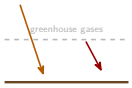
Global Change

AP Environmental Science ▪ Unit 9

AP Environmental Science

What we will cover

1. Ozone depletion
2. The greenhouse effect
3. Climate change
4. Ocean warming and acid
5. Invasive and endangered species
6. HIPPCO threats

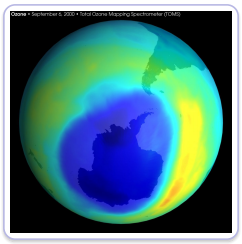


1 Ozone

Ozone depletion and the Montreal Protocol

The **ozone layer** 臭氧层 blocks UV. **CFCs** 氯氟烃 release chlorine that destroys it (catalyst).

> The 1987 **Montreal Protocol** 蒙特利尔议定书 phased out CFCs worldwide and is a rare environmental success – the layer is slowly recovering. The substitutes still carry a climate cost, which is the follow-up the question asks for.



Ozone hole: CFC chlorine catalysis

The ozone layer, and what took it apart

ozone layer 臭氧层	high in the stratosphere; absorbs harmful **ultraviolet** 紫外线 radiation before it reaches the ground
CFCs 氯氟烃	chlorofluorocarbons – once used in coolants and sprays; stable enough to drift up intact
the mechanism	UV splits off a chlorine atom, which destroys ozone catalytically – one atom, thousands of molecules
the consequence	more UV at the surface: skin cancer, cataracts, damage to crops and plankton

> The Montreal Protocol phased CFCs out and the layer is recovering – the one clear success story in the whole course.

2 Greenhouse

The greenhouse effect

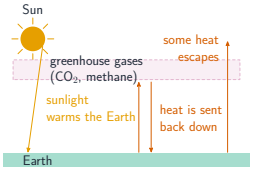
A *natural* warming: sunlight warms the ground, which radiates **infrared radiation** 红外辐射; **greenhouse gases** 温室气体 trap some heat.

- CO_2, **methane** 甲烷, **water vapor** 水蒸气

Keeps Earth **habitable** 宜居的: $+15°C$, not $-18°C$. The problem is making it too strong.

Endangered coral

Greenhouse gases absorb the heat the Earth



greenhouse gases trap some of the Earth's heat, so less escapes to space and the Earth warms up

Greenhouse gases absorb the heat the Earth gives off and send some back

3 Climate

Climate change

Human activities enhance the greenhouse effect. Weather is a day; climate change is decades.

- rising average temperature, melting ice, rising **sea level** 海平面
- fiercer extremes, and species ranges shifting polewards

Feedback: melting ice bares dark water that absorbs more heat.

Glacier loss: ice-albedo feedback

4 Ocean

Ocean warming and acidification

The ocean absorbs $>90\%$ of the extra heat and much of the CO_2.

- heat $\Rightarrow$ coral bleaching + thermal expansion
- $CO_2 \Rightarrow$ carbonic acid, lower pH

Ocean acidification dissolves shells of calcifying organisms.

Coral bleaching from ocean heat stress

Ocean acidification

the cause	the ocean absorbs about a quarter of our CO_2, which forms carbonic acid
the effect	pH falls – **ocean acidification** 海洋酸化
who it hits	corals, shellfish and plankton, which build shells and skeletons from **calcium carbonate** 碳酸钙
and warming	warmer water bleaches coral and expands, so **sea levels** 海平面 rise even before ice melt is counted

> Acidification and warming come from the same CO_2 and hit the same organisms twice over.

5 Species

Invasive and endangered species

An **invasive species** 入侵物种 is a non-native that spreads and outcompetes natives – often via trade.

> Endangered species lose habitat, face pollution, and overharvesting. Conservation can reverse it.

Invasive kudzu: spreads and outcompetes natives

6 HIPPCO

HIPPCO – threats to biodiversity

The six human threats, worst first is **H**abitat loss:

- **H**abitat destruction
- **I**nvasive species
- **P**ollution
- **P**opulation growth
- **C**limate change
- **O**verexploitation

> No single threat is the whole story – their combination drives today's rapid species loss.

Increases in the Greenhouse Gases

> Each gas has its own source: CO_2 from burning fossil fuels and deforestation, **methane** 甲烷 from livestock, landfills and rice paddies, nitrous oxide from fertiliser. To compare them fairly use **global warming potential** 全球变暖潜能值 (GWP) – the heat one unit traps relative to CO_2 over a set time.

Human Impacts on Biodiversity

two ways to conserve a species

in-situ (in the wild)
national parks,
marine reserves

ex-situ (away from the wild)
zoos, botanic gardens,
seed banks,
frozen zoos

In-situ and ex-situ conservation protect species

Habitat fragmentation is worse than losing the same area

what happens	roads, pipelines and development break one large habitat into small isolated patches
populations cut off	small patches cannot exchange individuals, so **genetic diversity** 遗传多样性 falls
more edge	a patch is nearly all boundary – exposed to predators, invasive species and a drier microclimate
the wider picture	habitat loss, **global climate change** 全球气候变化, pollution, **invasive species** 入侵物种 and overexploitation together drive what some call a sixth mass extinction

Ten one-hectare patches are not one ten-hectare habitat. Say *why* – isolation and edge – and the mark is yours.

Exam tips

- Keep **ozone depletion** (CFCs let in more UV) and **climate change** (greenhouse gases trap more heat) as **two different problems**.
- Explain the natural greenhouse effect and the **enhanced** version from extra CO and methane.
- Connect ocean warming (coral bleaching) and **ocean acidification** (CO $\rightarrow$ carbonic acid $\rightarrow$ weaker shells).
- An **invasive species** is dangerous because it has no natural predators in its new home.
- Summarise threats to biodiversity with **HIPPO** (Habitat loss, Invasive species, Pollution, Population, Overharvesting).

7 Recap

Worked example – the greenhouse effect

Explain how CO_2 warms Earth, and why melting Arctic ice makes it worse.

- Short-wave sunlight warms the surface, which re-radiates long-wave infrared.
- CO_2 absorbs and re-emits that infrared, sending part back down $\Rightarrow$ warming.
- Ice has high albedo (≈ 0.9); dark ocean has low albedo (≈ 0.06).
- Melting exposes ocean $\Rightarrow$ more absorbed $\Rightarrow$ more melting: positive feedback.

Greenhouse gases are transparent to incoming short-wave and opaque to outgoing long-wave – say both. Positive feedback amplifies; negative feedback stabilises.

Worked example – how much has CO_2 risen?

Atmospheric CO_2 rose from about 280 ppm before industrialisation to about 420 ppm today. What is the percentage increase?

- $\dfrac{420-280}{280} \times 100\%$
- $= \dfrac{140}{280} \times 100\% = 50\%$

A 50% rise in the main long-lived greenhouse gas is the core driver of the enhanced greenhouse effect and modern warming.

Unit 9 – key takeaways

1 Ozone

CFC chlorine catalyst; Montreal Protocol is healing it

2 Greenhouse

natural + habitable; humans enhance it → warming

3 Oceans

absorb heat + CO_2: bleaching, acidification, higher seas

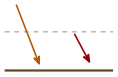
4 Biodiversity

invasive + endangered; the six HIPPCO threats

Global Change
└Recap

Check yourself

1. Why does one chlorine atom destroy so much ozone?
2. What treaty phased out CFCs?
3. What turns coral white in warm water?
4. What does the "H" in HIPPCO stand for?



Answers **1.** it acts as a catalyst, freed to repeat **2.** the Montreal Protocol **3.** heat stress (bleaching) **4.** Habitat destruction