IV. CONTROLLING OZONE-DEPLETING GASES

Q15: Are there regulations on the production of ozone-depleting gases?

Yes, the production of ozone-depleting gases is regulated under a 1987 international agreement known as the "Montreal Protocol on Substances that Deplete the Ozone Layer" and its subsequent Amendments and Adjustments. The Protocol, now ratified by over 180 nations, establishes legally binding controls on the national production and consumption of ozone-depleting gases. Production and consumption of all principal halogen-containing gases by developed and developing nations will be significantly reduced or phased out before the middle of the 21st century.

Montreal Protocol. In 1985, a treaty called the *Convention for the Protection of the Ozone Layer* was signed by 20 nations in Vienna. The signing nations agreed to take appropriate measures to protect the ozone layer from human activities. The Vienna Convention supported research, exchange of information, and future protocols. In response to growing concern, the *Montreal Protocol on Substances that Deplete the Ozone Layer* was signed in 1987 and ratified in 1989. The Protocol established legally binding controls for developed and developing nations on the production and consumption of halogen source gases known to cause ozone depletion. National consumption of a halogen gas is defined as the amount that production and imports of a gas exceed its export to other nations.

Amendments and Adjustments. As the scientific basis of ozone depletion became more certain after 1987 and substitutes and alternatives became available for the principal halogen source gases, the Montreal Protocol was strengthened with Amendments and Adjustments. These revisions added new controlled substances, accelerated existing control measures, and scheduled phaseouts of the production of certain gases. The initial Protocol called for only a slowing of chlorofluorocarbon (CFC) and halon production. The 1990 London Amendments to the Protocol called for a phaseout of the production of the most damaging ozone-depleting substances in developed nations by 2000 and in developing nations by 2010. The 1992 Copenhagen Amendments accelerated the date of the phaseout to 1996 in developed nations. Further controls on ozone-depleting substances were agreed upon in later meetings in Vienna (1995), Montreal (1997), and Beijing (1999).

Montreal Protocol projections. The future stratospheric abundances of effective stratospheric chlorine can be projected based on the provisions of the Montreal Protocol. The concept of effective stratospheric chlorine accounts for the combined effect on ozone of chlorine- and bromine-containing gases. The results are shown in ***Figure Q15-1*** for the following cases:

- No Protocol and continued production increases of 3% per year (business-as-usual scenario).
- Continued production as allowed by the Protocol's original provisions agreed upon in Montreal in 1987.
- Restricted production as outlined in the subsequent Amendments and Adjustments: London, 1990; Copenhagen, 1992; and Beijing, 1999. (The city names and years signify where and when the agreements were made.)
- Zero emissions of ozone-depleting gases starting in 2003.

In each case, production of a gas is assumed to result in its eventual emission to the atmosphere. Without the Montreal Protocol, continued production and use of CFCs and other ozone-depleting gases are projected to have increased effective stratospheric chlorine tenfold by the mid-2050s compared with the 1980 value. Such high values likely would have increased global ozone depletion far beyond that currently observed. As a result, harmful UV-B radiation would have increased substantially at Earth's surface, causing a rise in excess skin cancer cases (see lower panel of ***Figure Q15-1*** and *Q17*).

The 1987 provisions of the Montreal Protocol would have only slowed the approach to high effective chlorine values by one or more decades in the 21st century. Not until the 1992 Copenhagen Amendments and Adjustments did the Protocol projections show a *decrease* in future effective stratospheric chlorine values. Now, with full compliance to the Montreal Protocol and its Amendments and Adjustments, use of the major human-produced ozone-depleting gases will ultimately be phased out and effective stratospheric chlorine will slowly decay, reaching pre-ozone-hole values in the mid-21st century.

Zero emissions. Effective chlorine values in the coming decades will be influenced by emissions of halogen source gases produced in those decades as well as the emission of currently existing gases that are now being used or stored in various ways. Some continued

production and consumption of ozone-depleting gases is allowed, particularly in developing nations, under the 1999 Beijing agreements. As a measure of the contribution of these continued emissions to the effective chlorine value, the "zero emissions" case is included in ***Figure Q15-1***. In this hypothetical case, all emissions of ozone-depleting gases are set to zero beginning in 2003. The reductions in effective stratospheric chlorine beyond the values expected for the 1999 Beijing agreement would be significantly smaller than most earlier changes, as shown.

HCFC substitute gases. The Montreal Protocol provides for the transitional use of hydrochlorofluorocarbons (HCFCs) as substitute compounds for principal halogen source gases such as CFC-12. HCFCs differ chemically from most other halogen source gases in that they contain hydrogen (H) atoms in addition to chlorine and fluorine atoms. HCFCs are used for refrigeration, for blowing foams, and as solvents, which were primary uses of CFCs. HCFCs are 1 to 15% as effective as CFC-12 in depleting stratospheric ozone because they are chemically removed primarily in the troposphere. This removal partially protects stratospheric ozone from the halogens contained in HCFCs. In contrast, CFCs and many other halogen source gases are chemically inert in the troposphere and, hence, reach the stratosphere without being significantly removed. Because HCFCs still contribute to the halogen abundance in the stratosphere, the Montreal Protocol requires the production and consumption of HCFCs to end in developed and developing nations by 2040.

HFC substitute gases. Hydrofluorocarbons (HFCs) are also used as substitute compounds for CFCs and other halogen source gases. HFCs contain only hydrogen, fluorine, and carbon atoms. Because HFCs contain no chlorine or bromine, they do not contribute to ozone depletion. As a consequence, the HFCs are not regulated by the Montreal Protocol. However, HFCs (as well as all halogen source gases) are radiatively active gases that contribute to human-induced global warming and climate change as they accumulate in the atmosphere (see *Q18*). HFCs are included in the group of gases listed in the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCC).

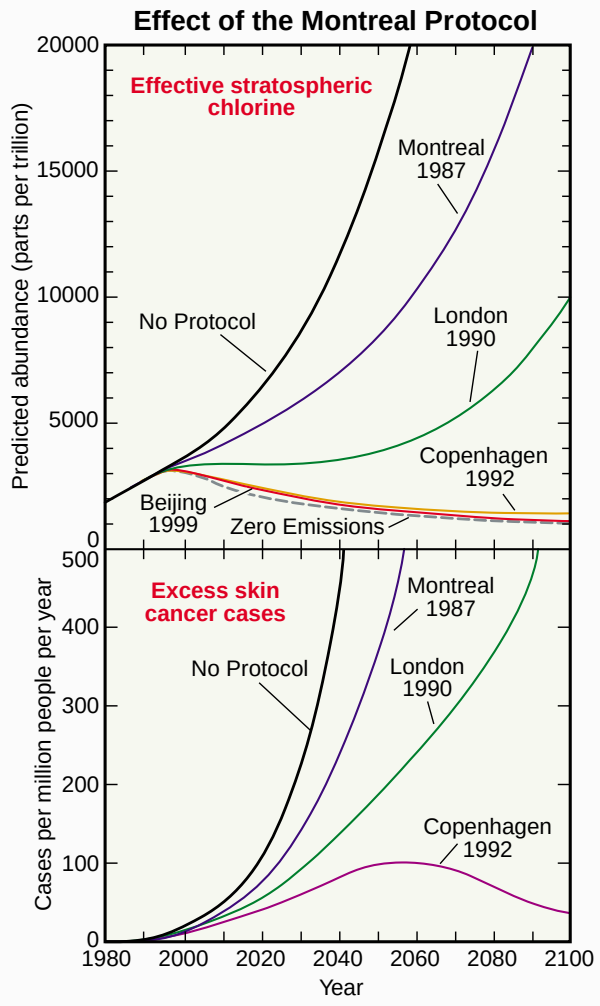

Figure Q15-1. Effect of the Montreal Protocol. The purpose of the Montreal Protocol is to achieve reductions in stratospheric abundances of chlorine and bromine. The reductions follow from restrictions on the production and consumption of manufactured halogen source gases. Predictions for the future abundance of *effective stratospheric chlorine* are shown in the top panel assuming (1) no Protocol regulations, (2) only the regulations in the original 1987 Montreal Protocol, and (3) additional regulations from the subsequent Amendments and Adjustments. The city names and years indicate where and when changes to the original 1987 Protocol provisions were agreed upon. Effective stratospheric chlorine as used here accounts for the combined effect of chlorine and bromine gases. Without a Protocol, stratospheric halogen gases are projected to have increased significantly in the 21st century. The "zero emissions" line shows stratospheric abundances if all emissions were reduced to zero beginning in 2003. The lower panel shows how excess skin cancer cases (see *Q17*) would increase with no regulations and how they will be reduced under the Protocol provisions. (The unit "parts per trillion" is defined in the caption of ***Figure Q7-1***.)