12. Nitrogen and sulfur

12.1 Nitrogen and sulfur

Paper 1

Question Paper

1 A reaction between two gases takes place on the surface of the catalytic converter of a petrol-engined car.

In this reaction, four reactant molecules produce three product molecules.

What could be the two reactant gases in this reaction?

A nitrogen and carbon dioxide

B nitrogen monoxide and carbon dioxide

C nitrogen monoxide and carbon monoxide

D nitrogen dioxide and carbon monoxide

2 Which statement is correct?

A An ammonium ion is basic due to a lone pair of electrons on the nitrogen atom.

B Nitrogen monoxide, NO, reacts with peroxyacetyl nitrate to produce a component of photochemical smog.

C Nitrogen dioxide catalyses the oxidation of atmospheric sulfur dioxide.

D Nitrogen is very unreactive due to the very strong permanent dipole–permanent dipole attractions between the nitrogen atoms.

3 Compound L decomposes on heating. One of the products is gas M.

M reacts with unburned hydrocarbons to form peroxyacetyl nitrate, PAN.

What could be the formula of L?

A $CaNO_3$ **B** $Ca(NO_3)_2$ **C** $MgCO_3$ **D** $Mg(CO_3)_2$

4 7.5 g of nitrogen monoxide reacts with 7.0 g of carbon monoxide on the surface of the catalytic converter in the exhaust system of a car.

What is the total volume of the product gases measured at room conditions?

A 3.0 dm^3 **B** 6.0 dm^3 **C** 9.0 dm^3 **D** 12.0 dm^3

5 Three statements about ammonia molecules and ammonium ions are given.

1 In aqueous solution, ammonia molecules form coordinate bonds with hydroxide ions.

2 Ammonium ions are Brønsted–Lowry acids.

3 The H–N–H bond angle is larger in the ammonium ion than in the ammonia molecule.

Which statements are correct?

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

6 Nitrogen dioxide is a gas that contributes to air pollution. It is produced in internal combustion engines.

Which statement is correct?

A Nitrogen dioxide acts as a catalyst in the atmospheric oxidation of sulfur dioxide to sulfur trioxide.

B Nitrogen dioxide reacts to form nitrogen monoxide in the catalytic converter of a car exhaust system.

C PAN forms when nitrogen dioxide reacts with the gases formed by complete combustion of the fuel.

D Under high pressure in an internal combustion engine, nitrogen dioxide forms from impurities in the fuel.

7 Which statement describes a property of an ammonium ion?

A An aqueous ammonium ion is a weak Brønsted–Lowry base.

B Aqueous ammonium sulfate reacts with dilute hydrochloric acid to make ammonia gas.

C An ammonium ion has a pyramidal shape with an H–N–H bond angle of 107°.

D The four N–H covalent bonds in an ammonium ion are identical to each other.

8 Catalytic converters are fitted in the exhaust systems of many cars.

Gas X:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter.

What is gas X?

A carbon dioxide

B carbon monoxide

C hydrocarbon vapour

D nitrogen dioxide

9 If ammonium cyanate is heated in the absence of air, the only product of the reaction is urea, $CO(NH_2)_2$. No other products are formed in the reaction.

What is the formula of the cyanate ion present in ammonium cyanate?

A CON_2^- **B** CON_2^{2-} **C** OCN^- **D** OCN^{2-}

10 Which emission from an internal combustion engine contributes to the erosion of marble statues?

A carbon monoxide

B nitrogen

C nitrogen dioxide

D unburnt hydrocarbons

11 J dissolves in water to give an aqueous solution K.

K gives a dense white precipitate when aqueous silver nitrate is added.

When heated with aqueous potassium hydroxide, K gives off a gas that turns moist universal indicator paper blue.

What is J?

A ammonium chloride

B ammonium sulfate

C sodium chloride

D sodium hydroxide

12 Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, NH_4NO_3, are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of wet neutral soil.

Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

13 The equation shows a reaction that occurs between carbon monoxide and nitrogen monoxide in a catalytic converter.

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

Which statement is correct?

A The catalyst used is finely divided iron.

B The reaction prevents greenhouse gas emissions into the atmosphere.

C The reaction reduces the possibility of the formation of photochemical smog.

D The reaction results in increased ozone depletion.

14 Which statement about ammonia or the ammonium ion is correct?

A Ammonia gas is produced when an aqueous solution containing the ammonium ion is reacted with a strong acid.

B Silver iodide is soluble in a concentrated aqueous solution of ammonia.

C The ammonium ion has the same number of electrons as a methane molecule.

D The square planar ammonium ion contains a dative covalent bond.

15 Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.

Which reaction shows how the catalyst is reformed?

A $N_2 + 2O_2 \rightleftharpoons 2NO_2$

B $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

C $N_2 + O_2 \rightarrow 2NO$

D $NO + \frac{1}{2}O_2 \rightarrow NO_2$

16 R is a solid. R fizzes when hydrochloric acid is added.

R reacts with hot aqueous sodium hydroxide, giving off a gas which turns red litmus blue.

What is the formula of R?

A NH_4CO_3 **B** $(NH_4)_2CO_3$ **C** $(NH_4)_2HCO_3$ **D** $(NH_4)_2SO_4$

17 Photochemical smog is a type of air pollution produced in urban areas by the effect of sunlight on substances released from vehicle exhausts.

Which mixture of primary pollutants leads to the formation of photochemical smog?

A carbon dioxide and water vapour

B carbon monoxide and unburnt hydrocarbons

C nitrogen oxide and unburnt hydrocarbons

D sulfur dioxide and water vapour

18 A student reacts 1 mol of copper with concentrated nitric acid to produce 1 mol of copper(II) nitrate, 2 mol of water and substance X. No other product is formed.

Substance X does not contain copper or hydrogen.

What could be substance X?

A N_2 **B** N_2O **C** NO **D** NO_2

19 In a catalytic converter, 5.6 g of carbon monoxide react with an excess of nitrogen monoxide.

What is produced in this reaction?

A 2.4 g of C and 6.0 g of NO_2

B 2.4 g of C and 9.2 g of NO_2

C 8.8 g of CO_2 and 1.4 g of N_2

D 8.8 g of CO_2 and 2.8 g of N_2

20 Carbon monoxide, CO, nitrogen dioxide, NO_2, and sulfur dioxide, SO_2, are all atmospheric pollutants.

Which reaction occurs in the atmosphere?

A CO is spontaneously oxidised to CO_2.

B NO_2 is reduced to NO by SO_2.

C NO_2 is reduced to NO by CO.

D SO_2 is oxidised to SO_3 by CO_2.

21 A catalytic converter reduces the amount of pollutants in the fumes from a car exhaust.

Which row identifies a pollutant and shows how it is removed by the action of the catalyst?

	pollutant	chemical removal
A	carbon dioxide	reduced to carbon
B	carbon monoxide	oxidised to carbon dioxide
C	oxides of nitrogen	oxidised to nitric acid
D	unburnt hydrocarbons	oxidised to carbon dioxide and hydrogen

22 The table describes two possible environmental consequences of adding too much ammonium nitrate fertiliser to the soil.

Which row is correct?

	increased plant growth in rivers	photochemical smog
A	✗	✗
B	✓	✗
C	✗	✓
D	✓	✓

23 NO and NO_2 are both present in the lower atmosphere as pollutants.

The reaction sequence shows the production of ozone from oxygen in the lower atmosphere.

This sequence repeats many times.

$$NO_2(g) \rightarrow NO(g) + O(g)$$

$$NO(g) + \tfrac{1}{2}O_2(g) \rightarrow NO_2(g)$$

$$O_2(g) + O(g) \rightarrow O_3(g)$$

Which statement about this reaction sequence is correct?

A NO is acting as a catalyst, but NO_2 is not acting as a catalyst.

B NO_2 is acting as a catalyst, but NO is not acting as a catalyst.

C Neither NO nor NO_2 are acting as catalysts.

D Both NO and NO_2 are acting as catalysts.

24 Oxides of nitrogen are present in the environment due to natural and man-made sources.

Which row is correct?

	natural source of nitrogen oxides	man-made source of nitrogen oxides
A	electrical discharges in the atmosphere	internal combustion engines
B	electrical discharges in the atmosphere	as a by-product of the Haber process
C	decomposition of dead plants in rivers	internal combustion engines
D	decomposition of dead plants in rivers	as a by-product of the Haber process

25 The gaseous products of heating a mixture of $Ca(OH)_2$ and NH_4Cl are passed through solid CaO. A single gaseous product, W, is collected.

A sample of W reacts with $Cl_2(g)$ to produce two gases, X and Y.

X is an element. Y is acidic.

Y reacts with W to produce Z.

What are X and Z?

	X	Z
A	N_2	$CaCl_2$
B	N_2	NH_4Cl
C	O_2	$CaCl_2$
D	O_2	NH_4Cl

26 Acid rain is a dilute solution of sulfuric acid.

Which pollutant also contributes to the formation of acid rain?

A carbon monoxide

B carbon dioxide

C nitrogen dioxide

D hydrocarbons

27 What is an environmental consequence of the uncontrolled use of nitrate fertilisers?

A acid rain

B low oxygen levels in streams

C ozone depletion

D the greenhouse effect

28 Ammonia gas, NH_3, and hydrogen sulfide gas, H_2S, react together to form the salt ammonium sulfide, $(NH_4)_2S$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.

$$(NH_4)_2S(aq) \rightleftharpoons NH_3(aq) + NH_4SH(aq)$$

The addition of NaOH(aq) to this solution produces a gas, X.
The addition of HCl(aq) to a separate portion of this solution produces a gas, Y.

X and Y could represent different gases or identical gases.

What are the identities of X and Y?

	X	Y
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	NH_3

29 Sulfur dioxide, SO_2, reacts with calcium hydroxide in aqueous solution.

What is the main product that is first formed?

A $Ca(HSO_4)_2$ **B** CaS **C** $CaSO_3$ **D** $CaSO_4$

30 A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. An excess of aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

An excess of concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.

Which statement about X or Y is correct?

A X is a pure white colour.

B X is pure silver iodide.

C Y is pure silver chloride.

D Y is yellow.

31 Catalytic converters are fitted in the exhaust systems of many cars.

Which gas:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter?

A carbon dioxide

B carbon monoxide

C hydrocarbon vapour

D nitrogen dioxide

32 Which emission from an internal combustion engine contributes to the erosion of marble statues?

A carbon monoxide

B nitrogen

C nitrogen dioxide

D unburnt hydrocarbons

33 At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as CH_3 in the catalytic converter of a motor vehicle.

$$4CH_3 + 7NO_2 \rightarrow 3\tfrac{1}{2}N_2 + 4CO_2 + 6H_2O$$

Which row gives the energy change for this reaction and a possible reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO_2 and H_2O have negative $\Delta H_f^\ominus$ values
D	exothermic	double bonds are broken in NO_2

34 Which statement is correct?

A Ammonia reacts with alkalis to form the ammonium ion.

B Ammonium chloride contains ionic, covalent and co-ordinate bonds.

C The ammonium ion reacts with acids to produce ammonia.

D The bond angle in the ammonium ion is approximately 107°.

35 Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, NH_4NO_3, are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of wet neutral soil.

Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

36 Which reaction gives a product that is an atmospheric pollutant causing acid rain?

A $3Mg(s) + SO_2(g) \rightarrow MgS(s) + 2MgO(s)$

B $(NH_4)_2SO_4(s) + Ca(OH)_2(s) \rightarrow 2NH_3(g) + CaSO_4(s) + 2H_2O(l)$

C $2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \rightarrow 2Mn^{2+}(aq) + 4H^+(aq) + 5SO_4^{2-}(aq)$

D $2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$

37 The product of the Contact process is Z.

Which reaction or process leads to the formation of a gas that can neutralise an aqueous solution of Z?

A atmospheric lightning

B combustion of fuel in an internal combustion engine

C the Haber process

D thermal decomposition of Group 2 nitrates

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D	decomposition of dead plants in rivers	as a by-product of the Haber process

39 Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.

Which reaction shows the regeneration of the catalyst?

A $N_2 + 2O_2 \rightleftharpoons 2NO_2$

B $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

C $N_2 + O_2 \rightarrow 2NO$

D $NO + \frac{1}{2}O_2 \rightarrow NO_2$