

12. Nitrogen and sulfur

12.1 Nitrogen and sulfur

Paper 2

Question Paper

- 1** Nitrogen and phosphorus are elements in Group 15 of the Periodic Table.
- (a)** Nitrogen is found in inorganic compounds such as nitrogen oxides (NO_x), nitrates and nitric acid.
- (i)** Identify **one** natural and **one** man-made occurrence of nitrogen oxides in the atmosphere.
- natural
- man-made [2]
- (ii)** Write an equation to describe the role of NO_2 in the direct formation of acid rain.
- [1]
- (iii)** Peroxyacetyl nitrate, PAN, is a component of photochemical smog.
- Describe how PAN forms from NO_2 .
-
- [1]
- (iv)** Nitric acid reacts with basic oxides to form nitrates.
- Write an equation for the reaction of nitric acid with calcium oxide.
- [1]
- (v)** Describe what is seen when solid calcium nitrate is heated strongly.
- [1]

2 (b) When petrol is burned in an internal combustion engine, oxides of nitrogen are released into the atmosphere. Oxides of nitrogen are responsible for the formation of acid rain.

(i) Suggest the conditions required for the production of oxides of nitrogen during combustion of **M** in an internal combustion engine. Use an appropriate equation in your answer.

.....

 [2]

(ii) Describe how acid rain is formed in the atmosphere in the presence of oxides of nitrogen and SO₂. Identify the role of the oxides of nitrogen in this process. Include **all** relevant equations.

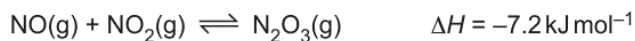
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 [3]

(iii) State **one** other type of air pollution that is caused by the production of oxides of nitrogen in an internal combustion engine.

..... [1]

3 NO and NO₂ react at 25 °C to give N₂O₃ as shown in the equation.



The reaction is reversible and reaches equilibrium in a closed system.

(d) Identify one natural process and one man-made process that cause the formation of atmospheric NO and NO₂.

natural process

man-made process

[2]

(e) NO_2 is a brown gas that can be used to form nitric acid.

(i) NO_2 is a free radical.

Define free radical.

..... [1]

(ii) NO_2 has a catalytic role in the oxidation of atmospheric sulfur dioxide.

Write equations to show the catalytic role of NO_2 in this oxidation.

.....
 [2]

(iii) State **one** environmental consequence of the oxidation of atmospheric sulfur dioxide.

..... [1]

4 Phosphoric(V) acid, H_3PO_4 , is used in both inorganic and organic reactions.

(a) H_3PO_4 is made in a two-step process from phosphorus.

step 1 Phosphorus reacts with an excess of oxygen to form a white solid.

step 2 The white solid then reacts with water to form H_3PO_4 .

(i) Write an equation for each step.

step 1

step 2 [2]

5 Nitrogen molecules, $N_2(g)$, contain two atoms attracted to each other by a triple covalent bond.

(b) Nitrogen oxides, NO_2 and NO , are produced in internal combustion engines. Release of these gases into the atmosphere leads to the formation of photochemical smog.

(i) Outline how nitrogen oxides are involved in the formation of photochemical smog.

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 [2]

(ii) Construct an equation to demonstrate how a catalytic converter reduces the amount of nitrogen oxide gases released into the atmosphere.

..... [1]

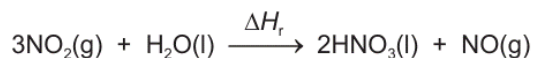
(c) $N_2(g)$ is very unreactive. It is difficult to make ammonia, $NH_3(g)$, directly from its elements but it can be made from $NH_4Cl(s)$.

Identify a reagent and the conditions required to make $NH_3(g)$ from $NH_4Cl(s)$.

..... [1]

6 Nitric acid, HNO_3 , can be made by reacting nitrogen dioxide with water.

The enthalpy change for the reaction can be measured indirectly using a Hess' cycle.



Nitrogen oxides can be formed naturally in the Earth's atmosphere from nitrogen and oxygen in the air.

(d) State **one** way that nitrogen oxides are produced naturally.

..... [1]

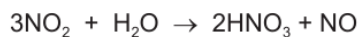
7 Nitric acid can be made in a 3-stage process.

Stage 1 Ammonia is oxidised by oxygen from the air, to form nitrogen monoxide and water. This reaction is carried out at 10–13 atmospheres pressure and 900 °C in the presence of a platinum catalyst.

Stage 2 Nitrogen monoxide reacts with more oxygen to form nitrogen dioxide.



Stage 3 Nitrogen dioxide reacts with water to make nitric acid and nitrogen monoxide.



(a) Write an equation to show the reaction occurring in stage 1.

..... [1]

(d) The release of nitrogen monoxide into the atmosphere causes atmospheric pollution.

State and explain the effect of nitrogen monoxide gas in contact with moist air.

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

(f) State **one** use of ammonium nitrate.

..... [1]