OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY B (SALTERS)

Chemistry of Natural Resources

F332/TEST

Candidates answer on the question paper.

OCR supplied materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Understanding our Changing Atmosphere'* (inserted)

Other materials required:
- Scientific calculator

Thursday 20 January 2011
Afternoon

Duration: 1 hour 45 minutes

F332TEST

OCE/25642

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The inserts will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Answer **all** the questions.
- Do **not** write in the bar codes.

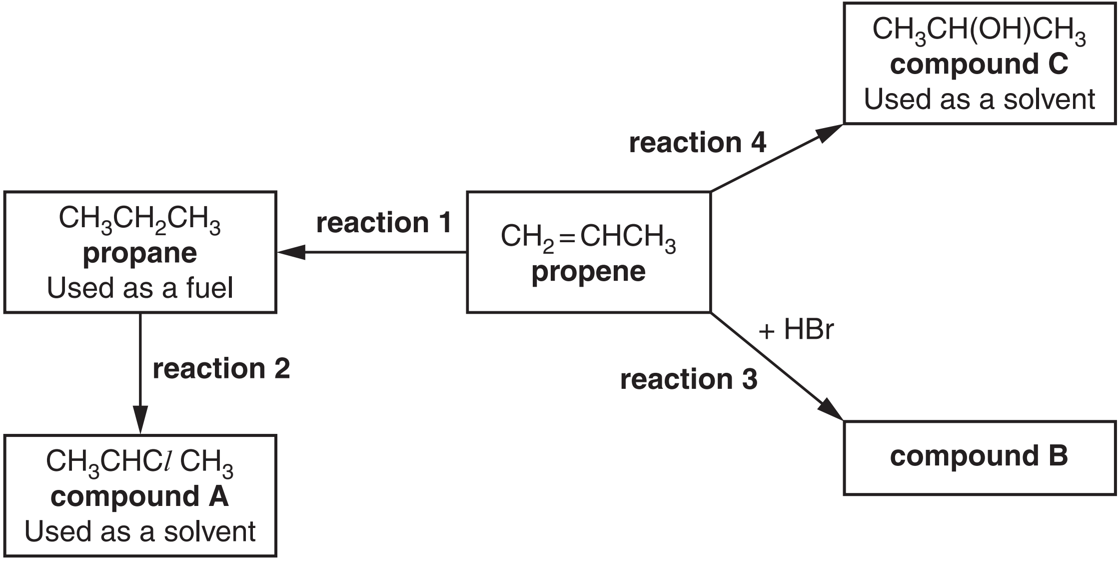
INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- The insert *'Understanding our Changing Atmosphere'* is provided for use with question 5.
- A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **100**.
- This document consists of **16** pages. Any blank pages are indicated.

Turn over

Answer **all** the questions.

1 Propene can be converted into a wide range of chemicals, some of which are shown in the flow chart below.



(a) Name the homologous series that includes propene.

.... **[1]**

(b) Suggest a source for the propene used in industrial processes.

.... **[1]**

(c) It is possible to test propene, to show it is unsaturated, by reacting it with bromine water. Give the colour change of the bromine water during this test.

from .... to ....**[1]**

(d) Underline **two** words that describe the mechanism of both **reaction 3** and **reaction 4**.

addition **electrophilic** **elimination**

nucleophilic **radical** **substitution** **[2]**

(e) **Reaction 4** produces an alcohol.

(i) Classify the alcohol produced in **reaction 4** as primary, secondary or tertiary.

.... **[1]**

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

....

.... **[1]**

(iii) Give the reagents and conditions that would be required when **reaction 4** is carried out in industry.

....

.... **[3]**

(f) Give **two** possible structures for **compound B**.

[2]

(g) Give the reagent and condition required for **reaction 2**.

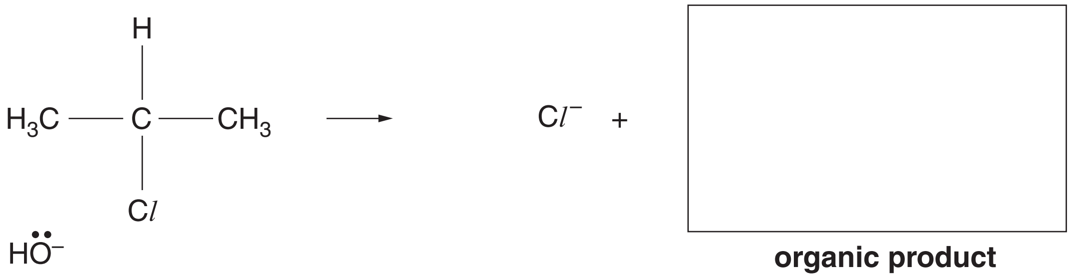
....

....

.... **[2]**

(h) **Compound A** takes part in a substitution reaction with hydroxide ions.

(i) Add 'curly arrows' to the diagram below to show the attack of one hydroxide ion on $CH_3CHClCH_3$ and the resulting electron pair movement within the molecule.



[2]

(ii) Draw, in the box above, the structure of the organic product that forms in the reaction in **(i)**. **[1]**

(iii) Draw a '*dot-and-cross*' diagram to represent the bonding in an hydroxide ion.

[1]

(iv) Explain why the hydroxide ion is classified as a nucleophile in the reaction shown in **(i)**.

....

....

.... **[1]**

[Total: 19]

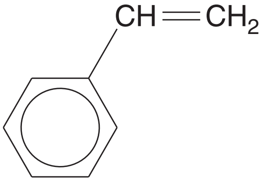
Turn over

2 Scientists have investigated the use of 'expanded' poly(phenylethene) for building houses in countries with cold climates and countries prone to earthquakes. 'Expanded' poly(phenylethene) is an insoluble polymer with a honeycomb structure containing air.

(a) Suggest a property of 'expanded' poly(phenylethene), other than its insolubility, which makes it suitable for building houses in these countries.

.... **[1]**

(b) The poly(phenylethene) monomer has the structure shown below.



phenylethene

Draw the structure of the repeating unit of poly(phenylethene).

[1]

(c) Poly(phenylethene) is a thermoplastic.

Explain the meaning of the term *thermoplastic*.

....

.... **[1]**

(d) The phenylethene monomer is made by passing ethylbenzene vapour over a heated catalyst at a low pressure. **Equation 2.1** represents the reaction that occurs.

$$C_6H_5CH_2CH_3(g) \rightleftharpoons C_6H_5CHCH_2(g) + H_2(g) \quad \Delta H = +117\,kJ\,mol^{-1}$$ **equation 2.1**

Describe and explain the effect of the following changes on the **yield** of phenylethene produced in the equilibrium represented by **equation 2.1**.

(i) Carrying out the reaction at a higher temperature.

In your answer, you should use technical terms, spelled correctly.

....

....

.... **[2]**

(ii) Carrying out the reaction at a higher pressure.

....

....

....

.... **[2]**

(e) The catalyst used in the manufacture of phenylethene is in the form of a finely divided powder.

(i) Explain why the use of a finely divided powder increases the reaction rate.

....

....

.... **[2]**

(ii) Explain how the use of a catalyst increases the reaction rate.

....

....

....

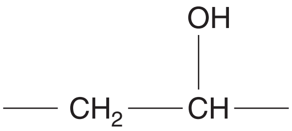
.... **[2]**

(f) Underline the word that best describes the type of reaction to produce phenylethene occurring in **equation 2.1**.

addition **elimination** **reduction** **substitution**

[1]

(g) Poly(phenylethene) is insoluble in water. Other polymers, such as poly(ethenol), can dissolve in water.



$$-CH_2-\overset{\overset{\Large OH}{|}}{CH}-$$

repeating unit of **poly(ethenol)**

Poly(ethenol) forms hydrogen bonds between its chains.

Poly(phenylethene) forms instantaneous dipole–induced dipole bonds between its chains.

- Explain how hydrogen bonds and instantaneous dipole–induced dipole bonds are formed.
- Explain why poly(ethenol) is slightly soluble in water, but poly(phenylethene) is insoluble.

In your answer, you should make it clear how the structure of a polymer links to its solubility in water.

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.... **[7]**

[Total: 19]

3 Some people are advised to reduce the amount of sodium chloride in their diet, as sodium salts can contribute to high blood pressure. One method for making this dietary change is to use a ‘low salt’ alternative, which contains a mixture of sodium and potassium chlorides.

(a) A certain brand of ‘low salt’ contains one third potassium chloride, $\mathrm{KC}l$, and two thirds sodium chloride, $\mathrm{NaC}l$, by mass. Calculate the mole ratio of sodium to potassium in the mixture.

mole ratio Na : K = **1 :** .... **[2]**

(b) A student tests the ‘low salt’ for the presence of chloride ions. A sample of ‘low salt’ is dissolved in water and silver nitrate solution is added. A precipitate forms confirming the presence of chloride ions.

(i) Give the colour of the precipitate that the student would see.

.... **[1]**

(ii) Give the chemical name of the precipitate.

.... **[1]**

(iii) Write an ionic equation for the reaction that takes place to form the precipitate.

→

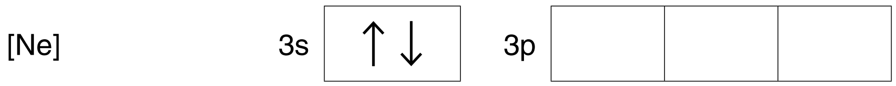
[1]

(c) Potassium chloride can be made by burning potassium in chlorine.

(i) Give the appearance and physical state of chlorine at room temperature.

.... **[1]**

(ii) Complete the diagram below, showing the arrangement of electrons in atomic orbitals for a chlorine atom.



[1]

(d) Potassium atoms become potassium ions during the reaction of potassium with chlorine.

(i) Write the electronic sub-shell arrangement for electrons in an **atom** of potassium.

.... **[1]**

(ii) Write an equation representing the first ionisation enthalpy of potassium.
Include state symbols.

$$\boxed{\quad\quad\quad\quad \rightarrow \quad\quad\quad\quad}$$

[2]

(iii) The first ionisation enthalpy for potassium is less than that for sodium. Explain why.

....

....

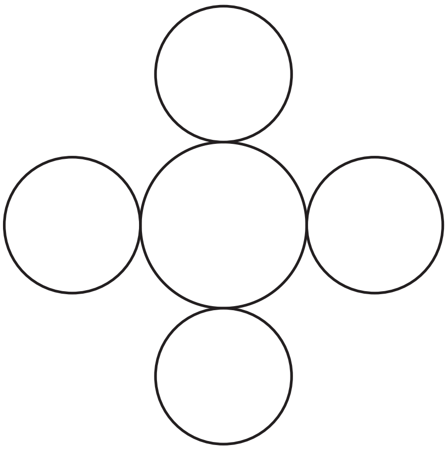
....

....

.... **[2]**

(e) Solid potassium chloride has a lattice structure similar to that of sodium chloride. The diagram below shows part of a layer of the potassium chloride lattice.

Label each type of particle and complete the diagram by drawing in enough particles to show the structure of the **layer** clearly.



[2]

(f) Another method for making potassium chloride is to neutralise a solution of potassium hydroxide with hydrochloric acid. A student carries out a titration to find out how much hydrochloric acid is needed to neutralise a known volume of potassium hydroxide solution using methyl orange as the indicator.

(i) The student measures out exactly 25.0 cm^3 of a 0.100 $mol\,dm^{-3}$ solution of potassium hydroxide using a volumetric pipette.

Calculate the number of moles of potassium hydroxide in the sample.

moles KOH = ...mol **[1]**

(ii) Name a suitable piece of equipment for the student to use to add the hydrochloric acid to the potassium hydroxide solution.

.... **[1]**

(iii) The equation for the reaction between potassium hydroxide and hydrochloric acid is shown in **equation 3.1**.

$$KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$$ **equation 3.1**

State the number of moles of hydrochloric acid that would be needed to react exactly with the amount of potassium hydroxide calculated in **(i)**.

moles = ... mol **[1]**

(iv) The student used 20.10 cm^3 of the acid to neutralise the potassium hydroxide solution. Calculate the concentration of the hydrochloric acid that was used.

Give your answer to **three** significant figures.

concentration = ... $mol\,dm^{-3}$ **[3]**

(g) Two methods for making potassium chloride are shown below.

method 1: $2K(g) + Cl_2(g) \rightarrow 2KCl(s)$

method 2: $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$

(i) State which method has the greater atom economy and explain your answer.

....

.... **[1]**

(ii) Explain why the reaction with the greater atom economy is not the more economical method to use for making potassium chloride.

....

.... **[1]**

(h) Magnesium carbonate can be added to salt to keep it free-flowing. This is because the magnesium and carbonate ions attract water molecules and absorb them into the crystal, where they become bonded to the ions.

(i) Explain the link between the charge on a magnesium ion and the position of magnesium in the Periodic Table.

....

.... **[1]**

(ii) Give the formula of magnesium carbonate.

.... **[1]**

(iii) Minerals such as diamond have a different type of crystal structure.

Describe the structure and bonding of diamond.

....

....

....

.... **[3]**

[Total: 27]

4 The halogenoalkanes CCl_4, CF_3Br and $CBrClF_2$ have been used in fire extinguishers.

(a) Give the systematic name for CF_3Br.

.... **[1]**

(b) Draw a diagram of the shape of a CF_3Br molecule. Give a value for the bond angle.

[2]

(c) When $CBrClF_2$ is exposed to high temperatures in a fire, one of the bonds breaks.

Suggest which bond is most likely to break.

.... **[1]**

(d) When CCl_4 vapour gets into Earth's stratosphere, a C–Cl bond can be broken by UV radiation from the Sun.

(i) Name the **type** of bond breaking that would occur.

.... **[1]**

(ii) The minimum frequency of radiation needed to break one C–Cl bond is 8.67×10^{14} Hz. Calculate the minimum energy, in J, required to break one C–Cl bond.

Planck constant, $h = 6.63 \times 10^{-34}\,\mathrm{J\,Hz^{-1}}$

minimum energy = ... J **[2]**

(iii) Calculate the bond enthalpy of the C–Cl bond, in $\mathrm{kJ\,mol^{-1}}$.

Avogadro constant, $N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$

bond enthalpy = + ... $\mathrm{kJ\,mol^{-1}}$ **[2]**

(e) The production of $CBrClF_2$ has been banned in most countries since 1994, because it contributes to ozone depletion.

Describe the theoretical work and research that led to the discovery of ozone depletion in the stratosphere and how the evidence was originally overlooked.

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.... **[3]**

(f) Some halogenoalkanes also contribute to global warming.

(i) Explain how an increase in the concentration of a greenhouse gas leads to an enhanced greenhouse effect.

....

....

.... **[2]**

(ii) Describe the evidence for the relationship between the increased concentration of greenhouse gases and global warming.

....

....

.... **[1]**

[Total: 15]

5 This question is based on the Advance Notice article **'Understanding our Changing Atmosphere'** which is provided as an insert to this paper.

(a) The article explains that, in the atmosphere, 'hydrocarbons are oxidised as part of a propagating chain'. Explain what is meant by the term *propagating chain*. Give an example from the article of a propagating chain.

Explanation: ....

....

.... **[2]**

Example: ....

....

.... **[1]**

(b) Hydroxyl radicals form in the troposphere.

(i) Explain what is meant by the term *radical*.

....

.... **[1]**

(ii) Write the equation for the formation of hydroxyl radicals from an oxygen atom and a water molecule in the troposphere.

$$\boxed{\quad\quad\quad\quad \rightarrow \quad\quad\quad\quad}$$

[1]

(c) Ethanal can form during radical reactions that occur in the troposphere.

(i) Draw the full structural formula of ethanal, CH_3CHO.

[1]

(ii) Explain how infrared spectroscopy could be used on a sample of gas from a simulation chamber to show the presence of ethanal. Indicate how the infrared spectrum would show the presence of aldehydes and then how ethanal itself could be detected.

....

....

....

....

.... **[2]**

(d) Describe how hydroxyl radicals remove HCFCs from the troposphere.

....

....

.... **[2]**

(e) One of the graphs in **Fig. 1** shows the variation of NO_2 concentration during the day. Describe this variation and explain it using the other graph in **Fig. 1** and the diagram in **Scheme 1**.

....

....

....

....

....

....

.... **[3]**

(f) There are competing processes that cause the formation and removal of ozone in the troposphere. These processes are summarised in the **Scheme 1** diagram and elsewhere in the article.

- Describe the processes that occur in the troposphere that cause the formation and removal of ozone.
- Describe the evidence that has been used to predict a significant rise in tropospheric ozone levels over the next century.
- Explain why a rise in tropospheric ozone levels is a cause for concern.

In this question, you should make it clear how the steps you describe are linked to one another.

[7]

[Total: 20]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE

ADVANCED SUBSIDIARY GCE

CHEMISTRY B (SALTERS)

F332/ADVANCE NOTICE

Chemistry of Natural Resources: Advance Notice article

For issue on or after:
17 NOVEMBER 2010

Thursday 20 January 2011
Afternoon

Duration: 1 hour 45 minutes

NOTES FOR GUIDANCE (CANDIDATES)

1. This leaflet contains an article which is needed in preparation for a question in the externally assessed examination F332.
2. You will need to read the article carefully and also have covered the learning outcomes for Unit F332 (*Chemistry of Natural Resources*). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in Unit F332 to answer these questions. There are 20 marks available on the paper for these questions.
3. You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.
4. You will **not** be able to bring your copy of the article, or other materials, into the examination. The examination paper will contain a fresh copy of the article as an insert.
5. You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

This document consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Advance Notice for marking; it should be retained in the centre or destroyed.

Turn over

Understanding our Changing Atmosphere

Adapted from 'Understanding our Changing Atmosphere'
Educ. Chem. 2007

Chemical processes occurring in the atmosphere determine current and future atmospheric compositions, which in turn affect climate, air quality, and the spread of pollution. What are these processes and can they help us understand the likely impacts of climate change upon atmospheric conditions?

William Bloss

While the bulk of our atmosphere is made up of nitrogen, oxygen, carbon dioxide and water vapour, atmospheric chemistry is dominated by reactions of trace constituents, specifically gas phase radicals, present in parts per million (ppm), billion (ppb) or even trillion (1 part in 10^{12}). Through chain reaction cycles, these highly reactive compounds control the levels of the more abundant species in the atmosphere.

Tropospheric chemistry

The basic chemistry of the first 10–15 km of our atmosphere, the troposphere, is dominated by the reactions of hydrocarbons with hydroxyl radicals ($^\bullet$OH), see **Scheme 1**. Ozone (O_3) is broken down by sunlight, leading to high-energy oxygen atoms, which may be stabilised by colliding with nitrogen or oxygen molecules, or may react with water vapour to form two $^\bullet$OH radicals. The $^\bullet$OH radicals then react with hydrocarbons to form organic peroxy radicals ($RO_2^\bullet$) – for example, $CH_3O_2^\bullet$ is formed when an $^\bullet$OH reacts with methane in the presence of dioxygen.

What happens next depends upon the availability of the nitrogen oxide radicals, $NO^\bullet$ and $NO_2^\bullet$ (collectively called 'NO_x'). The main source of NO_x is the combustion of fossil fuels – atmospheric scientists refer to low NO_x environments, e.g. the remote atmosphere over the Pacific Ocean, as 'clean' and high NO_x environments, e.g. cities, as 'polluted'.

In the presence of NO_x, organic peroxy radicals (e.g. $CH_3O_2^\bullet$) can react with $NO^\bullet$ (and dioxygen) to form $HO_2^\bullet$ and methanal. $HO_2^\bullet$ can react with another $NO^\bullet$, forming $OH^\bullet$ again. This can react with another methane and thus hydrocarbons are oxidised as part of a propagating chain. This is shown in **Scheme 1**. Notice that the $NO_2^\bullet$ can be broken down by photolysis forming $NO^\bullet$ (to take part in the cycle again) and oxygen atoms that can form more ozone.

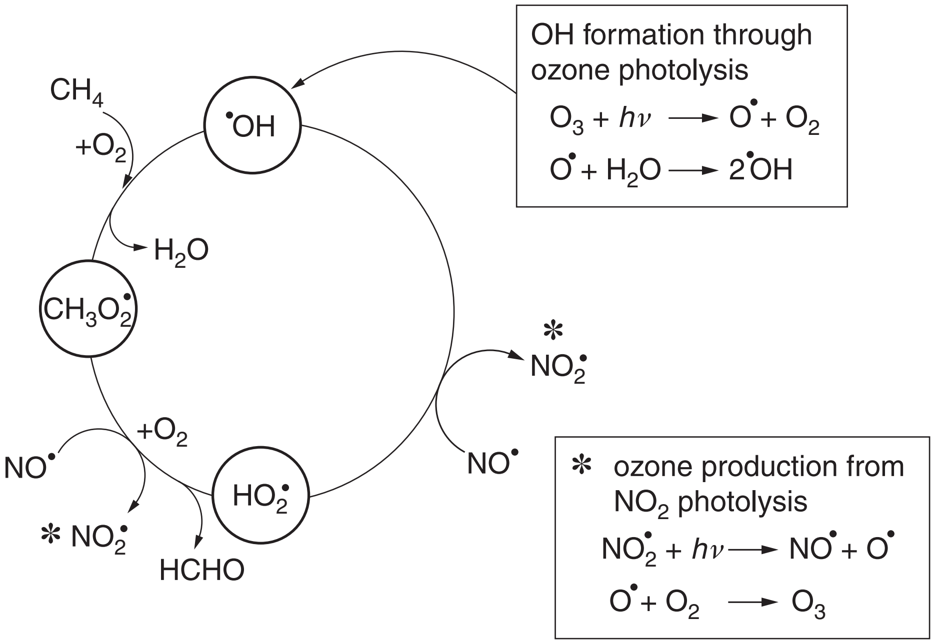
Impacts of tropospheric chemistry

The chemical processes shown in **Scheme 1** control many aspects of atmospheric composition: reaction with $^{\bullet}OH$ dominates the removal of most pollutants emitted to the atmosphere, determining their lifetime and abundance. Tropospheric $^{\bullet}OH$ levels thus regulate the self-cleansing ability, or oxidising capacity, of the atmosphere, and control the levels of greenhouse gases such as CH_4. (Note CH_4 is the second most significant greenhouse gas after CO_2; CO_2 does not react with $^{\bullet}OH$.)

This behaviour has been used advantageously in the case of hydrochlorofluorocarbons (HCFCs), such as CHF_2Cl, the hydrogenated replacements for chlorofluorocarbons (CFCs, such as CF_2Cl_2), introduced in the 1980s and 1990s to prevent stratospheric ozone loss. The $^{\bullet}OH$ reacts with HCFCs by removing the H atom to form water, leaving an alkyl radical, which then undergoes further breakdown in the atmosphere. So HCFCs are removed in the lower atmosphere, while CFCs pass unimpeded to the stratosphere.

Tropospheric chemistry also affects air quality. Oxidation of hydrocarbons such as methane, carbon monoxide and larger molecules such as volatile organic compounds (VOCs) in the presence of NO_x leads to the production of ozone, see **Scheme 1**. This is important because ozone is both a greenhouse gas, contributing to climate change, and a major constituent of the photochemical smog observed over many cities during summertime, which is harmful to human and animal health, vegetation and certain materials such as plastics.

Current UK National Air Quality strategy suggests a target level of 50 ppb for ozone. Mild health problems, owing to ozone inhalation, may become noticeable for sensitive individuals at levels of 50–90 ppb, requiring them to spend less time outdoors, while at levels over 90–100 ppb asthma sufferers may need to increase their use of an inhaler. For comparison, ozone levels in remote environments may be 5–10 ppb, typical background UK levels are around 30 ppb, while levels in Los Angeles in the late 1970s reached up to 500 ppb. Thus by understanding tropospheric atmospheric chemistry we can put forward strategies to improve air quality, such as identifying particular compounds with a high ozone creation potential, whose emissions should be controlled.



Scheme 1 A simplified diagram representing tropospheric oxidation chemistry.

Simulation chambers and field experiments

Our understanding of atmospheric chemistry has been developed through a combination of laboratory studies, field measurements and computer modelling. Laboratory experiments are used to determine the molecular properties (reaction rate constants and photolysis rates) governing the fate of individual atmospheric species. The results are used to design reaction mechanisms for specific species, which are then used in computer models of atmospheric chemistry. Comparisons of such models with field measurements of concentrations in the ambient atmosphere are then used to test the model, and refine the reaction mechanism as necessary.

A ‘smog chamber’ at the European Photoreactor (EUPHORE) in Valencia, Spain

‘Smog chambers’ or simulation chambers are used to study artificial atmospheres. The EUPHORE (‘European Photoreactor’) simulation chamber in Valencia, Spain, for example, comprises two 200 m^3 hemispherical reaction vessels, each about 4 m tall, made from a (transparent) non-reactive polymer ‘bag’ 0.2 mm thick. Each vessel has covers which can be raised to block sunlight, and houses a range of analytical instruments. Artificial atmospheric mixtures of a particular chemical system are introduced into the chambers and the photochemical reactions started by opening the covers and admitting sunlight. The resulting changing chemical composition is monitored.

Fig. 1, below, shows observed concentrations of NO_2 and NO (black lines) during an experiment to investigate benzene removal. This was obtained as part of the EXACT (Effects of the OXidation of Aromatic Compounds in the Troposphere) research project involving a consortium of scientists from European universities. The concentration of benzene falls because of its reaction with $^{\bullet}OH$, and the resulting increase in ozone levels through the reactions shown in **Scheme 1**. Also shown in the figure are the predictions (dotted lines) of an atmospheric model, the Master Chemical Mechanism, which agree well with the observations, giving us confidence in the reaction mechanisms.

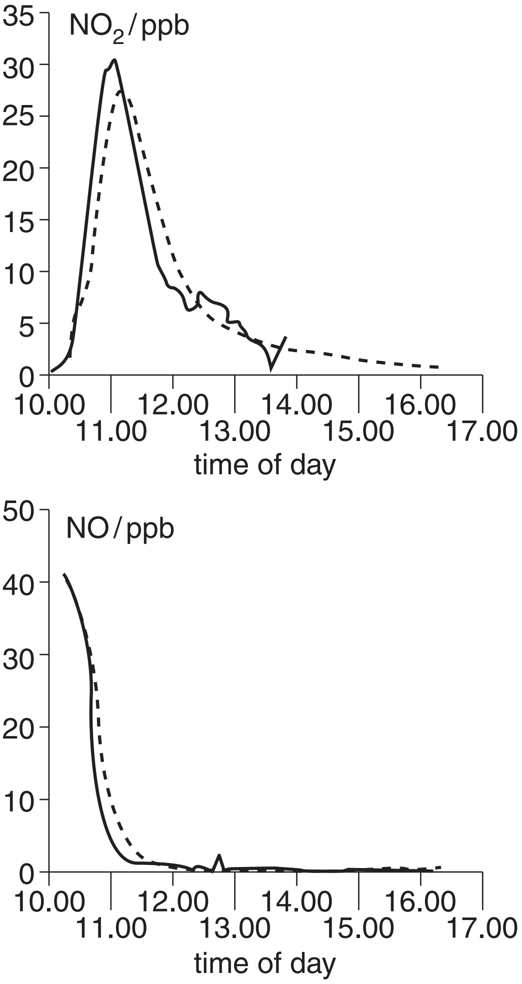


Fig. 1 Observed (black lines) and simulated (dotted lines) concentrations of NO_2 and NO during EUPHORE experiments

Another approach involves taking a range of measurements of as many of the atmospheric reactants as possible at a particular location over a short time, typically 4–6 weeks. This often involves teams of scientists from different institutions, specialising in a variety of measurement techniques. The data acquired are then compared with calculations and model predictions. Consider, for example, •OH, one of the most highly reactive radicals. The lifetime of •OH is extremely short, typically 0.1–2 s, in the lower atmosphere. Thus •OH concentrations are determined by local chemical production and loss, rather than transport, in other words •OH is not blown to a particular location from elsewhere. This behaviour allows us to use observations of very short-lived species like •OH to test our understanding of the chemistry. We suggest a chemical mechanism based upon our best knowledge, measure the levels of (comparatively) long-lived species such as O_3, NO_x and VOCs, use the mechanism to calculate the levels of short-lived species based upon measurements of those with longer lifetimes, and compare the resulting calculations with measurements of •OH etc. This approach eliminates the need to worry about the transport of atmospheric constituents by winds.

Model studies based upon our current understanding of atmospheric chemistry, and estimates of likely future emissions under various scenarios, predict the change in tropospheric ozone levels which might be expected in the future. Surface ozone levels at mid-latitudes are predicted to rise by approximately 30 ppb by 2100 – an increase which will lead to background ozone levels being comparable to the limits set in current air quality standards. If these predictions are borne out, people's health in polluted regions will be adversely affected – and the improvements in air quality observed in many Western nations over the past few decades may be reversed (as far as ozone is concerned) in the future.

END OF ADVANCE NOTICE

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