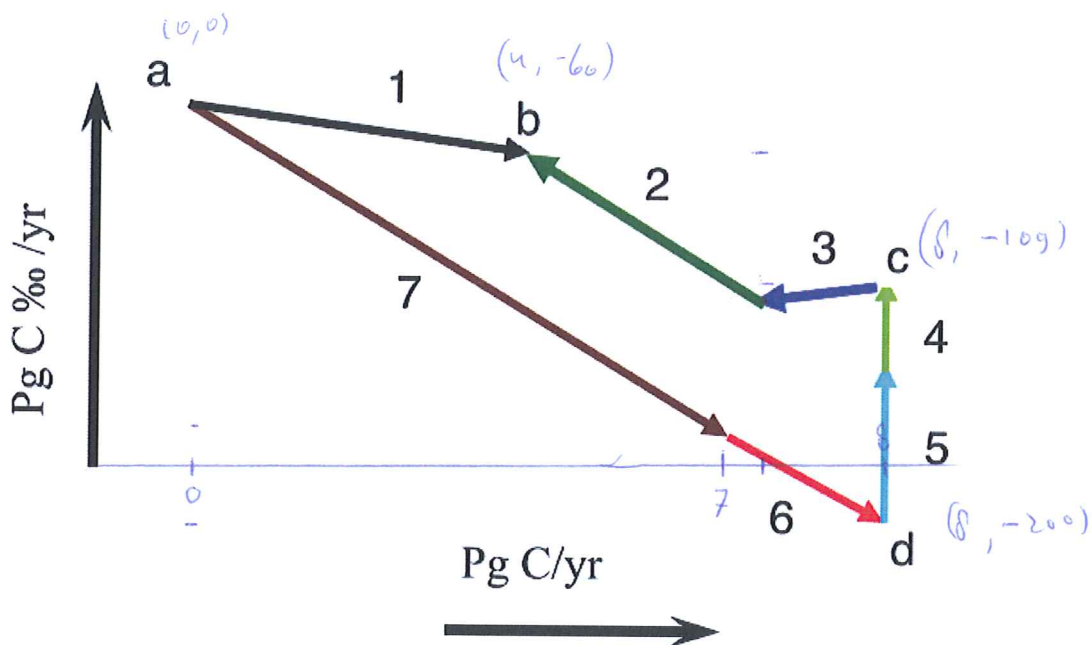


- please write name and student number on each sheet of paper you hand in
- please use a separate sheet of paper for each question

points per question: 1.5/2/1.5/2/2

1.



The plot above shows the average balance of the global Carbon Cycle per year.

Assume the points to be: $a = (0; 0)$ $b = (4; -60)$ $c = (8; -109)$ $d = (8; -200)$

- Explain the units on the axes.
- Explain the meaning of the arrows by number, including their direction.
Give a rough number for the respective slopes.
- How large is the net annual atmosphere \rightarrow ocean uptake on average?

2.

a) What is the definition of the fractionation factor α ?

b) Assume for the fractionation factor: ${}^{m+1}\alpha = \frac{m+1}{m}$ with m the abundant isotope mass. What is ${}^{m+2}\alpha$ in terms of ${}^{m+1}\alpha$?

c) The same question as (b) but now for ${}^{m+2}\delta$ in terms of ${}^{m+1}\delta$.

d) Explain how this can be used for fractionation corrections in ${}^{14}\text{C}$ dating.

3.

How did the temperature in recent decades change around the North Pole and South Pole? Give several reasons (at least 3) why both areas behaved differently.

4.

Given: half-life ${}^{14}\text{C}$ = 5568 yr (conventional), or 5730 yr (physical)

a) What is the average ${}^{13}\delta$ value for a C3 plant, and what for a C4 plant?

b) A tree ring from a C3 type tree (with this average ${}^{13}\delta$ value) is dated by ${}^{14}\text{C}$. The measured ${}^{14}\text{C}$ activity is 50%. What is the Radiocarbon age in BP for this tree ring?

c) Tree ring analysis shows that the absolute age of this tree ring is 4400 BC. What is the ${}^{14}\Delta$ value (in ‰) for the tree ring?

d) What does this mean in terms of ${}^{14}\text{C}$ content of the atmosphere, compared with the "standard" value?

(EXTRA) BONUS QUESTION:

e) What is the Radiocarbon age in BP for a C4 plant (with the average ${}^{13}\delta$ value for C4) with the same measured ${}^{14}\text{C}$ activity? Suppose this C4 plant also happens to date from 4400 BC, what would be its ${}^{14}\Delta$ value?

5.

Last month, an article was published in the journal *Science*, on climate change data recorded in a speleothem from Peru. The article features the figure shown on the next page. In the figure, the speleothem record (C, blue) is compared with ice from Greenland (B, green) and Antarctica (D, red).

a) explain the difference in the ${}^{18}\text{O}$ scales for B, C and D

b) explain briefly: what are the H events (in the figure H1-H5)

c) explain briefly: what are the D/O events (in the figure nr. 2-13)

d) what is the significance of the observation of these events in this speleothem, found in a cave in Peru in the Andes mountains

