2.3 Biogeochemical cycles

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS carbon cycle • carbon sink • nitrogen fixation • nitrification • denitrification • ocean acidification

Objective

Build the skills to answer exam questions on **biogeochemical cycles** : the **carbon cycle** and the **nitrogen cycle** , their stores and flows, and how humans change them.

You must be able to:

- name the stores and flows of the carbon and nitrogen cycles
- explain sinks and sources, and how fossil fuels and deforestation change the carbon cycle
- explain nitrogen fixation, nitrification, denitrification and ammonification
- evaluate human impacts such as fertilizer use and ocean acidification

1 Key knowledge and worked examples

■ Carbon and nitrogen cycles

carbon store	carbon flow
atmosphere (CO_2, CH_4)	photosynthesis: atmosphere → biomass
biomass (plants, animals)	respiration: biomass → atmosphere
soil and dead matter	decomposition, feeding
oceans (dissolved CO_2, shells)	dissolving into and out of the ocean
fossil fuels, limestone	combustion; weathering

A **sink** stores more carbon than it releases (a growing forest, the ocean); a **source** releases more than it stores (burning fuels, cleared land). Burning fossil fuels moves carbon stored for millions of years into the atmosphere quickly; **deforestation** removes a sink and adds a source.

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Ocean acidification: CO_2 dissolves to form carbonic acid, lowering ocean pH. Shell-building animals (corals, molluscs) find it harder to build calcium carbonate shells.

nitrogen process	what happens	done by
nitrogen fixation	N_2 gas → ammonium (NH_4^+)	bacteria in soil and in legume root nodules; lightning; the Haber process
nitrification	ammonium → nitrite → **nitrate** (NO_3^-)	nitrifying bacteria (need oxygen)
assimilation	nitrate taken up to make proteins	plants
ammonification	proteins in dead matter and waste → ammonium	decomposers
denitrification	nitrate → N_2 gas	denitrifying bacteria, in waterlogged soil with little oxygen

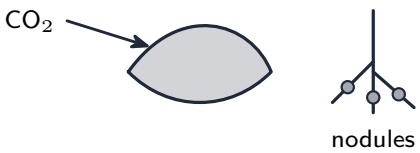
Fertilizers add nitrate and phosphate; runoff into water causes **eutrophication** (see 4.4).

Worked example. Fossil fuels add about 10 and land clearing about 1 GtC a year; the ocean and land sinks each take about 3: the atmosphere gains about $10+1-3-3 =$ **5** GtC a year.

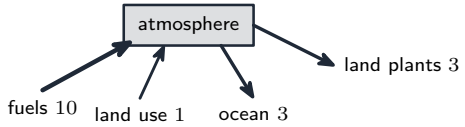
Answer shapes: name the store **and** the process; say which way carbon or nitrogen moves.

2 Practice

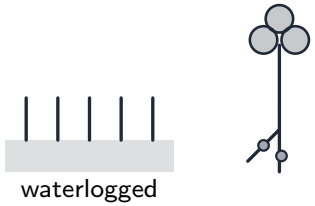
2.1 Name the process: (i) CO_2 is taken from the air into a leaf to make glucose; (ii) N_2 gas is changed to ammonium in root nodules. [2]



2.2 Each year, about 10 GtC of carbon is released by burning fossil fuels and 1 GtC by land clearing; the oceans absorb 3 GtC and land plants 3 GtC more than they release. (i) Calculate the yearly change in atmospheric carbon. (ii) Identify **one** sink and **one** source in the data. [3]



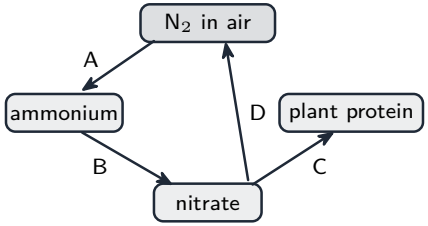
2.3 Explain why farmers on waterlogged soils lose nitrate faster, and why planting legumes such as beans or clover can reduce the need for fertilizer. [3]



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3 Exam-style questions

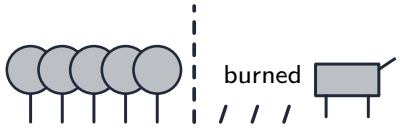
3.1 The diagram shows part of the nitrogen cycle.



(a) Name processes A and B. [2]

(b) Explain why ploughing that lets air into soil increases the nitrate in the soil. [2]

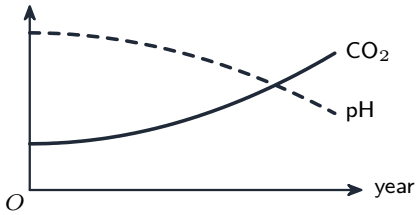
3.2 A large area of tropical rainforest is cleared and burned for cattle pasture.



(a) Explain **two** ways this changes the carbon cycle. [4]

(b) State **one** other effect of the clearing on a biogeochemical cycle. [1]

3.3 The ocean has absorbed about a quarter of the CO_2 released by human activity.



(a) Describe how the ocean takes in CO_2 and becomes more acidic. [2]

(b) Discuss the claim that the ocean "solves" the problem of carbon emissions. [4]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

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

2.1

(i) photosynthesis; (ii) nitrogen fixation

2.2

(i) $10 + 1 - 3 - 3 = +\mathbf{5}$ GtC a year; (ii) sink: oceans or land plants; source: fossil fuel burning or land clearing

2.3

waterlogged soil has little oxygen; denitrifying bacteria then change nitrate to N_2 gas, which is lost to the air; legumes have nitrogen-fixing bacteria in root nodules, which add ammonium to the soil when the plants die or are ploughed in

3.1

(a) A: nitrogen fixation (N_2 to ammonium); B: nitrification (ammonium to nitrate)

(b) nitrifying bacteria need oxygen; more oxygen speeds up nitrification, and denitrification slows

3.2

(a) burning moves carbon from biomass into the atmosphere quickly as CO_2; the forest was a sink, so less CO_2 is removed by photosynthesis in future, and soil carbon is lost as the soil is exposed and decomposes

(b) any one: nutrients (nitrogen) are lost in runoff and leaching; cattle release methane; less transpiration changes the water cycle

3.3

(a) CO_2 dissolves in surface water; it reacts with water to form carbonic acid, so the pH falls

(b) award up to [4]: the ocean slows the rise of atmospheric CO_2 and so slows warming; but acidification harms corals, shellfish and plankton with carbonate shells, and the food webs that depend on them; warmer water dissolves less CO_2, so the sink may weaken; conclusion: the ocean delays the problem and creates another, so emissions still must fall

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