Map of the unit: The Atmosphere

This shows the relationship between the Storyline, the Activities and the Chemical Ideas. To aid planning, laboratory-based practical work is indicated by (P), activities involving IT skills are indicated by (IT) and those developing study skills by (S).

ACTIVITIES	CHEMICAL STORYLINE	CHEMICAL IDEAS
	A1 WHAT'S IN THE AIR?	
A2.1 What substances can act as sunscreens? **A2.2** Investigating sunscreens (P) **A2.3** What is the effect of the atmosphere on the Sun's radiation?	**A2** SCREENING THE SUN	**6.2** What happens when radiation interacts with matter?
A3.1 More about ozone **A3.2** The photodissociation of bromine (optional teacher demonstration) (P) **A3.3** Investigating the reaction between bromine and cyclohexane (P)	**A3** OZONE: A VITAL SUNSCREEN	**6.3** Radiation and radicals **10.1** Factors affecting reaction rates **10.2** The effect of temperature on rate ***10.4*** *What is a catalyst? (revision)* **10.5** How do catalysts work?
A4.1 How do halogenoalkanes differ in reactivity? (P) **A4.2** Making a halogenoalkane (P) **A4.3** Designing refrigerants (IT)	**A4** THE CFC STORY	**13.1** Halogenoalkanes
A5 Chemistry in the stratosphere (S)	**A5** HOW BAD IS THE OZONE CRISIS?	
A6 Which are the greenhouse gases?	**A6** TROUBLE IN THE TROPOSPHERE	
	A7 KEEPING THE WINDOW OPEN	
A8.1 The effect of concentration changes on chemical equilibria (P) **A8.2** Measuring the concentration of carbon dioxide in air samples	**A8** FOCUS ON CARBON DIOXIDE	**7.1** Chemical equilibrium
A9 Controlling carbon dioxide (IT)	**A9** COPING WITH CARBON	
A10 Check your notes on **The Atmosphere** (S)	**A10** SUMMARY	

Note Chemical Ideas shown in italics are revisited from earlier units.

A
THE ATMOSPHERE

Relation to other units

It is suggested that this teaching unit should be the fourth in the course. **The Elements of Life** and **Developing Fuels** introduce quantitative chemistry, the electromagnetic spectrum and the idea of quantisation of energy, the covalent bond, chemical energetics and catalysis. All these areas are developed further in this unit.

The chemistry of halogenoalkanes follows on well from the organic chemistry introduced in **Developing Fuels**.

The unit also contains a qualitative introduction to rates of reactions and this topic will be covered in more detail in **Engineering Proteins**. Similarly, the qualitative idea of dynamic equilibrium, introduced in this unit, is developed more fully in **Engineering Proteins**, **Aspects of Agriculture** and in **The Oceans** (where the interaction of carbon dioxide with water is revisited). The study of the interaction of radiation with matter is continued in **What's in a Medicine?** and several subsequent units.

Concept map

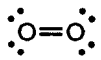
The concept map which follows shows how the major chemical ideas in this teaching unit develop throughout the course.

Concept	Introduced in unit	Developed in unit(s)	Assumed in unit(s)
Interaction of radiation with matter	EL	A, WM, EP, CD	SS, MD
Quantisation of energy	EL	A, SS, O	several
Electronegativity and bond polarity	EL	A, PR	several
Bond fission	A	–	several
Radicals	A	PR	MD
Organic functional groups	DF	A, PR, WM, DP, EP, CD	AA, MD
Halogenoalkanes	A	–	MD
Reaction mechanisms	A	PR, CD, MD	–
Chemical equilibrium	A	EP, AA, O	SS
Interaction of carbon dioxide with water	A	O	–
Molecular-kinetic theory	A	O	several
Rates of reactions	A	EP, AA	–
Catalysis	DF	A, EP, SS, AA	several
Enthalpy changes and thermochemical cycles	DF	A, O	several
Bond enthalpies	DF	A	–

A note on the treatment of radicals

In keeping with modern practice, we have used the term *radical* rather than *free radical*. In the **Chemical Ideas**, radicals are represented in the conventional way using a dot to represent an unpaired electron. However, in the **Chemical Storylines** we have omitted the dot where radicals appear, in order to give a less cluttered presentation.

In **Chemical Ideas 6.3**, there is brief mention of the O_2 biradical, $^{\bullet}O_2$. The explanation for its existence rather than the species



predicted by dot–cross diagrams lies in molecular orbital theory. Of the 12 outer electrons in O_2, eight electrons are in bonding molecular orbitals and four electrons are in antibonding orbitals. This means that overall there are four bonding electrons, which are equivalent to a double bond. The last two electrons go into two separate antibonding orbitals with the same energy and so O_2 is a biradical. This explanation is likely to be beyond most students, who will have to content themselves with the 'explanation' that dot–cross diagrams are not always adequate to represent bonding fully.

Advance warning

The following items needed for activities in this unit may not already be in your school, and might take a little time to obtain.

Activity	Item(s)	Essential/Optional	Typical quantity per experiment
A2.2	Ultraviolet light source (mid-range)	Essential (but see note in activity about using sunlight)	
	Ultraviolet sensitive paper	Optional	
	Sunscreens with different screening factors	Essential	
A3.2, A3.3	Hexane	Essential	6 cm^3, 35 cm^3
A4.2	2-Methylpropan-2-ol	Essential	6.5 cm^3 (m.p. 25.5 °C)

Useful information about some common atmospheric gases (at year 2000)

	Carbon dioxide CO_2	Methane CH_4	Dinitrogen oxide N_2O	Chlorofluorocarbons CFCs	Tropospheric ozone O_3	Carbon monoxide CO	Water vapour H_2O
Greenhouse role	heating	heating	heating	heating	heating	none	heats in air; cools in clouds
Principal sources from human activities	fossil fuels; deforestation	rice culture; cattle; fossil fuels; biomass burning	fertilised soils; changes in land use	refrigerants; aerosols; solvents; foam blowing agents	hydrocarbons (with NO_x); biomass burning	fossil fuels; biomass burning	changes in land use; irrigation
Principal natural sources	balanced in nature	wetlands	soils; oceans	none	hydrocarbons + NO_x	hydrocarbon oxidation	evaporation
Atmospheric lifetime	50–200 years*	10 years	150 years	60–130 years (some longer)	days	months	days
Present atmospheric concentration at surface in parts per billion by volume	367 000	1800	310	CFC-11: 0.26	*ca* 20–40†	*ca* 100†	variable
Pre-industrial concentration (1750–1800) at surface in parts per billion by volume	280 000	790	288	0	10(?)	40–80 (?)	–
Approx relative contribution to the greenhouse effect due to human activities‡	56%	17%	6%	11%	10% (?)	none	unknown

* Values depend on whether the lifetime is calculated for the atmosphere only or includes residence time in the atmosphere–ocean system. † Northern Hemisphere.
‡ From *Global Warming: The Complete Briefing*, 2nd edn. John Houghton. CUP, 1997.