

Nitrogen & Sulfur

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Nitrogen & Sulfur
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: 78 minutes

Score: /65

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 Ammonium sulfate is a fertiliser which is manufactured by the reaction between ammonia and sulfuric acid.

(a) Ammonia is described as a weak base and sulfuric acid as a strong acid.

By using an equation, explain clearly what is meant by the term *weak base*.

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

(b) Ammonia and sulfuric acid are both manufactured by processes which involve chemical equilibria.

(i) Sulfuric acid is produced from sulfur trioxide which is made by the Contact process.

State **three** important operating conditions for the Contact process for the manufacture of sulfur trioxide.

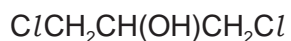
For **each** of your conditions, you should avoid the use of vague phrases such as 'high temperature'.

condition 1
.....
condition 2
.....
condition 3
.....

(ii) How is the sulfur trioxide produced converted into sulfuric acid?

.....
..... [4]

- (c) Chloropropanols such as 1,3-dichloropropan-2-ol (1,3-DCP) are present in some foods.



1,3-DCP

- (i) What will be produced when 1,3-DCP is reacted separately with the following reagents under suitable conditions?
In each case give the **structural** formula.

concentrated sulfuric acid

an excess of ammonia

- (ii) Describe as fully as you can what type of reaction occurs with ammonia.

.....
[4]

[Total: 11]

2 Oxides are compounds which usually contain oxygen combined with one other element.

Oxides are classified as follows.

acidic alkaline amphoteric basic

(a) Using these terms only, complete the table to describe the oxides of the elements of the third period of the Periodic Table sodium to sulfur.

Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₂	Cl ₂ O ₇
						acidic

[4]

(b) Give the names of **two** elements from sodium to chlorine which form more than one oxide.

..... and

[1]

(c) Sodium reacts with water.

(i) Describe, as fully as you can, what you would see when a piece of sodium is reacted with water.

.....

(ii) Write an equation for the reaction of sodium with water.

.....

[4]

(d) Sulfur dioxide is present in small, but significant, amounts in the Earth's atmosphere.

(i) State **one** way by which sulfur dioxide enters the atmosphere.

.....

(ii) Give the formula of another sulfur compound which is formed in the atmosphere from sulfur dioxide.

.....

(iii) What are the environmental consequences of the compound you have identified in (ii)?

.....

[3]

(e) Sulfur dioxide is used as a food preservative.

What property of sulfur dioxide enables it to act in this way?

..... [1]

(f) Another sulfur compound which is present in the Earth's atmosphere is carbonyl sulfide, OCS. The sequence of atoms in the molecule is oxygen-carbon-sulfur and the molecule is **not** cyclic.

(i) Draw a 'dot-and-cross' diagram of the OCS molecule.
Show outer electrons only.

(ii) Suggest a value for the O–C–S bond angle.

.....

[2]

[Total: 15]

- 3 Nitrogen makes up about 79% of the Earth’s atmosphere. As a constituent element of proteins, it is present in living organisms.

Atmospheric nitrogen is used in the Haber process for the manufacture of ammonia.

- (a) Write an equation for the formation of ammonia in the Haber process.

.....[1]

- (b) The Haber process is usually carried out at a high pressure of between 60 and 200 atmospheres (between 60×10^5 Pa and 200×10^5 Pa).
State **two further** important operating conditions that are used in the Haber process.
For **each** of your conditions, explain why it is used.

condition 1

reason

condition 2

reason[4]

- (c) State **one** large-scale use for ammonia, other than in the production of nitrogenous fertilisers.

.....[1]

- (d) The uncontrolled use of nitrogenous fertilisers can cause environmental damage to lakes and streams. This is known as ‘eutrophication’.

What are the processes that occur when excessive amounts of nitrogenous fertilisers get into lakes and streams?

.....

.....

.....[2]

In many countries, new cars have to comply with regulations which are intended to reduce the pollutants coming from their internal combustion engines.

Two pollutants that may be formed in an internal combustion engine are carbon monoxide, CO, and nitrogen monoxide, NO.

(e) (i) Outline how **each** of these pollutants may be formed in an internal combustion engine.

CO

.....

NO

.....

(ii) State the main hazard associated with **each** of these pollutants.

CO

NO [4]

Pollutants such as CO and NO are removed from the exhaust gases of internal combustion engines by catalytic converters which are placed in the exhaust system of a car.

(f) (i) What metal is most commonly used as the catalyst in a catalytic converter?

.....

(ii) Construct **one** balanced equation for the reaction in which **both** CO **and** NO are removed from the exhaust gases by a catalytic converter.

..... [2]

[Total: 14]

- 4 Sulfur and its compounds are found in volcanoes, in organic matter and in minerals. Sulfuric acid, an important industrial chemical, is manufactured from sulfur by the Contact process.

The Contact process may be considered to be a three-stage process in which sulfur is converted into sulfuric acid. Each stage consists of a single chemical reaction.

- (a) Write a balanced equation for **each** of these reactions **in the correct sequence**. Where appropriate, use \rightleftharpoons to indicate that the reaction is an equilibrium.

first reaction

second reaction

third reaction [4]

- (b) Give **three** different operating conditions that are used in the **second** stage.

condition 1

condition 2

condition 3 [3]

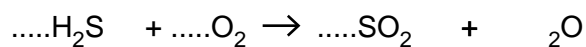
- (c) State **one** large scale use of sulfuric acid.

..... [1]

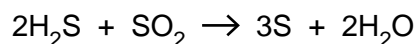
- (d) Most of the sulfur that is used in the Contact process is recovered from sulfur compounds present in crude oil and natural gas by using the Claus process.

- (i) In this process, about one third of the hydrogen sulfide, H_2S , present in the oil or gas, is converted into sulfur dioxide, SO_2 .

Balance the equation for this reaction.



- (ii) The SO_2 formed is then reacted catalytically with the remaining H_2S , producing sulfur and water.



What are the oxidation numbers of each of the sulfur-containing substances in this reaction?

H_2S SO_2 S

Which substance is reduced? Explain your answer.

substance

explanation [3]

The sulfur present in crude oil is removed in order to prevent the formation of sulfur dioxide when fuels such as petrol (gasoline) or diesel fuel are burned in internal combustion engines.

Other substances that may be present in the exhaust gases of motor vehicles include CO , CO_2 , NO/NO_2 , and unburnt hydrocarbons.

The emission of sulfur dioxide can produce ‘acid rain’.

- (e) (i) Outline, with the aid of equations, how acid rain is formed from the exhaust gases of motor vehicles.

.....
.....
.....
.....

- (ii) State **one** environmental effect of acid rain.

..... [4]

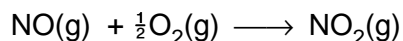
- (f) Sulfur dioxide is used to preserve dried fruits and vegetables.

What chemical property of SO_2 enables it to be used as a food preservative?

..... [1]

[Total: 16]

- 5 The oxidation of nitrogen monoxide occurs readily according to the following equation.



The following table shows how the initial rate of this reaction depends on the concentrations of the two reactants.

[NO] / mol dm ⁻³	[O ₂] / mol dm ⁻³	initial rate / mol dm ⁻³ s ⁻¹
0.0050	0.0050	0.02
0.0050	0.0075	0.03
0.010	0.0075	0.12

- (a) (i) Use the data to determine the order of reaction with respect to each of the reagents.

order with respect to NO

order with respect to O₂

- (ii) Write the rate equation for the reaction, and use it to calculate a value for the rate constant, *k*, stating its units.

rate equation

numerical value of *k* =

units of *k*

- (iii) Use your rate equation in (ii) to calculate the rate of reaction when [NO] = [O₂] = 0.0025 mol dm⁻³.

rate of reaction =

[6]

(b) Nitrogen monoxide plays an important catalytic role in the oxidation of atmospheric SO_2 in the formation of acid rain.

(i) State the type of catalysis shown in this process.

.....

(ii) Explain the steps involved in this process by writing equations for the reactions that occur.

.....

.....

.....

[3]

[Total: 9]