Paper 3

Questions are applicable for both core and extended candidates

1 A list of substances is shown.

brass
calcium oxide
carbon monoxide
diamond
glucose
hydrogen
litmus
magnesium bromide
methyl orange
sodium chloride
stainless steel
thymolphthalein
water
zinc oxide

Answer the following questions about these substances.
Each substance may be used once, more than once or not at all.

State which substance:

(d) is a reactant in photosynthesis

..... [1]

2 Sulfur is an element in Group VI of the Periodic Table.

(e) Sulfur dioxide is formed when sulfur burns in air.

(i) State the percentage of oxygen in clean, dry air.

..... [1]

(ii) State **one** source of the pollutant sulfur dioxide in the air other than from burning sulfur.

..... [1]

(iii) State **one** adverse effect of sulfur dioxide in the air.

..... [1]

(iv) State **one** method of reducing the emissions of sulfur dioxide.

..... [1]

(v) Sulfur dioxide dissolves in water to form sulfurous acid.

Give the formula of the ion that is present in all aqueous acids.

..... [1]

(vi) Sulfur dioxide reacts with oxygen in the presence of a catalyst to form sulfur trioxide. This is a reversible reaction.

Complete the equation for this reaction by writing the sign for a reversible reaction in the box.

$2SO_2 + O_2$ ☐ $2SO_3$ [1]

3 A list of symbols and formulae is shown.

Br_2
CH_4
C_2H_4
Cl^-
CO_2
Cr^{3+}
Cu^{2+}
H_2
K^+
N_2
N^{3-}
O_2
SO_4^{2-}

Answer the following questions about these symbols and formulae.
Each symbol or formula may be used once, more than once or not at all.

State which symbol or formula represents:

(f) a product of photosynthesis.

..... [1]

4 This question is about compounds of nitrogen.

(a) Complete the dot-and-cross diagram in Fig. 3.1 of a molecule of ammonia.

Show outer shell electrons only.

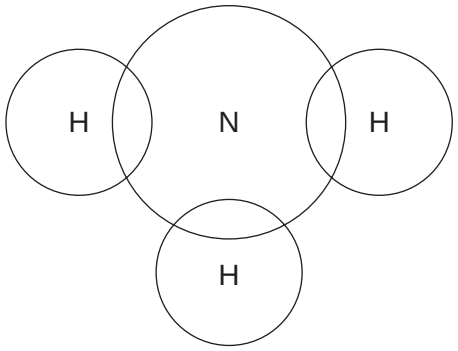


Fig. 3.1

[2]

(b) Oxides of nitrogen are air pollutants.

(i) State **one** source of oxides of nitrogen in the air.

..... [1]

(ii) State **one** adverse effect of oxides of nitrogen.

..... [1]

(c) State whether nitrogen dioxide is an acidic or basic oxide.

Give a reason for your answer.

.....

..... [1]

[Total: 5]

5 Fig. 1.1 shows part of the Periodic Table.

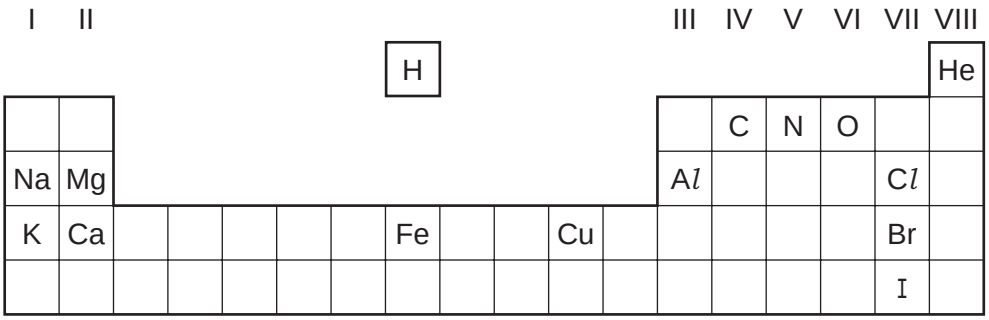


Fig. 1.1

Answer the following questions using only the elements in Fig. 1.1.
Each symbol of the element may be used once, more than once or not at all.

Give the symbol of the element that:

(a) forms 78% by volume of clean, dry air

..... [1]

6 **(a)** Water from natural sources contains dissolved gases.

Choose from the list, the gas that is essential for aquatic life.
Draw a circle around your chosen answer.

argon **hydrogen** **nitrogen** **oxygen** [1]

(b) Polluted water may contain harmful substances such as metal compounds, plastics, nitrates and phosphates.

(i) Name one **other** harmful substance which is present in polluted water.

..... [1]

(ii) State why nitrates are harmful to aquatic life.

..... [1]

7 This question is about nitrogen and compounds of nitrogen.

(a) Nitrogen is a non-metal. Nitrogen is a poor electrical conductor.

Describe two **other** physical properties which are typical of non-metals.

1 .....

2 .....
[2]

(b) Oxides of nitrogen are air pollutants which contribute to acid rain.

(i) State **one** source of oxides of nitrogen in the air.

..... [1]

(ii) State one **other** adverse effect of oxides of nitrogen.

..... [1]

8 A list of substances is shown.

ammonium nitrate
carbon monoxide
copper(II) chloride
ethane
ethene
litmus
methane
methyl orange
sodium chloride
sodium sulfate
sulfur dioxide
thymolphthalein

Answer the following questions using only the substances from the list.
Each substance may be used once, more than once or not at all.

Give the name of the substance that:

(d) is a waste gas from digestion in animals

..... [1]

9 **(a)** Table 3.1 shows the average concentrations, in ng / 1000 cm^3, of air pollutants in four different years.

Table 3.1

year	concentration of air pollutant in ng / 1000 cm^3				
	ammonia	hydrocarbons	oxides of nitrogen	particulates	sulfur dioxide
2019	10.6	12.0	15.3	30.1	20.5
2020	11.2	13.0	21.6	28.2	20.0
2021	14.3	15.2	23.5	26.5	25.0
2022	15.5	9.0	14.0	25.2	18.2

(i) Name the pollutant that has the lowest concentration in 2019.

..... [1]

(ii) Name the pollutant that shows a continuous decrease in concentration from 2019 to 2022.

..... [1]

(iii) Calculate the average mass, in ng, of sulfur dioxide in a 250 cm^3 sample of polluted air in 2020.

mass = ... ng [1]

(b) **(i)** State **one** source of sulfur dioxide in the atmosphere.

..... [1]

(ii) State **one** adverse effect of sulfur dioxide in the atmosphere.

..... [1]

(iii) Choose the compound used to remove sulfur dioxide in flue gas desulfurisation.

Tick (✓) **one** box.

aluminium chloride	☐
calcium oxide	☐
methane	☐
sulfuric acid	☐

[1]

10 Aqueous sodium hydroxide is a base.

(e) Bacteria in the soil convert ammonium compounds to oxides of nitrogen.
The oxides of nitrogen escape into the atmosphere.

(i) State one **other** source of oxides of nitrogen in the atmosphere.

..... [1]

(ii) Oxides of nitrogen contribute to photochemical smog.

Describe one **other** adverse effect of oxides of nitrogen on the environment.

..... [1]

11 Hydrogen is a fuel which can be obtained from water by electrolysis.

(c) Refinery gas contains methane.

Methane is a gas which is responsible for climate change.

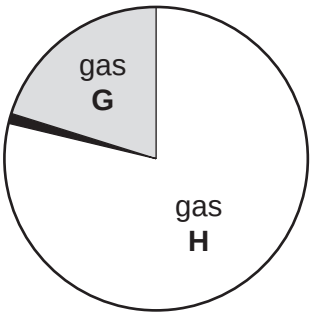
State **two** strategies to reduce the amount of methane entering the atmosphere.

1 .....

2 .....
[2]

12 This question is about air.

(a) The pie chart shows the proportions of the main gases in clean, dry air.

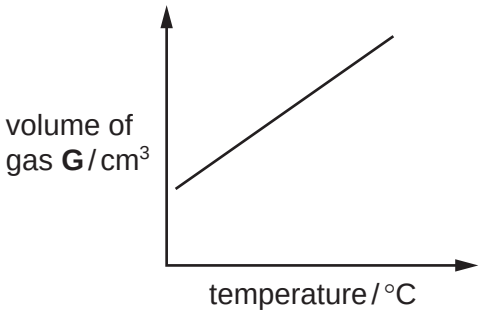


(i) Name the gases **G** and **H**.

gas **G** .....

gas **H** .....
[2]

(ii) The graph shows how the volume of a sample of gas **G** changes as temperature increases. The pressure is kept constant.



Describe how the volume of gas **G** changes as temperature increases.

..... [1]

(iii) There is a small percentage of noble gases in the air.
The noble gases are unreactive.

Explain why the noble gases are unreactive in terms of their electronic structure.

.....

..... [1]

(iv) Describe the arrangement and separation of the particles in a gas.

arrangement .....

separation .....
[2]

(b) Two of the pollutants in air are oxides of nitrogen and lead compounds.

(i) Give **one** effect of each of these pollutants on health.

oxides of nitrogen .....

lead compounds .....
[2]

(ii) Name **two** other pollutants present in air.

State the source of each of these pollutants.

pollutant 1 .....

source of pollutant 1 .....

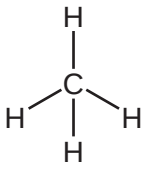
pollutant 2 .....

source of pollutant 2 .....
[4]

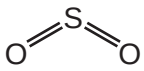
[Total: 12]

13 The structures of seven compounds, **A**, **B**, **C**, **D**, **E**, **F** and **G**, are shown.

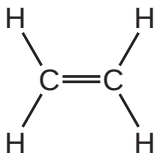
A



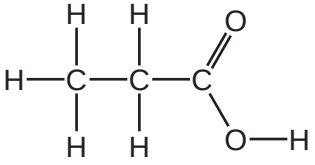
B



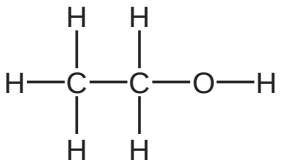
C



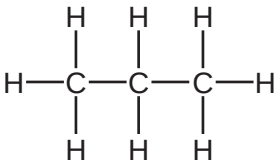
D



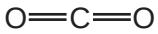
E



F



G



Answer the following questions about these structures.
Each structure may be used once, more than once or not at all.

(a) State which structure, **A**, **B**, **C**, **D**, **E**, **F** or **G**, represents:

(i) a compound that contributes to acid rain

..... [1]

(ii) a product of respiration

..... [1]

14 This question is about compounds of nitrogen.

(d) Bacteria in the soil can convert ammonium ions into oxides of nitrogen.

(i) Give one **other** source of oxides of nitrogen in the air.

..... [1]

(ii) State **one** adverse effect of oxides of nitrogen on health.

..... [1]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

15 This question is about gases found in clean, dry air and gases found in polluted air.

(a) Name **one** gas found in clean, dry air which contributes to global warming.

..... [1]

(b) State the percentage of nitrogen in clean, dry air.

..... [1]

(c) Name the substance used to remove sulfur dioxide in flue gas desulfurisation.

..... [1]

(d) Nitrogen dioxide, NO_2, is formed in car engines.

Name the equipment in a car exhaust used to remove the NO_2 formed in car engines.

..... [1]

(e) All gases diffuse.

(i) Choose from the list of formulae the gas which diffuses most quickly.

Draw a circle around your answer.

CO **CO_2** **CH_4** **NO_2** **SO_2**

[1]

(ii) Explain your answer to **(i)**.

..... [1]

(f) State **one** adverse effect of carbon monoxide on human health.

..... [1]

(g) Carbon dioxide, CO_2, is a reactant in photosynthesis.

Name the **two** products of photosynthesis.

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

16 Some symbol equations and word equations, **A** to **J**, are shown.

A $Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3$

B $H^+ + OH^- \rightarrow H_2O$

C ethane + chlorine → chloroethane + hydrogen chloride

D $C_{12}H_{26} \rightarrow C_8H_{18} + C_4H_8$

E ethene + steam → ethanol

F chlorine + aqueous potassium iodide → iodine + aqueous potassium chloride

G $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

H ethanoic acid + ethanol → ethyl ethanoate + water

I calcium carbonate → calcium oxide + carbon dioxide

J $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Use the equations to answer the questions that follow.
Each equation may be used once, more than once, or not at all.

Give the letter, **A** to **J**, for the equation that represents: **(extended only)**

(d) photosynthesis ..... [1]

17 **(a)** The symbols of the elements in Period 2 of the Periodic Table are shown.

Li Be B C N O F Ne

Use the symbols of the elements in Period 2 to answer the questions that follow.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

(i) makes up approximately 78% of clean, dry air ..... [1]

18 A list of gases is shown.

ammonia
carbon dioxide
carbon monoxide
ethene
fluorine
oxygen
sulfur dioxide
xenon

Answer the following questions using only the gases from the list.
Each gas may be used once, more than once or not at all.

Give the name of the gas that:

(a) causes acid rain

..... [1]

(b) forms an alkaline solution when dissolved in water

..... [1]

(c) is inert

..... [1]

(d) is a product of photosynthesis

..... [1]

19 Methane reacts with steam to produce hydrogen gas.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +200\,kJ/mol$$

The reaction takes place at 1000 °C and 100 kPa pressure.

(c) Methane is a greenhouse gas which contributes to global warming.

(i) Name a greenhouse gas found in clean, dry air.

..... [1]

(ii) Explain, in terms of thermal energy, how greenhouse gases cause global warming.
(extended only)

.....

.....

.....

.....

..... [3]

20 This question is about the first 30 elements in the Periodic Table.

Name the element which:

(a) is 78% of clean, dry air ..... [1]

21 Nitrogen dioxide, NO_2, is an atmospheric pollutant and is formed in car engines.

(a) Explain how nitrogen dioxide is formed in car engines. **(extended only)**

.....

..... [2]

(b) Nitrogen dioxide causes respiratory problems.

State one **other** adverse effect of nitrogen dioxide.

..... [1]

(c) Nitrogen dioxide emissions can be reduced by adding an aqueous solution of urea, $(NH_2)_2CO$, to car exhaust gases.

The heat of the exhaust gases breaks down the urea into simpler substances.

(i) Name the type of reaction which occurs when a substance is heated and breaks down into simpler substances.

..... [1]

(ii) One molecule of urea breaks down to form one molecule of ammonia and one other molecule.

Complete the chemical equation to show the formula of the other molecule formed in this reaction.

$$(NH_2)_2CO \rightarrow NH_3 + ...$$ [1]

(iii) State the test for ammonia.

test .....

observations .....

[2]

(d) The ammonia formed reacts with nitrogen dioxide to form nitrogen and water.

(i) Balance the equation for this reaction.

$$.....NO_2 + ...NH_3 \rightarrow .....N_2 + 12H_2O$$ [2]

(ii) State how the equation shows that the nitrogen in nitrogen dioxide is reduced.

..... [1]

(iii) This reaction is a redox reaction.

State the meaning of the term *redox*.

..... [1]

(e) 135 moles of urea, $(NH_2)_2CO$, is stored in the tank of a car.

Calculate the mass, in kg, of the stored $(NH_2)_2CO$.

mass of $(NH_2)_2CO$ = ... kg
[2]

(f) Another oxide of nitrogen formed in car engines is nitrogen monoxide, NO. A catalytic converter removes NO by reacting it with a gas formed by incomplete combustion of the fuel. Two non-toxic gases are formed.

(i) Name the gas formed by incomplete combustion of the fuel.

..... [1]

(ii) Name the **two** non-toxic gases formed. **(extended only)**

..... and ..... [1]

[Total: 15]

22 A list of substances is shown.

aluminium oxide	**carbon dioxide**	**chlorine**	**diamond**	**ethanol**
glucose	**iron(III) oxide**	**limestone**	**nitrogen**	**oxygen**

Answer the questions using the list of substances.

Each substance may be used once, more than once or not at all.

State which of the substances:

(a) is a reactant in photosynthesis

..... [1]

(f) is a greenhouse gas

..... [1]

(g) is a gas that is approximately 78% of clean, dry air

..... [1]

23 The names of the elements of Period 2 of the Periodic Table are shown.

lithium beryllium boron carbon nitrogen oxygen fluorine neon

Answer the following questions about these elements.
Each element may be used once, more than once or not at all.

Identify the element which:

(a) is a product of photosynthesis

..... [1]

(b) has an oxide found in clean, dry air

..... [1]

(h) has an oxide responsible for acid rain.

..... [1]