بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ

Quran Education Point

QuranEducationPoint.Com

Class	10th	Chapter	07
Subject	Chemistry	Board	Federal

Chapter 7: Nitrogen, Sulphur and Metals

1. Multiple Choice Questions (MCQs)

i. What is a key component of photochemical smog formed by the reaction of NO and NO_2 with unburned hydrocarbons?

a) Sulfuric acid b) Peroxyacetyl nitrate (PAN) c) Carbon monoxide d) Ozone

- **Correct Answer: b) Peroxyacetyl nitrate (PAN)**
- **Concept:** Photochemical smog is formed when nitrogen oxides (NO_x) react with volatile unburned hydrocarbons in the presence of sunlight, generating powerful secondary pollutants like Peroxyacetyl nitrate (PAN) and ground-level ozone (O_3).

ii. Which of the following is the balanced equation for the production of ammonia in the Haber process?

a) $N_{2(g)} + H_{2(g)} \rightleftharpoons NH_{3(g)}$ b) $N_{2(g)} + 2H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ c) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ d) $2N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

- **Correct Answer: c)** $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
- **Concept:** One mole of nitrogen gas reacts reversibly with three moles of hydrogen gas to produce two moles of ammonia gas.

iii. What are the sources of hydrogen and nitrogen in the Haber process?

a) Water and air b) Methane and air c) Methane and water d) Water and methane

- **Correct Answer: b) Methane and air**
- **Concept:** Nitrogen is obtained by fractional distillation of liquid **air**, while hydrogen is obtained by steam reforming of natural gas (**methane**, CH_4).

iv. Which catalyst is used in the Haber process?

a) Platinum b) Vanadium(V) oxide c) Iron d) Nickel

- **Correct Answer: c) Iron** (Finely divided iron with Al_2O_3/K_2O promoters)
- **Concept:** Finely divided iron serves as a heterogeneous catalyst to speed up the reversible formation of ammonia without affecting equilibrium yield.

v. At what temperature is the Haber process typically conducted?

a) 300°C b) 450°C c) 600°C d) 200°C

- **Correct Answer: b)** 450°C
- **Concept:** 450°C represents an optimal compromise temperature balancing a reasonable rate of reaction with an acceptable equilibrium yield (since the forward reaction is exothermic).

vi. What is the symbol equation for the conversion of sulphur dioxide to sulphur trioxide in the Contact process?

a) $SO_{2(g)} + O_{2(g)} \rightleftharpoons SO_{3(g)}$ b) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ c) $SO_{2(g)} + 2O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ d) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons SO_{3(g)}$

- **Correct Answer: b)** $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$
- **Concept:** Two moles of sulfur dioxide react reversibly with one mole of oxygen to yield two moles of sulfur trioxide.

vii. Which catalyst is used in the Contact process for the conversion of SO_2 to SO_3?

a) Iron b) Vanadium(V) oxide c) Platinum d) Nickel

- **Correct Answer: b) Vanadium(V) oxide** (V_2O_5)
- **Concept:** Vanadium(V) oxide (V_2O_5) acts as an efficient catalyst at 450°C for oxidation of SO_2 to SO_3.

viii. What are the sources of sulphur dioxide in the Contact process?

a) Burning sulphur or roasting sulphide ores b) Burning methane c) Electrolysis of water d) Combustion of natural gas

- **Correct Answer: a) Burning sulphur or roasting sulphide ores**
- **Concept:** SO_2 is produced directly by burning elemental sulfur ($S + O_2 \rightarrow SO_2$) or roasting sulfide minerals such as zinc blende (ZnS) or iron pyrites (FeS_2) in air.

ix. How do atmospheric oxides react with acids and bases?

(Note: Question contains a typographical context in text where "amphoteric oxides" is meant)

a) Forming a salt and water b) Forming an acid and a gas c) Forming a base and hydrogen d) Forming a salt and hydrogen

- **Correct Answer: a) Forming a salt and water**
- **Concept:** Amphoteric (and basic/acidic neutralization) oxides react with both acids and bases to produce salt and water.

x. Which of the following oxides is amphoteric?

a) SO_2 b) CO_2 c) CuO d) Al_2O_3

- **Correct Answer: d)** Al_2O_3
- **Concept:** Aluminum oxide (Al_2O_3) exhibits both basic and acidic properties, reacting with both acids and strong bases to form salts. SO_2 and CO_2 are acidic oxides, while CuO is a basic oxide.

2. Short Answer Questions

i. What is peroxyacetyl nitrate (PAN) and how is it formed?

- **Definition:** Peroxyacetyl nitrate ($CH_3COOONO_2$, abbreviated as **PAN**) is a toxic, eye-irritating secondary pollutant found in photochemical smog.
- **Formation:** It is formed in the atmosphere when nitrogen oxides (NO_x) emitted from vehicle exhausts react with volatile unburned hydrocarbons in the presence of ultraviolet (UV) light from sunlight.

ii. Describe the role of NO and NO_2 in the formation of acid rain.

- **Mechanism:**
  1. Nitrogen monoxide (NO) produced at high combustion temperatures in engine cylinders oxidizes in air to form nitrogen dioxide (NO_2):

$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

  2. NO_2 dissolves in rainwater and atmospheric moisture in the presence of oxygen to form nitric acid (HNO_3) and nitrous acid (HNO_2):

$$4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4HNO_{3(aq)}$$

  3. This nitric acid lowers rainwater pH below 5.6, resulting in acid rain.

iii. Write the balanced equation for the production of ammonia in the Haber process.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad (\Delta H = -92 \text{ kJ/mol})$$

نوٹس حاصل کرنے کے لیے QuranEducationPoint.com لکھ کر سرچ کریں۔

iv. What are the typical conditions (temperature, pressure, catalyst) for the Haber process?

- **Temperature:** 450°C
- **Pressure:** 200 atm (or 20 MPa)
- **Catalyst:** Finely divided Iron (Fe) with aluminum oxide (Al_2O_3) promoter

v. How is sulphur dioxide produced for the Contact process?

- **Production Methods:**
    1. By directly burning molten sulfur in air:

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

    2. By roasting metal sulfide ores (such as zinc blende, ZnS) in excess oxygen:

$$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)}$$

vi. State the balanced chemical equation for the conversion of sulphur dioxide to sulphur trioxide.

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad (\Delta H = -197 \text{ kJ/mol})$$

vii. Describe the role of vanadium(V) oxide in the Contact process.

- **Role:** Vanadium(V) oxide (V_2O_5) serves as a catalyst that speeds up the reversible reaction between SO_2 and O_2 without altering the position of equilibrium. It functions by temporarily transferring oxygen to SO_2 (reducing to V_2O_4) and then being re-oxidized by atmospheric oxygen back to V_2O_5.

viii. What are acidic oxides? Give two examples.

- **Definition:** Acidic oxides are non-metal oxides that react with water to form acidic solutions and neutralize bases to form salt and water.
- **Examples:**
    1. Carbon dioxide (CO_2)
    2. Sulfur dioxide (SO_2)

ix. What are basic oxides? Give two examples.

- **Definition:** Basic oxides are metal oxides that react with acids to form salt and water. When soluble in water, they form basic (alkaline) solutions.
- **Examples:**
    1. Sodium oxide (Na_2O)

نوٹس حاصل کرنے کے لیے QuranEducationPoint.com لکھ کر سرچ کریں۔

2. Calcium oxide (CaO)

x. What is meant by amphoteric oxides? Provide examples.

- **Definition:** Amphoteric oxides are oxides that display both acidic and basic chemical behavior, meaning they can react with both acids and strong bases to produce salt and water.
- **Examples:**
    1. Aluminum oxide (Al_2O_3)
    2. Zinc oxide (ZnO)

xi. Evaluate the environmental impact of acidic oxides like SO_2 and CO_2.

- **Sulfur Dioxide (SO_2):** Causes major acid rain, causing acidification of lakes (killing aquatic life), leaching essential nutrients from soils, damaging forest leaves, and corroding limestone structures and metal bridges. It also causes respiratory distress in humans.
- **Carbon Dioxide (CO_2):** Acts as a greenhouse gas that traps infrared radiation in the atmosphere, leading to global warming, ocean acidification, climate change, and polar ice melting.

xii. Evaluate the significance of controlling the emission of oxides like NO_2 and SO_2 in industrial processes.

- **Significance:** Controlling these emissions is essential to:
    1. **Prevent Acid Rain:** Protect terrestrial ecosystems, crops, and aquatic habitats from dangerous pH drops.
    2. **Reduce Photochemical Smog:** Prevent formation of harmful secondary pollutants like PAN and tropospheric ozone.
    3. **Protect Human Health:** Minimize chronic respiratory diseases like asthma, bronchitis, and lung irritation.
    4. **Preserve Infrastructure:** Prevent costly acid-induced corrosion of buildings, monuments, and metallic infrastructure.

نوٹس حاصل کرنے کے لیے QuranEducationPoint.com لکھ کر سرچ کریں۔

3. Long Answer Questions

i. Explain the environmental impact of nitrogen oxides in the atmosphere, particularly focusing on photochemical smog and acid rain.

- **Source:** Nitrogen oxides (NO_x, primarily NO and NO_2) are generated in internal combustion engines and power plants when atmospheric nitrogen and oxygen combine at extremely high temperatures.
- **1. Photochemical Smog:**
    - In the presence of ultraviolet radiation from sunlight, NO_2 photodecomposes into NO and reactive oxygen atoms (O).
    - These atomic oxygen species combine with molecular oxygen to form tropospheric ozone (O_3).
    - Ozone and NO_x react further with unburned hydrocarbons from exhaust fumes to yield **Peroxyacetyl nitrate (PAN)**.
    - *Impact:* Photochemical smog causes severe eye irritation, reduced visibility, respiratory damage, and crop degradation.
- **2. Acid Rain:**
    - NO_2 reacts with oxygen and atmospheric water droplets:

$$4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4HNO_{3(aq)}$$

    - Dissolved nitric acid lowers rain pH.
    - *Impact:* Causes lake acidification, leaf damage on vegetation, and corrosion of building materials.

ii. Discuss the Haber process, including the chemical reaction, sources of reactants, conditions required, and its significance in the production of ammonia.

- **Chemical Reaction:**

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad (\Delta H = -92 \text{ kJ/mol})$$

- **Sources of Reactants:**
    - **Nitrogen (N_2):** Extracted from air via fractional distillation of liquid air.
    - **Hydrogen (H_2):** Obtained via steam methane reforming ($CH_4 + H_2O \rightarrow CO + 3H_2$).
- **Industrial Conditions:**

نوٹس حاصل کرنے کے لیے QuranEducationPoint.com لکھ کر سرچ کریں۔

- **Temperature (**450°C**):** Since the forward reaction is exothermic, lower temperatures favor higher yield. However, 450°C provides an optimal balance between reaction rate and yield.
- **Pressure (**200 atm**):** High pressure shifts equilibrium to the right (fewer gas moles), increasing ammonia yield and rate.
- **Catalyst (Iron):** Increases rate of reaching equilibrium without affecting yield.

- **Significance:** Ammonia is a vital precursor for producing synthetic nitrogenous fertilizers (e.g., urea, ammonium nitrate) essential for global agriculture, as well as nitric acid, explosives, and industrial cleaners.

iii. Describe the Contact process for sulphuric acid production, detailing the chemical reactions involved, the sources of reactants, and the industrial conditions used.

- **Sources of Reactants:**
  - **Sulfur (**S**):** Obtained from underground deposits or extracted from natural gas/petroleum.
  - **Oxygen (**O_2**):** Supplied from atmospheric air.
- **Process Steps & Reactions:**
  1. **Stage 1: Combustion of Sulfur:**

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

  2. **Stage 2: Catalytic Oxidation of** SO_2 **to** SO_3**:**

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad (\Delta H = -197 \text{ kJ/mol})$$

     - *Conditions:* $450°C$, $1 - 2$ atm pressure, and Vanadium(V) oxide (V_2O_5) catalyst.

  3. **Stage 3: Absorption of** SO_3**:**SO_3 is dissolved in concentrated H_2SO_4 to form **oleum** ($H_2S_2O_7$) (direct addition to water is violently exothermic and forms uncontrollable acid mist):

$$SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$$

  4. **Stage 4: Dilution:** Oleum is safely mixed with water to produce concentrated sulfuric acid:

$$H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$$

iv. Compare and contrast acidic, basic, and amphoteric oxides with suitable examples for each type.

Parameter	Acidic Oxides	Basic Oxides	Amphoteric Oxides
Origin	Non-metals	Metals	Selected Metals
Reaction with Acids	No reaction	Forms Salt + Water	Forms Salt + Water
Reaction with Bases	Forms Salt + Water	No reaction	Forms Salt + Water
Effect on Water	Forms acidic solutions	Forms basic solutions (if soluble)	Insoluble in water
Examples	CO_2, SO_2, SO_3, NO_2	Na_2O,CaO,CuO,MgO	Al_2O_3,ZnO,PbO

v. How do industrial processes like the Haber and Contact processes contribute to environmental pollution, and what measures can be taken to minimize their impact?

- **Environmental Contributions:**
  - **Haber Process:** High energy required for methane reforming releases CO_2 (greenhouse gas). Runoff of synthetic nitrogen fertilizers causes **eutrophication** in water bodies.
  - **Contact Process:** Unconverted SO_2 gas leakage directly promotes **acid rain** and localized air pollution.
- **Mitigation Measures:**
  - **Flue Gas Desulfurization (FGD):** Scrubbing tail gases with wet limestone ($CaCO_3$) or lime (CaO) to trap leftover SO_2 before release.
  - **Double Absorption Systems:** Using Double Contact Double Absorption (DCDA) plants to increase $SO_2 \rightarrow SO_3$ conversion efficiency up to $> 99.8\%$.
  - **Green Hydrogen:** Producing hydrogen via renewable water electrolysis instead of steam methane reforming to lower CO_2 footprint.

vi. Compare the roles of NO and NO_2 in the formation of acid rain. How do their chemical behaviours contribute to both direct acid formation and the oxidation of sulphur dioxide?

- **Direct Acid Formation:**
    - NO oxidizes in air to NO_2: $2NO + O_2 \rightarrow 2NO_2$.
    - NO_2 directly reacts with atmospheric water vapor and oxygen to form nitric acid (HNO_3).
- **Catalytic Oxidation of SO_2:**
    - Nitrogen oxides act as atmospheric catalysts to speed up the conversion of SO_2 into SO_3:

$$SO_{2(g)} + NO_{2(g)} \rightarrow SO_{3(g)} + NO_{(g)}$$

    - NO then reacts with atmospheric oxygen to regenerate NO_2:

$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

    - The formed SO_3 dissolves in cloud water to form sulfuric acid (H_2SO_4), accelerating acid rain formation.

vii. Analyse the classification of oxides. Why are oxides like SO_2 considered acidic, while oxides like CuO are considered basic? Discuss how the metallic or non-metallic character of the element influences this classification.

- **Influence of Element Character:**
    - **Non-metals (SO_2):** Non-metal atoms have high electronegativities and hold electrons tightly. Their covalent bonds with oxygen produce oxides that react with water to form excess H^+ ions ($SO_2 + H_2O \rightarrow H_2SO_3$). Hence, SO_2 is classified as an **acidic oxide**.
    - **Metals (CuO):** Metals have low electronegativities and readily donate electrons to oxygen, forming ionic lattice compounds containing oxide ions (O^{2-}). The O^{2-} ion acts as a strong Lewis base that accepts protons from acids ($CuO + 2H^+ \rightarrow Cu^{2+} + H_2O$). Hence, CuO is classified as a **basic oxide**.

QuranEducationPoint.Com

THINK TANK

1. Explain why gold and platinum are often used in jewellery despite their high cost.

- **Explanation:** Gold and platinum lie at the very bottom of the reactivity series (noble metals). They are extremely unreactive and resistant to chemical attack by air, water, oxygen, and atmospheric pollutants. Consequently, they do not tarnish, corrode, or rust over time, maintaining their lustrous appearance permanently.

2. If a new metal was discovered and found to react with steam but not cold water, where would you place it in the reactivity series? Justify your placement.

- **Placement:** Positioned **below Calcium/Magnesium** (which react with cold water) and **above Iron/Lead** (which do not react rapidly with steam), alongside metals like **Aluminum** and **Zinc**.
- **Justification:** Reacting with steam ($H_2O_{(g)}$) requires higher thermal energy to kickstart electron transfer compared to cold water, indicating an intermediate reactivity level in displacing hydrogen from water molecules.

3. Give the expected reactivity series from the following data for the following three metals. Justify your placement.

- **Data Summary:**
  - **Metal A:** Reacts slowly with cold water, vigorously with steam, quickly with dilute acid.
  - **Metal B:** No reaction with cold water or steam; reacts slowly with dilute acid.
  - **Metal C:** No reaction with cold water, steam, or dilute acid.
- **Reactivity Order: Metal A > Metal B > Metal C**
- **Justification:**
  1. **Metal A** is the most reactive because it is strong enough to displace hydrogen from cold water.
  2. **Metal B** is moderately reactive; it cannot react with water/steam but can displace hydrogen from dilute acid.
  3. **Metal C** is the least reactive (noble metal behavior) as it cannot displace hydrogen even from dilute acids.

4. How can the knowledge of basic oxides, such as CaO, be applied to neutralize acidic pollutants in industrial wastewater treatment?

نوٹس حاصل کرنے کے لیے QuranEducationPoint.com لکھ کر سرچ کریں۔

- **Application:** Acidic industrial wastewater (containing excess H^+ ions like H_2SO_4 or HCl) can be treated by adding controlled amounts of calcium oxide (CaO, quicklime) or calcium hydroxide ($Ca(OH)_2$, slaked lime).
- **Reaction:** $CaO_{(s)} + 2H^+_{(aq)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(l)}$. This neutralizes harmful acidity, raising wastewater pH to neutral levels (6.5–8.5) before safe discharge into water bodies.

5. Evaluate the choice of 450°C and 200 atm for the Haber process.

- **Choice of** 450°C**:** The reaction ($N_2 + 3H_2 \rightleftharpoons 2NH_3$) is exothermic. According to Le Chatelier's Principle, lower temperatures yield higher percentage conversion to NH_3. However, lower temperatures drastically slow down the reaction rate. 450°C is a compromised temperature providing an optimal speed of reaction with a high enough conversion rate when paired with an iron catalyst.
- **Choice of** 200 atm**:** Converting 4 reactant gas moles into 2 product gas moles means higher pressure shifts equilibrium to the right, dramatically increasing both yield and rate. 200 atm is chosen because operating at higher pressures requires extremely expensive reinforced equipment and safety infrastructure.

6. Evaluate the environmental impact of acidic oxides.

- **Impact Summary:** Acidic oxides (SO_2, NO_2, CO_2) are primary drivers of global environmental degradation:
    - **Acid Deposition:** SO_2 and NO_2 cause acid rain, destroying aquatic ecosystems, leaching soil minerals (Mg^{2+}, Ca^{2+}), and dissolving structural stonework.
    - **Global Warming:** Atmospheric CO_2 buildup intensifies the greenhouse effect, raising global surface temperatures and altering weather patterns.

7. Evaluate the significance of controlling the emission of oxides like NO_2 and SO_2 in industrial processes.

- **Significance:** Industrial abatement (e.g., catalytic converters, flue gas scrubbers) is vital to halt environmental degradation. Controlling emissions prevents:
    - Acidification of freshwater reservoirs and loss of biodiversity.
    - Urban photochemical smog and hazardous breathing conditions for populations.
    - Million-dollar structural maintenance costs caused by acid corrosion.

نوٹس حاصل کرنے کے لیے QuranEducationPoint.com لکھ کر سرچ کریں۔