LESSON MAKER PRO

Where Carbon Goes

Use carbon budgets to explain changes in the atmosphere and climate.

HIGH SCHOOL · BIO.5.3

BIO.5.3 "Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases on the carbon dioxide cycle and global climate."

NAME _____ DATE _____

TRACK THE CARBON

In a simplified yearly carbon budget, CO_2 added to the atmosphere equals human emissions minus land uptake minus ocean uptake. When CO_2 builds up in the atmosphere, it strengthens the greenhouse effect and contributes to global warming.

WORKED EXAMPLE

Use the model data to find how much CO_2 is added to the atmosphere in one year.

MODEL CARBON BUDGET

Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
39	13	7

1. Subtract land uptake from emissions: 39 - 13 = 26 Gt CO_2.
2. Subtract ocean uptake: 26 - 7 = 19 Gt CO_2.
3. The remaining CO_2 is added to the atmosphere.

Answer: 19 Gt CO_2 added to the atmosphere

PRACTICE 6 problems

1 Use the table. How much CO_2 is added to the atmosphere?

YEARLY CARBON BUDGET

Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
40	12	10

ANSWER _____

2 Use the table. Find the atmospheric CO_2 addition in each year, then state how much it changed.

TWO YEARLY CARBON BUDGETS

Year	Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
2020	28	8	8
2030	34	10	10

ANSWER _____

3 Use the table. What fraction of emitted CO_2 is added to the atmosphere? Simplify your fraction.

YEARLY CARBON BUDGET

Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
32	8	8

ANSWER _____

4 These model runs differ only in atmospheric CO_2. How much higher is the temperature anomaly in run B? What effect of CO_2 does the model show?

CLIMATE MODEL RUNS

Run	Atmospheric CO2 (ppm)	Global temperature anomaly (°C)
A	400	1.0
B	420	1.2

ANSWER _____

5 A drought reduces land uptake in a carbon budget model. How much more CO_2 is added to the atmosphere during the drought? Explain why.

NORMAL YEAR AND DROUGHT YEAR

Condition	Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
Normal	36	12	10
Drought	36	8	10

ANSWER _____

6 The two model scenarios have equal emissions. Which scenario adds less CO_2 to the atmosphere, and by how much?

CARBON BUDGET SCENARIOS

Scenario	Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
A	46	16	10
B	46	18	12

ANSWER _____

APPLY IT Show your work

1 Your school climate club reviews a model of a worldwide transport plan. The plan reduces yearly emissions, while land and ocean uptake stay the same. What percent does the yearly addition of CO_2 to the atmosphere decrease? Explain what that means for the buildup of this greenhouse gas.

WORLDWIDE TRANSPORT PLAN MODEL

Scenario	Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
Before plan	42	12	10
With plan	38	12	10

ANSWER _____

2 A student sports group compares two future climate model runs to plan for outdoor practice. The runs differ only in atmospheric CO_2. How much higher is the global temperature anomaly in run B? Explain what the comparison suggests about CO_2 and climate.

FUTURE CLIMATE MODEL RUNS

Run	Atmospheric CO2 (ppm)	Global temperature anomaly (°C)
A	430	1.2
B	450	1.5

ANSWER _____

CHALLENGE One step up

In a simplified model, every 8 Gt of CO_2 added to the atmosphere raises its concentration by 1 ppm. The starting concentration is 420 ppm. Use the table to find the concentration after both years. Then explain why CO_2 can keep building up even though emissions fall in the second year.

TWO-YEAR CARBON BUDGET

Year	Emissions (Gt CO2)	Land uptake (Gt CO2)	Ocean uptake (Gt CO2)
First	40	12	12
Second	36	8	12

WORK SPACE AND ANSWER

Where Carbon Goes

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Use the table. How much CO_2 is added to the atmosphere?	**18 Gt CO_2**
2	Use the table. Find the atmospheric CO_2 addition in each year, then state how much it changed.	**2020: 12 Gt CO_2; 2030: 14 Gt CO_2. The yearly addition increased by 2 Gt CO_2.**
3	Use the table. What fraction of emitted CO_2 is added to the atmosphere? Simplify your fraction.	**1/2**
4	These model runs differ only in atmospheric CO_2. How much higher is the temperature anomaly in run B? What effect of CO_2 does the model show?	**The anomaly is 0.2°C higher in run B. In this model, more atmospheric CO_2 raises global temperature.**
5	A drought reduces land uptake in a carbon budget model. How much more CO_2 is added to the atmosphere during the drought? Explain why.	**The drought adds 4 Gt more CO_2 to the atmosphere. Land takes up 4 Gt less while emissions and ocean uptake stay the same.**
6	The two model scenarios have equal emissions. Which scenario adds less CO_2 to the atmosphere, and by how much?	**Scenario B adds 4 Gt less CO_2 to the atmosphere. A adds 20 Gt, and B adds 16 Gt.**

PART 2 · APPLY IT

1. **The yearly atmospheric addition decreases by 20%. CO_2 still builds up, but more slowly.** Before the plan, 42 - 12 - 10 = 20 Gt; with the plan, 38 - 12 - 10 = 16 Gt. The decrease is 4/20 = 20%.
2. **Run B has a 0.3°C higher anomaly. The model suggests that more atmospheric CO_2 increases global temperature.** Subtract the anomalies: 1.5 - 1.2 = 0.3°C. Because CO_2 is the only difference between the runs, the model links the higher concentration to the higher temperature.

CHALLENGE

The final concentration is 424 ppm. Each year adds 16 Gt CO_2, so the two years add 32 Gt, or 4 ppm. Emissions fall in the second year, but land uptake also falls, leaving the atmospheric addition unchanged.

Accept equivalent wording that distinguishes a slower CO_2 buildup from a decrease in atmospheric CO_2. The model comparisons support a temperature effect when CO_2 is the only changed factor.