

**ES2101 – Biogeochemical cycles and surface processes (Autumn, 2018)**  
**End-semester examination; Total marks: 50; Time allotted: 3 hours**  
**Calculations must be shown for numerical problems.**

**PART A**

1.a) The carbon emission rate from fossil fuels in 2000 was 6 Gt C/year. Estimate the fossil fuel carbon emission rate in 2030 using the following world growth data.

Population = 1.4%/year

Energy/GDP = -0.97%/year

GDP/person = 1.53%/year

Carbon/energy = -0.24%/year

1.b) Suppose carbon emissions associated with land use changes contribute an average of 1.2 GT C/year over this period of time. Assuming an airborne fraction of 46% estimate the carbon dioxide concentration change due to land use.

1.c) Calculate the total change in carbon dioxide concentration due to both fossil fuels and land use. What is the final carbon dioxide concentration in 2030 if the concentration in 2000 was 355 ppm? (4+4+7)

**PART-B**

2.a) The concentration of Pb in the blood of an individual is  $140 \mu\text{g L}^{-1}$ , and the individual's blood volume is 4.8 L. The net transfer of Pb to the bones followed by immobilization is  $7.5 \mu\text{g day}^{-1}$  while the excretion rate from the body is  $24 \mu\text{g day}^{-1}$ . Calculate the residence time of blood Pb in this individual.

2.b) The emission rate of CFC-114 (atmospheric lifetime: 300 y) in 1989 was  $2 \times 10^8 \text{ kg y}^{-1}$  and its mass in the atmosphere was  $4 \times 10^{10} \text{ kg}$ . Consider a scenario where the emission rate of CFC-114 was held constant from 1989 to 2000, followed by a complete phase-out as of 2000. Calculate the mass of CFC-114 in the atmosphere for the year 2050. (3+3)

3.a) With the help of a diagram, describe the Brewer-Dobson circulation that transports  $\text{O}_3$  from tropical regions toward the poles.

3.b) Consider the emission and transport of CFC-12 ( $\text{CF}_2\text{Cl}_2$ ) to the stratosphere. Describe with equations how would Cl released from this compound form temporary reservoir molecules in the stratosphere in the presence of NO and OH radical. (4+3)

4.a) What is the nitrogen cascade? Give two examples of how we can intervene in the nitrogen cascade to limit reactive nitrogen ( $\text{N}_r$ ).

4.b) Describe the direct and indirect effects of  $\text{N}_r$  emission on climate. (2+3+5)

5.a)  $\text{HO}_x$  and  $\text{NO}_x$  species catalyze  $\text{O}_3$  production in the troposphere – justify with the help of equations.

5.b) How might lake acidity be affected by soil type and water flow path in a lake watershed area? (4+4)

6.a) Write a brief note on the role of organic matter in the release of As to groundwater.

6.b) Provide a schematic diagram of the Hg cycle in a freshwater system.

**OR**

6.b) Briefly describe how emission control technologies installed in power plants can achieve Hg control as a secondary benefit. (2+2)