HL Paper 3

The discovery of penicillin was one of the most significant scientific discoveries of the last century.

State the type of hybridization of each of the carbon atoms (**I**, **II**, and **III**) in the β-lactam ring of ampicillin by completing the table below, and explain why the amide group is highly reactive.

Carbon atom	I	II	III
Hybridization			

Ozone prevents UV radiation emitted from the Sun reaching the surface of the Earth.

d. Explain, with the aid of Lewis (electron-dot) structures, the difference between oxygen and ozone in terms of the energy required to dissociate both molecules. [2]

Oxygen: Ozone:

e. One CFC, Freon-13 (chlorotrifl uoromethane), which can be used as a refrigerant, has been phased out by the Montreal Protocol. Describe, using equations, the mechanism of the catalysis of ozone depletion by this particular CFC. [2]

a. The following reactions take place in the ozone layer by the absorption of ultraviolet light. [2]

$$\text{I} \quad \mathrm{O_3} \rightarrow \mathrm{O_2} + \mathrm{O}\bullet$$
$$\text{II} \quad \mathrm{O_2} \rightarrow \mathrm{O}\bullet + \mathrm{O}\bullet$$

State and explain, by reference to the bonding, which of the reactions, **I** or **II**, requires a shorter wavelength.

b. CFCs and $\mathrm{NO_x}$ are pollutants responsible for the depletion of the ozone layer. Discuss the role of $\mathrm{NO_x}$ in this process and include equations for a stepwise mechanism. [3]

Increasing concentrations of greenhouse gases are considered to cause global warming. Ozone depletion is another environmental concern.

Ozone and oxygen are in equilibrium in the stratosphere. Both gases absorb ultraviolet radiation and dissociate producing oxygen atoms.

Describe the dependence of ozone and oxygen dissociation on the wavelength of radiation absorbed, and explain how this is related to the bonding in each molecule.

Ozone and oxygen both dissociate in the ozone layer when they absorb ultraviolet light of different wavelengths.

$$\mathrm{O_3(g) \rightarrow O_2(g) + O \bullet (g)} \quad \lambda = 330\ \mathrm{nm}$$
$$\mathrm{O_2(g) \rightarrow O \bullet (g) + O \bullet (g)} \quad \lambda = 242\ \mathrm{nm}$$

a. Explain, on a molecular level, why ozone dissociates with radiation of a longer wavelength than oxygen. [2]

b. Nitrogen(II) oxide, NO, is a primary pollutant that depletes the ozone layer. State **two** equations that show how this oxide catalyses the depletion of ozone in the stratosphere. [2]

The ozone layer protects us by absorbing ultraviolet (UV) radiation from the Sun during its natural formation and depletion.

a. Explain how the bonding in $\mathrm{O_2}$ and $\mathrm{O_3}$ affects the wavelengths of UV light they absorb. [3]

b. The chemical balance of the stratosphere is disrupted by the presence of chlorofluorocarbons (CFCs) and other ozone-depleting compounds. Describe, using equations, how CFCs contribute to ozone depletion. [3]

The ozone in the stratosphere protects us from harmful UV radiation. Above Australia there is an area of decreased ozone concentration that has led to an increase in the incidence of some skin cancers.

a. Explain how the dissociation of $\mathrm{O_2}$ and $\mathrm{O_3}$ is dependent on the wavelength of light. [2]

b. Use equations to describe the mechanism of ozone depletion catalysed by the $\mathrm{CCl_2F_2}$ molecule. [3]

The ozone layer has also been depleted by certain pollutants that have been released into the atmosphere. State examples of **two** such ozone-depleting substances.

Nuclear reactions transform one nuclide into another. Fission, splitting a large nucleus into two smaller nuclei, releases vast amounts of energy.

(i) Uranium hexafluoride, UF_6, is used in the uranium enrichment process that produces fuel for nuclear reactors.

State the molecular shape of uranium hexafluoride.

(ii) Explain why uranium dioxide, UO_2, has a very high melting point whereas uranium hexafluoride vapourises easily into gas.

One of the winners of the 1995 Nobel Prize in Chemistry was Paul J. Crutzen, who showed that emissions of nitrogen oxides from jet airplanes could contribute to the destruction of the ozone layer.

Using chemical equations, outline a mechanism by which nitrogen oxides are able to deplete ozone.

Chlorofluorocarbons, CFCs, deplete the ozone layer.

Chlorine atoms and nitrogen oxides react at the surface of ice particles in the arctic winter.

a. State the equations that represent the depletion of ozone in the stratosphere which is catalysed by chlorine free radicals. [2]

b. (i) Deduce the type of catalysis that occurs. [3]

(ii) Outline why the depletion of ozone is greatest during the arctic spring.

Another major source of concern is the depletion of ozone in the stratosphere as a result of human activity.

b.i. Describe, by means of equations, how nitrogen(II) oxide, NO, catalyses the depletion of ozone. [3]

b.ii. Identify and state the source of **one** other ozone-depleting pollutant. [1]
