20.3.1 Sewage, fertiliser, plastics and the greenhouse gases

Name: _____ Class: _____ Date: _____ **Total: 32 marks**

KEY WORDS oxygen 氧气 • fish 鱼类 • eutrophication 富营养化 • dissolved oxygen 溶解氧 • nitrate 硝酸盐

Objective

Sheet 20.3 covered eutrophication and the greenhouse gases in outline. This sheet takes 20.3 to exam level: exactly what **untreated sewage** 未经处理的污水 and **excess fertiliser** 过量化肥 do to a river, the **eutrophication** 富营养化 chain written out one arrow at a time, why **non-biodegradable** 不可降解 plastics cause the harm they do in water and on land, and where **methane** 甲烷 and **carbon dioxide** come from and what the **enhanced greenhouse effect** 增强温室效应 does. Every answer on this unit is a chain of consequences. This sheet covers syllabus 20.3.

You must be able to:

- describe the effects of untreated sewage and excess fertiliser on **aquatic ecosystems** 水生生态系统
- explain the process of eutrophication: more **nitrate** 硝酸盐 and other ions, more growth of producers, more **decomposition** 分解 after they die, more **aerobic respiration** by **decomposers** 分解者, less **dissolved oxygen** 溶解氧, and the death of organisms that need it
- describe the effects of non-biodegradable plastics in aquatic and **terrestrial** 陆生 ecosystems
- describe the sources and effects of air pollution by methane and carbon dioxide, limited to the enhanced greenhouse effect and **climate change** 气候变化

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

■ Two pollutants, one result

Untreated sewage and **excess fertiliser** reach a river by different routes but do the same two things:

pollutant	where it comes from	what it adds to the water
untreated **sewage**	drains and waste pipes that run straight into a river	**nitrate** and other ions, **and** a large amount of organic waste for decomposers to feed on
excess **fertiliser**	rain washes it off farmland into the river – this is **leaching** 淋溶	**nitrate** and phosphate ions

- Both raise the concentration of **nitrate ions** in the water, which is where the eutrophication chain begins.
- Sewage does something extra: the organic waste itself feeds bacteria, so the decomposers multiply immediately, before any plant has grown.
- Untreated sewage also carries **pathogens**, which is a separate problem – cholera and typhoid are water-borne.

■ Eutrophication, one arrow at a time

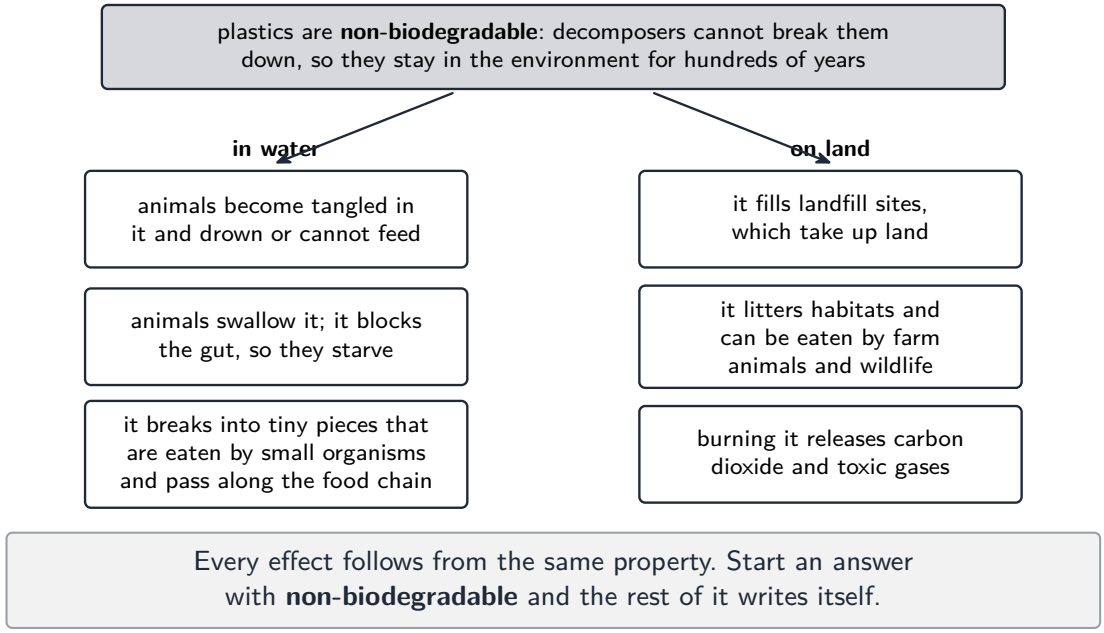
more nitrate → more producers → they die → more decomposers → less oxygen → fish die

Write it as six numbered steps and the marks follow:

1. The water gains **nitrate and other ions**.
2. **Producers** – algae and water plants – grow much faster, and cover the surface.
3. Plants below them are **shaded**, so they cannot photosynthesise, and they **die**.
4. **Decomposers** feed on the dead material and multiply.
5. The decomposers carry out **aerobic respiration**, which uses up the **dissolved oxygen** in the water.
6. Fish and other organisms that need dissolved oxygen **die**.

- △ The fish die because of the **decomposers' respiration**, not because the algae used the oxygen up and not because the algae are poisonous. Step 4 is the step students leave out.

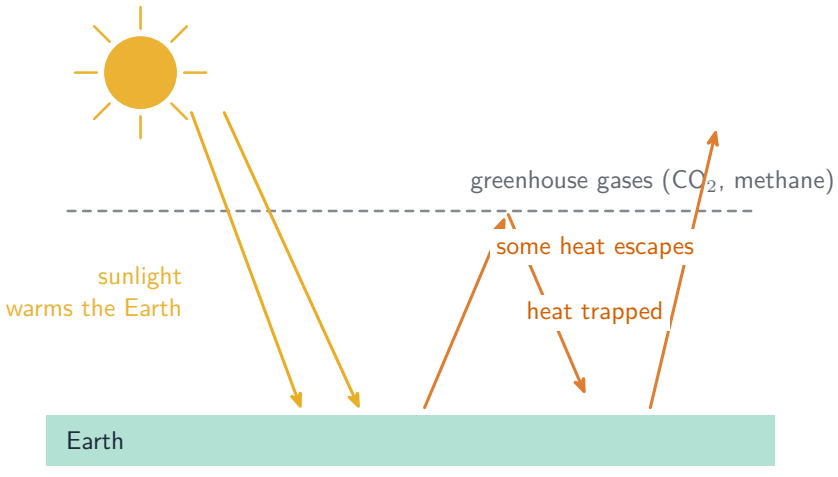
■ Plastics: everything follows from one word



Plastics are **non-biodegradable**: **decomposers cannot break them down**, so they stay in the environment for hundreds of years.

- **In water:** animals become **tangled** in it and drown or cannot feed; animals **swallow** it and it blocks the gut, so they starve; it breaks into tiny pieces that small organisms eat, so it passes **along the food chain**.
- **On land:** it fills **landfill** sites, taking up land; it litters habitats and is eaten by farm animals and wildlife; **burning** it releases carbon dioxide and toxic gases.

The greenhouse gases: sources, then effects



greenhouse gases trap heat, so the Earth gets warmer

gas	where it comes from
carbon dioxide	burning **fossil fuels** 化石燃料 and wood; **deforestation** 森林砍伐, which also removes the trees that would absorb it
methane	**cattle** and other livestock; **rice** fields; **landfill** sites; decaying waste

The enhanced greenhouse effect. Both gases let sunlight through to the Earth's surface, but **absorb the heat the Earth radiates back out**. More of these gases means **more heat is trapped**, so the average temperature of the atmosphere rises. That is **climate change**, and its consequences are melting ice, rising sea level, shifting rainfall and habitats becoming unsuitable for the species living in them.

- "The greenhouse effect" on its own is natural and keeps the Earth warm enough to live on. The exam is asking about the **enhanced** effect: the extra warming caused by the gases we add.

2 Practice

Now use the methods above.

2.1 State **two** substances that untreated sewage adds to a river. [2]

2.2 Explain how excess fertiliser applied to a field ends up in a river. [2]

2.3 In eutrophication, explain why the water plants growing near the river bed die. [2]

2.4 Explain why the fish in a eutrophic river die. [3]

2.5 State what is meant by a non-biodegradable plastic. [2]

2.6 Name one source of methane and one source of carbon dioxide. [2]

3 Exam-style questions

3.1 In a river polluted by fertiliser, the fish die because [1]

A | B
C | D

A the algae release a poison into the water.
B the algae use up the dissolved oxygen at night.
C decomposers use up the dissolved oxygen as they respire.
D the nitrate ions are poisonous to fish.

3.2 A stretch of river runs past a farm and then past a town where untreated sewage enters it.

(a) Explain the effect of the excess fertiliser from the farm on the number of algae in the river. [2]

(b) Explain why untreated sewage lowers the dissolved oxygen concentration more quickly than fertiliser does. [2]

(c) State one other danger of untreated sewage in a river used for drinking water. [1]

3.3 A survey of a river measured the concentration of nitrate ions and of dissolved oxygen at five points downstream of a sewage outflow.

distance downstream / km	**nitrate ions / mg per dm^3**	**dissolved oxygen / mg per dm^3**
0 (the outflow)	2	9
1	18	5
2	24	1
5	16	3
10	5	8

(a) Describe how the dissolved oxygen concentration changes with distance downstream. [3]

(b) Explain why the dissolved oxygen concentration is lowest at 2 km. [4]

(c) Suggest why the dissolved oxygen concentration has recovered by 10 km. [2]

(d) Only one species of fish was found at 2 km, but eleven species were found at 10 km. Explain this difference. [2]

(e) Plastic waste was also found along the river bank. Describe **two** effects this plastic could have on the animals living in and beside the river. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- **nitrate ions** (and other mineral ions)
- **organic waste**, which decomposers feed on – also acceptable: **pathogens**

2.2

- fertiliser that the crop does not take up stays in the soil
- **rain washes it through the soil** and into the river; this is **leaching**

2.3

- the algae at the surface multiply and **cover the water**, shading the plants below
- those plants cannot **photosynthesise** enough, so they die

2.4

- **decomposers** feed on the dead algae and water plants, and multiply
- they carry out **aerobic respiration**, which uses up the **dissolved oxygen** in the water
- the fish need dissolved oxygen for their own respiration, so they die or leave

2.5

- **decomposers cannot break it down**
- so it stays in the environment for hundreds of years

2.6

- methane: **cattle**, **rice fields**, **landfill sites** or decaying waste
- carbon dioxide: burning **fossil fuels**, burning wood or **deforestation**

3.1 C

- the extra nitrate makes the algae grow, and when they die the **decomposers** multiply and use up the dissolved oxygen in their respiration
- **A** and **D** invent a poison; **B** names the wrong organisms – the algae's respiration is far smaller than the decomposers'

3.2

(a)

- the fertiliser adds **nitrate ions** to the water
- so the algae have more of the mineral ions they need and **grow and reproduce faster**, increasing in number

(b)

- fertiliser only adds **ions**, so the decomposers cannot multiply until the algae have grown and died first
- sewage adds **organic waste** as well, which decomposers can feed on **immediately**, so they multiply and use up the oxygen straight away

(c)

- it carries **pathogens**, which cause water-borne diseases such as **cholera**

3.3

(a)

- it **falls** from 9 mg per dm^3 at the outflow to **1 mg per dm^3** at 2 km
- it then **rises** again, to 8 mg per dm^3 at 10 km
- so it is lowest at **2 km**, a little way downstream of the outflow, not at the outflow itself

(b)

- the nitrate concentration is **highest** at 2 km (24 mg per dm^3), so the algae grew most there
- the algae and shaded plants then **died**
- **decomposers** fed on the dead material and multiplied
- their **aerobic respiration** used up the dissolved oxygen faster than it could be replaced

(c)

- by 10 km most of the nitrate has been used up or diluted, so far fewer algae die
- the decomposers therefore use less oxygen, and oxygen dissolves back into the water from the air as the river flows

(d)

- at 2 km there is almost **no dissolved oxygen**, so only a species that can survive at 1 mg per dm^3 can live there
- by 10 km the oxygen has recovered to 8 mg per dm^3, so many more species can respire and survive, giving greater **biodiversity**

(e)

- any **two** of: animals become **tangled** in it and drown or cannot feed; animals **swallow** it and it blocks the gut, so they starve; it breaks into small pieces that are eaten and pass along the **food chain**