Brown ring test-

Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated  $\text{H}_2\text{SO}_4$  is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers.



Hydrated nitrosoferrous

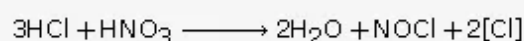
Sulphate(brown ring)

- (b) Freshly prepared ferrous sulphate solution is used in the ring test otherwise Ferrous sulphate undergoes aerial oxidation and converts to ferric sulphate
- (c) If the test tube is disturbed brown ring will disappear because the complex formed will get dissolved in the layers of the liquid.

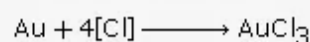
### Solution 11:

- (a) In laboratory preparation of nitric acid all the apparatus including cork should be made up of glass because nitric acid vapours are highly corrosive in nature and corrodes cork, rubber etc.
- (b) Commercial nitric acid is yellow in colour because of presence of nitrogen dioxide but when it is diluted with water, it turns colourless because nitrogen dioxide get dissolved in water.
- (c) Aluminum does not react with nitric acid of any concentration because of the formation of extremely thin, unreactive, protective layer of insoluble metallic oxide on the surface of aluminium which stops further reaction.
- (d) Concentrated nitric acid renders iron passive because of the formation of extremely thin, unreactive, protective layer of insoluble metallic oxide on the surface which stops further reaction.
- (e) Nitric acid is used in the purification of gold because impurities of other metals are dissolved in it.

(f)



Gold in Aqua regia:



Platinum in Aqua regia:



- (g) Nitric acid usually do not yield hydrogen gas with metals, instead it reacts with metals and form respective nitrates , nitric oxide and water.
- (h) Lightning is a blessing as it is the natural source of synthesis of nitric acid.
- (i) Concentrated nitric acid is brown in colour due to the presence of nitrogen dioxide formed by heating the acid.
- (j) Concentrated nitric acid is a stronger oxidizing agent due to nascent oxygen which it gives on decomposition.



(Conc.)                                      nascent oxygen



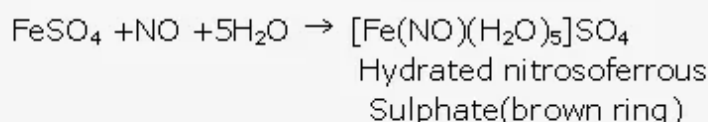
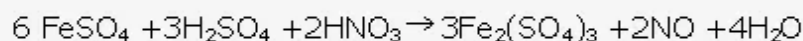
(Dilute)                                      nascent oxygen

### Solution 12:

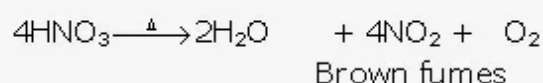
Two tests for nitric acid are-

(i) Brown ring test-

Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated  $\text{H}_2\text{SO}_4$  is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers.

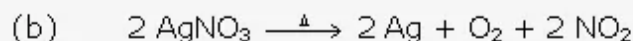
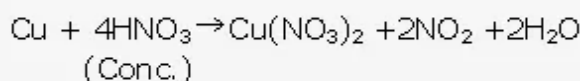


(ii) Nitric acid on heating gives brown fumes of nitrogen dioxide.



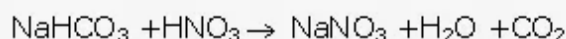
### Solution 13:

(a) Action of concentrated nitric acid on copper-

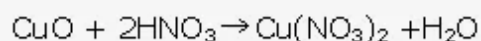


### Solution 14:

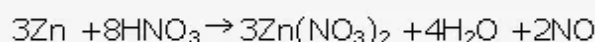
(a) When sodium hydrogen carbonate is added to nitric acid, formation of sodium nitrate, water and carbon dioxide will occur.



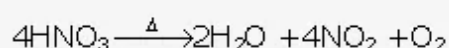
(b) When cupric oxide reacts with nitric acid formation of copper nitrate and water will occur.



(c) When zinc reacts with dilute nitric acid formation of zinc nitrate, water and nitric oxide will occur.



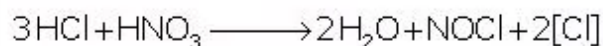
(d) When concentrated nitric acid is heated formation of nitrogen dioxide will occur-





**Solution 15:**

Aqua –regia is a mixture of Conc. Nitric acid and conc. Hydrochloric acid in 1:3.

**Solution 16:**

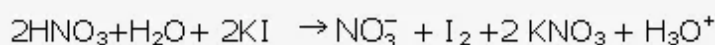
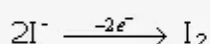
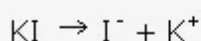
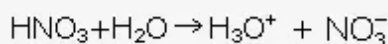
- (i) Reddish brown fumes of nitrogen dioxide are observed
- (ii) When hydrogen sulphide is bubbled through conc.  $\text{HNO}_3$  formation of sulphur, nitric oxide and water will occur.  
$$3\text{H}_2\text{S} + 2\text{HNO}_3 \rightarrow 3\text{S} + 2\text{NO} + 4\text{H}_2\text{O}$$
- (iii) When conc.  $\text{HNO}_3$  drops on the skin of a person it reacts with the protein of the skin and forms a yellow compound called xanthoproteic acid, hence skin becomes yellow. Excess of conc.  $\text{HNO}_3$  causes blisters on the skin and is highly corrosive.
- (iv) When scrap zinc is heated with conc.  $\text{HNO}_3$  formation of zinc nitrate, water and nitrogen dioxide will occur.  
$$\text{Zn} + 4\text{HNO}_3 \rightarrow \text{Zn}(\text{NO}_3)_2 + 2\text{H}_2\text{O} + 2\text{NO}_2$$

**Solution 17:**

- (a) When sulphur is added to hot and conc.  $\text{HNO}_3$  formation of oxide or oxy-acid will occur.



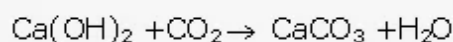
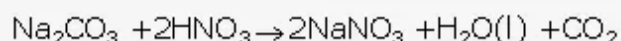
- (b) Nitric acid act as oxidizing agent and oxidizes iodide to iodine.



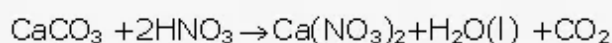
- (c) Nitric acid ionizes in water to form free hydronium ions and nitrate ions.



- (d) When nitric acid is added to washing soda carbon dioxide will form which when passed through a freshly prepared lime water, turns lime water milky.



- (e) When limestone reacts with nitric acid-

**PAGE NO : 218****Solution 18:**

- (i)  $\text{C} + 4\text{HNO}_3 \longrightarrow 2\text{H}_2\text{O} + 4\text{NO}_2 + \text{CO}_2$
- (ii)  $3\text{SO}_2 + 2\text{HNO}_3 + 2\text{H}_2\text{O} \longrightarrow 3\text{H}_2\text{SO}_4 + 2\text{NO}$
- (iii)  $3\text{Fe} + 8\text{HNO}_3 \text{ (conc.)} \longrightarrow 3\text{Fe(NO)}_3 + 4\text{H}_2\text{O} + 2\text{NO}$
- (iv)  $\text{FeSO}_4 + \text{NO} + 5\text{H}_2\text{O} \longrightarrow [\text{Fe(NO)(H}_2\text{O)}_5]\text{SO}_4$
- (v)  $\text{Pt} + \text{HNO}_3 + \text{HCl} \longrightarrow \text{PtCl}_4$
- (vi)  $2\text{HNO}_3 + 6\text{FeSO}_4 + 3\text{H}_2\text{SO}_4 \longrightarrow 3\text{Fe}_2(\text{SO}_4)_3 + 2\text{NO} + 4\text{H}_2\text{O}$



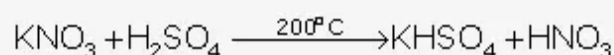
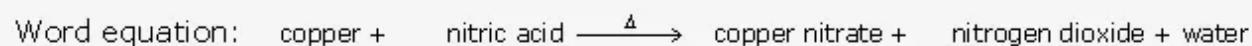
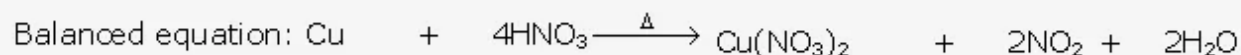
**Solution 19:**

Dilute nitric acid	Dilute hydrochloric acid
1. On reacting copper metal with nitric acid brown fumes of nitrogen dioxide. $\text{Cu} + 4\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$	1. On treating copper metal with HCl  We don't observe any reaction.
2. Brown ring test: Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated $\text{H}_2\text{SO}_4$ is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers. $6\text{FeSO}_4 + 3\text{H}_2\text{SO}_4 + 2\text{HNO}_3 \rightarrow 3\text{Fe}_2(\text{SO}_4)_3 + 2\text{NO} + 4\text{H}_2\text{O}$ $\text{FeSO}_4 + \text{NO} + 5\text{H}_2\text{O} \rightarrow [\text{Fe}(\text{NO})(\text{H}_2\text{O})_5]\text{SO}_4$ <p style="text-align: center;">Hydrated nitrosoferrous Sulphate(brown ring)</p>	2. No brown ring test is observed in the case of hydrochloric acid.

**Solution 1991-1:**

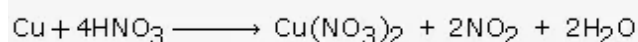
Gold will dissolve only in aqua regia i.e., a mixture of conc. hydrochloric acid and conc. nitric acid in 1:3 but copper will dissolve in nitric acid.

To separate gold from a mixture of gold and platinum add some nitric acid to the mixture, gold will remain undissolved hence can be filtered.

**Solution 1991-2:****Solution 1991-3:****Solution 1992-1:**

In the laboratory preparation of nitric acid, the mixture of concentrated sulphuric acid and sodium nitrate should not be heated very strongly, above  $200^\circ\text{C}$  because a higher temperature can cause following problems:

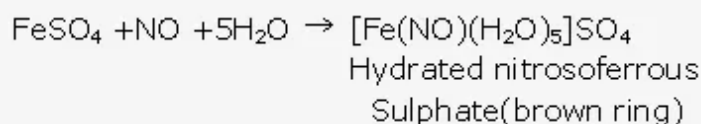
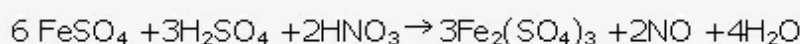
1. Nitric acid would decompose to form nitrogen dioxide.
2. Sodium sulphate is formed which may stick to the glass and cannot be removed easily
3. The glass apparatus may break.

**Solution 1992-2:****Solution 1992-3:**

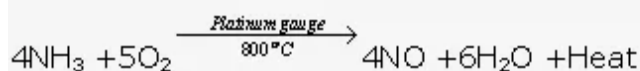
Commercial nitric acid is yellow in colour because of presence of nitrogen dioxide but when it is diluted with water, it turns colourless because nitrogen dioxide gets dissolved in water.

Brown ring test can be used to test nitric acid:

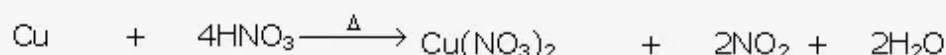
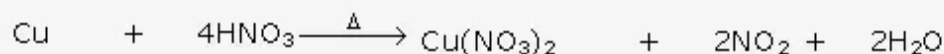
Brown ring test: Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated  $\text{H}_2\text{SO}_4$  is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers.

**Solution 1992-4:**

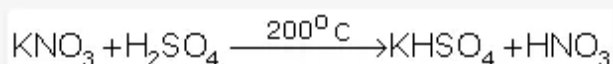
Oxidation of ammonia in catalytic chamber.

**Solution 1994-1:**

Copper is heated with nitric acid, they react together to produce nitrogen dioxide.

**Solution 1994-2:****Solution 1994-3:**

The nitric acid is manufactured by Ostwald process. In ostwald process ammonia gas and air are taken in 1:10 ratio. Temperature is maintained at  $800^\circ\text{C}$  I the catalytic chamber, as the reaction is exothermic so the heat evolved maintains the temperature in the catalytic chamber.

**Solution 1994-4:**

**Solution 1995-1:**

During a thunderstorm, the rainwater contains nitric acid. The nitric acid is formed as a result of three chemical reactions which is described as follows:

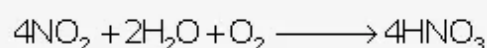
1. During lightning discharge , nitrogen in atmosphere combines with oxygen to form nitric oxide.



2. Nitric oxide is further oxidized to nitrogen dioxide.



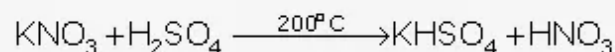
3. Nitrogen dioxide dissolves in moisture or rain water to form nitric acid.

**Solution 1997-1:**

Lead nitrate is a soluble salt . On heating lead nitrate the following reaction occurs:



Preparation of nitric acid from potassium nitrate:



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**Solution 1998-1:****Solution 1999-1:**

When concentrated nitric acid is added to copper brown fumes of nitrogen dioxide are observed.

**Solution 2000-1:**

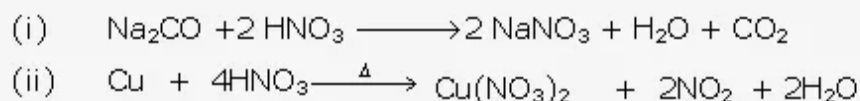
When concentrated nitric acid is added to copper brown fumes of nitrogen dioxide are observed.

**Solution 2001-1:**

1. Nitrogen dioxide
2. Ammonia gas

**Solution 2001-2:**

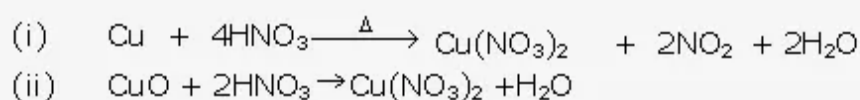
- (i) concentrated  
(ii)  $\text{S} + 6\text{HNO}_3 \rightarrow \text{H}_2\text{SO}_4 + 2\text{H}_2\text{O} + 6\text{NO}_2$

**Solution 2001-3:****Solution 2002-1:**

For laboratory preparation of nitric acid potassium nitrate or sodium nitrate and conc. Sulphuric acid is required.

**Solution 2002-2:**

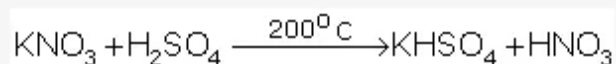
Yellowish brown colour of nitric acid is due to the presence of nitrogen dioxide formed due to thermal decomposition of nitric acid.

**Solution 2002-3:****Solution 2002-4:**

Platinum glaze is used as catalyst in the manufacture for nitric acid

**Solution 2003-1:**

The apparatus used is made up of glass as nitric acid is highly corrosive in nature.

**Solution 2003-2:****Solution 2005-1:****Solution 2005-2:**

- (i) Dilute nitric acid is generally considered to be a typical acid except for its reaction with metals, nitric acid did not evolve hydrogen gas on reacting with any metal, other than manganese and magnesium.
- (ii)  $\text{Cu} + 4\text{HNO}_3 \xrightarrow{\Delta} \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$
- (iii) In a glass apparatus nitric acid gets decomposed by sunlight. Yellowish brown colour of nitric acid is due to the presence of nitrogen dioxide formed due to thermal decomposition of nitric acid.

**Solution 2006-1:**

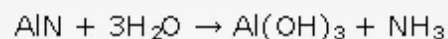
- (i) Nitric acid is highly corrosive in nature and corrodes cork, rubber, etc.
- (ii) Nitric acid ionizes in water to form free hydronium ions and nitrate ions. This shows that nitric acid is acidic in nature.

**Solution 2007-1:**

- (i) A =sulphuric acid, B=potassium nitrate , C= nitric acid
- (ii)  $4\text{HNO}_3 \longrightarrow 4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2$
- (iii)  $\text{Cu} + 4\text{HNO}_3 \xrightarrow{\Delta} \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$

**Solution 2007-2:**

If nitric acid is kept in a bottle for long time then it will become brown in colour.

**Solution 2008-1:****Solution 2008-2:**

Name of process	Inputs	Catalyst	Equation for catalysed reaction	Output
Haber Process	Hydrogen +	Iron	$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \xrightleftharpoons{\text{Fe, Al}_2\text{O}_3} 2\text{NH}_3(\text{g})$	Ammonia
Ostwald process	Ammonia + Air	Platinum	$\begin{array}{l} 4\text{NH}_3 + 5\text{O}_2 \\ \xrightarrow[\text{+Heat}]{\text{Platinum gauge, } 800^\circ\text{C}} 4\text{NO} + 6\text{H}_2\text{O} \end{array}$	Nitric acid

**Solution 2009-1:**

oxygen gas is evolved on heating sodium nitrate.