Q6.16 As discussed in Topic Study 1, insight into the chemical processes that control the ozone concentration at a given altitude in the *natural* stratosphere can be obtained by considering the following reaction scheme:

$$O_2 + h\nu \xrightarrow{j_1} 2O \qquad \textit{step 1}$$

$$O + O_2 + M \xrightarrow{k_2} O_3 + M \qquad \textit{step 2}$$

$$O_3 + h\nu \xrightarrow{j_3} O + O_2 \qquad \textit{step 3}$$

$$O + O_3 \xrightarrow{k_4} 2O_2 \qquad \textit{step 4}$$

$$X + O_3 \xrightarrow{k_5} XO + O_2 \qquad \textit{step 5}$$

$$XO + O \xrightarrow{k_6} X + O_2 \qquad \textit{step 6}$$

where X can be atomic chlorine (Cl·), or the hydroxyl radical (HO·), or nitric oxide (NO).

With reference to this scheme, select from the key the *three* statements that are **incorrect**.

KEY for Q6.16

A Step 1 represents the photolysis of O_2 following the absorption of incoming solar radiation at wavelengths in the uv region.

B Steps 2 and 3 have no effect on the concentration of odd oxygen, O_x.

C According to this scheme, the rate of change of the concentration of odd oxygen is given by the following expression:

$$\frac{d[O_x]}{dt} = j_1[O_2] - k_4[O][O_3] - k_5[X][O_3] - k_6[XO][O]$$

D Steps 5 and 6 can be considered to represent a catalytic cycle whereby X catalyses the loss of odd oxygen via step 4.

E Water vapour transported up from the troposphere is the main natural source of HO· radicals in the stratosphere.

F At a given altitude in the stratosphere, the concentration of Cl· is independent of the concentration of methane (CH_4).

G Throughout most of the stratosphere, nitric acid (HNO_3) acts as a relatively unreactive reservoir of the NO_x species (NO and NO_2).

H Nitrous oxide (N_2O) transported up from the troposphere is the main natural source of NO in the stratosphere.

Q6.17 to Q6.20 Figure 6.2 summarizes in diagrammatic form some of the processes that link the chlorine radicals Cl· and ClO· to other chlorine-containing species in the stratosphere. In some cases, the reaction partner that effects a transformation is included within the arrow, with photochemical change being indicated by *hv*. The remaining arrows, labelled a to h in Figure 6.2, are listed in the key.

KEY for Q6.17 to Q6.20

A Arrow a	E Arrow e
B Arrow b	F Arrow f
C Arrow c	G Arrow g
D Arrow d	H Arrow h

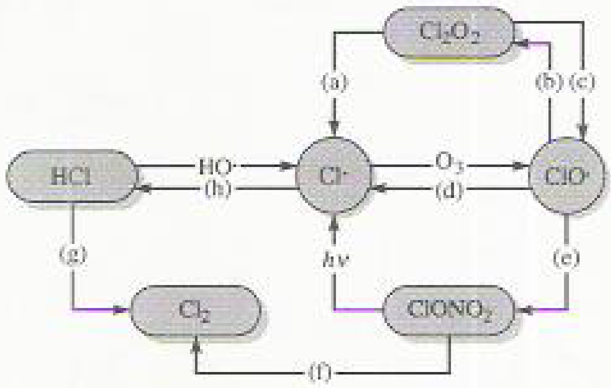

Figure 6.2 For use with questions Q6.17 to Q6.20.

Q6.17 Which *two* of the arrows labelled a to h in Figure 6.2 represent processes whereby Cl· and ClO· become locked up as more stable reservoir molecules? Select *two* items from the key for Q6.17 to Q6.20.

Q6.18 Which *two* of the arrows labelled a to h in Figure 6.2 represent fast heterogeneous reactions that are thought to take place on the surfaces of the particles in polar stratospheric clouds? Select *two* items from the key for Q6.17 to Q6.20.

Q6.19 Which *one* of the arrows labelled a to h in Figure 6.2 represents a process that is suppressed in the presence of polar stratospheric clouds? Select *one* item from the key for Q6.17 to Q6.20.

Q6.20 Which *two* of the arrows labelled a to h in Figure 6.2 represent processes that are part of the main catalytic cycle implicated in the formation of the Antarctic ozone hole? Select *two* items from the key for Q6.17 to Q6.20.

Q6.21 Examine the statements in the key, and then select *three* that are **incorrect**.

KEY for Q6.21

A The compound $C_2F_4Br_2$ (halon-2402) is likely to have a higher ozone depletion potential (ODP) than the compound $C_2F_4Cl_2$ (CFC-114).

B The compound CF_3CHCl_2 is likely to have a longer atmospheric lifetime than $CFCl_3$ (CFC-11).

C Enhanced concentrations of CO_2 in the atmosphere are predicted to lead to a warming of the stratosphere.

D Reduced concentrations of ozone in the lower stratosphere are predicted to lead to a cooling of this region of the atmosphere.

E In the absence of other changes, stratospheric ozone depletion is predicted to lead to enhanced levels of UV-B at the Earth's surface.

F Stratospheric ozone depletion in spring is less severe over the Arctic than it is over Antarctica, because wintertime concentrations of ClO· in the Arctic polar vortex never build up to the enhanced levels found in the Antarctic polar vortex.