Name: ____ **Date:** ___________________________

Period: __________ **AP Environmental Science**

BALANCING THE CARBON BUDGET

The cycling of carbon through photosynthesis and respiration is only part of the global cycling of carbon. Geochemical processes also contribute to carbon cycling. Biological processes transfer carbon between organisms and the environment; geochemical processes transfer carbon between sedimentary rocks and the atmosphere, oceans and living organisms. Biological processes are relatively short term, occurring over years to hundreds of years while geochemical processes work on a time scale of millions of years.

Carbon occurs primarily as carbon dioxide (CO_2) in air and water, organic carbon (proteins, fats, carbohydrates, and nucleic acids) in living and dead organisms, and carbonate ions (CO_3^{-2}) in water, rocks, shells, and bones. To understand how these are connected in a cycle, it is useful to think in terms of sources, sinks, and fluxes. Sources are carbon emitters; sinks are carbon absorbers; fluxes are flows of carbon between sources and sinks. A source may also be a sink. For example, the atmosphere is a source of carbon dioxide for photosynthesis, but it is also a sink for carbon released during respiration, burning, and decay.

Because carbon dioxide is a greenhouse gas, scientists are concerned that continued increases in atmospheric carbon may lead to global climate change.

In this activity you will model the carbon reservoirs and fluxes and consider what might happen to the increasing carbon dioxide produced by human activities.

Table 1: Carbon Reservoirs

Reservoir	Carbon in Gt
Ocean surface	1,000
Ocean life	6
Organic material in ocean	1,000
Deep ocean water	38,000
Ocean sediments	3,000
Sedimentary rocks	100,000,000
Soil	1,600
Fossil fuels	4,000
Living land organisms	600
Atmosphere	750

Table 2: Carbon Fluxes

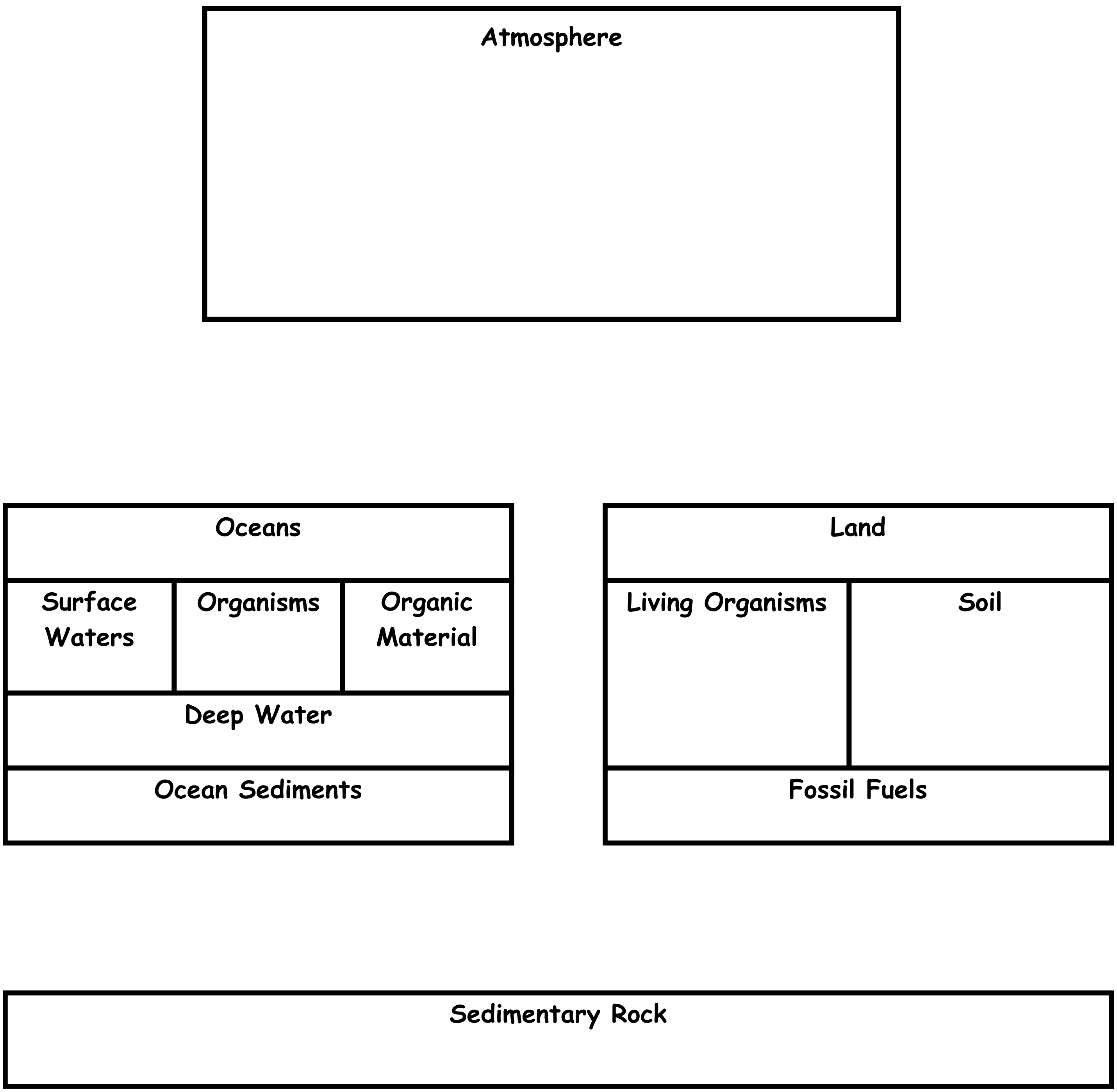
Direction of Movement	Flux (Gt/yr)
Ocean to atmosphere	102
Atmosphere to ocean	105
Ocean surface to deep waters	39
Deep waters to ocean surface	37
Ocean surface to ocean life	28
Ocean life to ocean surface	29
Soil to atmosphere	60
Life on land to soil	60
Life on land to atmosphere	50
Atmosphere to life on land	110
Deforestation to atmosphere	1.6
Fossil fuel combustion to atmosphere	5.4

1. Use the information in the table "Carbon Reservoirs" to complete the diagram of the global carbon cycle. Put the number of gigatonnes of carbon stored in each reservoir in the small boxes in each reservoir. One gigatonne (Gt) equals 1,000 million tones, and 1 tonne equals 1,000 kg.

2. Table 2 shows the fluxes of carbon between reservoirs, measured in gigatonnes of carbon per year (Gt/yr). Add these fluxes to the diagram of the global carbon cycle.

→ **Clearly label each line and indicate the direction of flow.**
Using different colors make it easier to distinguish between each line and the data.

Global Carbon Cycle



3. Calculate the net flux for the atmosphere, the land, and the oceans. Show your work, including units! *Note: 102 Gt/yr are going to the atmosphere and add to the CO_2 to the atmosphere, so this is +102, however 105 Gt/yr ar going to the oceans from the atmosphere, so this is -105 Gt/yr.*

(Recall the law of conservation of matter to check your answer!)

Add Fluxes	Atmosphere	Land	Oceans
Sum of Fluxes			
Net Flux			

4. The average time that carbon atoms spend in a reservoir is called the residence time. You can calculate residence time by dividing the number of gigatonnes of carbon in the reservoir by the total flux **from** that reservoir. For example, to calculate the residence time of carbon in the atmosphere, divide the total amount of carbon in the atmosphere (750 Gt) by the total flux out (105 Gt to ocean + 110 Gt to life on land).

$$\frac{750\ Gt}{215\ Gt/yr} = 3.5\ years$$

Calculate the average residence time for carbon in living land organisms, for carbon in soil, and for carbon in the ocean. **Show your work, including units!**

Living Land Organisms	**Carbon in soil**	**Carbon in the Ocean**

CARBON BUDGET

<u>Discussion</u>:

5. Which is the largest reservoir of carbon?

6. Which is the second largest reservoir of carbon?

7. Which fluxes release carbon into the atmosphere?

8. Which fluxes facilitate diffusion carbon into the atmosphere?

9. Which fluxes are the result of human activity and where is the carbon coming from and going to? Which on is the fastest?

10. Which fluxes remove carbon from the atmosphere? Which of these is the fastest?

11. What is one carbon flux and sink that humans have the ability to increase in capacity?

12. Why is residence time important in terms of carbon sequestration and climate change mitigation?

13. In addition to absorbing carbon dioxide, the ocean is also absorbing heat from the atmosphere. However, the ocean has a limit to the amount of carbon dioxide and heat that it can absorb. What do you think will happen to the atmosphere when the ocean reaches it's upper limit in terms of heat and CO_2 absorption?