Examination, Science of Environmental Change. FFR 166
Oct 21, 2010, 8.30-13.30 in Hörsalsvägen

Note ! The time is 5 hours.

Aids:
- -Pocket calculator of category a "Chalmers-approved calculator":
  Casio FX82, Texas TI30, Sharp EL531 (checked by teacher on duty).
- -Language dictionaries.
- -Physical and mathematical tables.

Teacher on duty: Sten Karlsson, extension: 3149, mobile 0737-553398

Grading scale: 3: 37p, 4: 55p, 5: 73p (of total 92 points).
The achieved points from the three hand-ins (max 60) and the oral presentation (16) are weighted (14/76), rounded to nearest halfpoints and then added for grades 4 and 5. (Thus max 14 additional points.)

Write structured and if possible be concise. Use figures if they make your answers clearer. Your answers should prove *good understanding* of the subject.

Note! Always start on a *new paper* when you turn to the next question. Write your *exam code* on every paper.

Note! Your answers should be in *English*.

Katarina Gårdfeldt

1 a/ Which are the names of the elements in $CaCO_4$ and how many atoms of each element are found in one mole $CaCO_4$? (3p)

b/ In the chemical context, what is meant by a radical ? (1p)

c/ Which of the following species are radicals? NO_3, NO_2, NO, OH, OH^-, O, O_2, O_3 (4p)

2/ Methane is a greenhouse gas which may react with a hydroxyl radical in the atmosphere. Write a balanced reaction formula for the initial step. (2p)

3/ Why is the hydroxyl radical a daytime oxidant and the nitrate radical a night time oxidant ? (2p)

4/ Describe the layers in the atmosphere and why it is stratified i.e. explain the temperature profile. Present your answer by a picture and in words. (5p)

5 a/ Describe how photochemical smog is formed including the role of each component necessary for the formation. Discriminate between primary and secondary pollutants. Use reaction formulas and/or words. (5p)

b/ What is the end product when sulphur containing compounds are oxidised in the atmosphere? What is the ultimate fate of the end compound? (2p)

Sten Karlsson

6. a)
- Define the *residence time* and *age*, respectively, used when dealing with materials fluxes in the environment.
- Give an example of and explain a system in steady state, for which the *average age* is larger than the *average residence time*. (4p)

b) Estimate (give a rough figure and motivate) the *optical depth* of the cloud-free atmosphere for solar radiation in the visible spectra. (3p)

7. a) An isolated system (that is, it has no energy or materials exhange with the environment), which is not in equilibrium is left untouched. Draw and motivate a principal diagram showing the development over time for the system's energy, entropy and exergy, respectively. (2p)

b) A person keeps a house at 20 °C by using the wind resource: A wind power plant, which converts to electricity 35% of the kinetic energy in the wind resource hitting the wind turbine, drives an electrically driven air-to-air heat pump for heating of the house. The heat pump takes heat from the outdoor air and has an energy COP (coefficient of performance) of 4.5 at a temperature of 5 °C outside the house.
- Which exergy COP is achieved for the overall system (that is, from the wind energy flux hitting the turbine to the heat flux going into the house)? (3p)

8. a) Define the *lapse rate* concept used in atmospheric science and relate it to atmospheric *stability*. (3p)

b) Temperature and salinity is important parameters in the ocean density and circulation and are affected by the atmosphere above.
-How varies in general the salt concentration in the surface ocean from equator to pole?
-How is this variation connected to the atmospheric circulation? (3p)

9. C, N and S species can be utilized as electron acceptors in processes of oxidation of organic materials to yield energy/exergy.
- Gives examples of end product species in these processes for C, N and S, respectively.
- What is a common condition for these processes to take place? (4p)

10. Carbon turnover.
a) The oceanic uptake of carbon dioxide from the atmosphere is very important for the future possible build up of CO_2 concentration in the atmosphere.
- Describe shortly the processes controlling the future oceanic uptake and fluxes of CO_2 from the atmosphere. (4p)

b) What is meant by "the missing sink"?
How large is it?
And where is it plausibly according to current knowledge? (3p)

11. Identify and describe briefly the major human disturbances in the nitrogen turnover giving rise to emissions to the environment of nitrate (NO_3^-), ammonium (NH_3) and nitric oxide (NO), respectively ! (6p)

12 a) A new green house gas has been identified and you now shall calculate its *Global Warming Potential*.
- What data do you need to gather to be able to calculate the GWP for this substance? (3p)

b) Now political focus and talk are on avoiding a larger than 2 °C increase in Earth mean surface temperature.
- Which *climate sensitivity* is the maximum allowable if the maximum future *radiative forcing* will correspond to that of a doubling of the CO_2 concentration in the atmosphere from the preindustrial level? (2p)

c) What is meant by a *feedback* in the climate change discourse? Which are and how works the three major feedbacks in the climate system according to current knowledge? (4p)

Rod Stevens

13. Sketch a curve for water production over time (use production and time as axes) from a renewable water source. Indicate "Peak Water" production on this curve and indicate what is the limiting factor for "Peak Water" production".
(3p)

14. Sketch a curve for water production over time (use production and time as axes) from a groundwater source. Indicate what part of the curve is renewable and what part is non-renewable. Indicate "Peak Non-renewable Water" production on this curve. What factor is most limiting for the "Peak Renewable Water" production in this curve?
(5p)

Stefan Wirsenius

15. (Stefan W1) Identify the four major soil-forming processes and describe how these processes develop and shape soils. (4p)

16 . (Stefan W2) Explain the mechanisms of how nitrogen deposition causes actual soil acidification. Also describe the case in which nitrogen deposition *do not* cause actual soil acidification. For each case, make drawing(s) of the relevant flows in the soil-plant profile. (4p)

Kjell Wallin

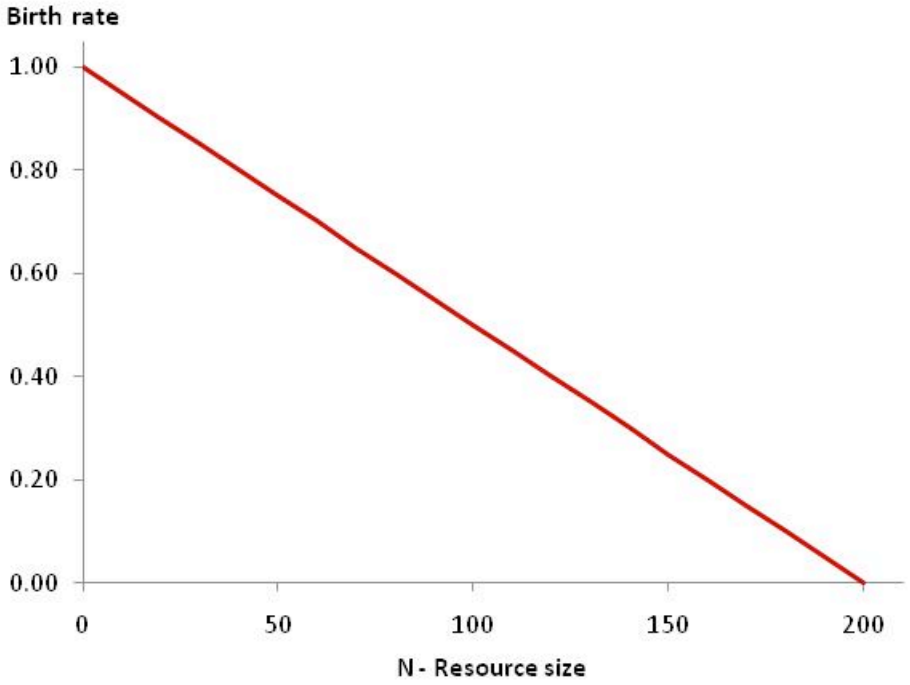
17. For Darwinian evolution to occur, three requirements are needed – which are those? (3p)

18. The development of every biological resource (N) over time is basically exponential. This pattern will depend of the birth (b) and death rate (d) of the individuals of the resource.
An expression for this would be

$$N_{t+1} = N_t(1+b_t-d_t)$$

This model assumes both birth rate and death rate to be constant over time (t)
If instead birth rate will depend on the size of the biological resource, as illustrated by the figure below,

a. How will the equation look like?
b. If the death rate equals 0.2, when will the biological resource stop to grow?
c. What is the maximum size of this biological resource? (5p)



IUPAC Periodic Table of the Elements

1												13	14	15	16	17	18
1 **H** hydrogen 1.007 94(7)	2																2 **He** helium 4.002 602(2)
3 **Li** lithium 6.941(2)	4 **Be** beryllium 9.012 182(3)											5 **B** boron 10.811(7)	6 **C** carbon 12.0107(8)	7 **N** nitrogen 14.0067(2)	8 **O** oxygen 15.9994(3)	9 **F** fluorine 18.998 4032(5)	10 **Ne** neon 20.1797(6)
11 **Na** sodium 22.989 769 28(2)	12 **Mg** magnesium 24.3050(6)	3	4	5	6	7	8	9	10	11	12	13 **Al** aluminium 26.981 5386(8)	14 **Si** silicon 28.0855(3)	15 **P** phosphorus 30.973 762(2)	16 **S** sulfur 32.065(5)	17 **Cl** chlorine 35.453(2)	18 **Ar** argon 39.948(1)
19 **K** potassium 39.0983(1)	20 **Ca** calcium 40.078(4)	21 **Sc** scandium 44.955 912(6)	22 **Ti** titanium 47.867(1)	23 **V** vanadium 50.9415(1)	24 **Cr** chromium 51.9961(6)	25 **Mn** manganese 54.938 045(5)	26 **Fe** iron 55.845(2)	27 **Co** cobalt 58.933 195(5)	28 **Ni** nickel 58.6934(2)	29 **Cu** copper 63.546(3)	30 **Zn** zinc 65.409(4)	31 **Ga** gallium 69.723(1)	32 **Ge** germanium 72.64(1)	33 **As** arsenic 74.921 60(2)	34 **Se** selenium 78.96(3)	35 **Br** bromine 79.904(1)	36 **Kr** krypton 83.798(2)
37 **Rb** rubidium 85.4678(3)	38 **Sr** strontium 87.62(1)	39 **Y** yttrium 88.905 85(2)	40 **Zr** zirconium 91.224(2)	41 **Nb** niobium 92.906 38(2)	42 **Mo** molybdenum 95.94(2)	43 **Tc** technetium [98]	44 **Ru** ruthenium 101.07(2)	45 **Rh** rhodium 102.905 50(2)	46 **Pd** palladium 106.42(1)	47 **Ag** silver 107.8682(2)	48 **Cd** cadmium 112.411(8)	49 **In** indium 114.818(3)	50 **Sn** tin 118.710(7)	51 **Sb** antimony 121.760(1)	52 **Te** tellurium 127.60(3)	53 **I** iodine 126.904 47(3)	54 **Xe** xenon 131.293(6)
55 **Cs** caesium 132.905 4519(2)	56 **Ba** barium 137.327(7)	57-71 lanthanoids	72 **Hf** hafnium 178.49(2)	73 **Ta** tantalum 180.947 88(2)	74 **W** tungsten 183.84(1)	75 **Re** rhenium 186.207(1)	76 **Os** osmium 190.23(3)	77 **Ir** iridium 192.217(3)	78 **Pt** platinum 195.084(9)	79 **Au** gold 196.966 569(4)	80 **Hg** mercury 200.59(2)	81 **Tl** thallium 204.3833(2)	82 **Pb** lead 207.2(1)	83 **Bi** bismuth 208.980 40(1)	84 **Po** polonium [209]	85 **At** astatine [210]	86 **Rn** radon [222]
87 **Fr** francium [223]	88 **Ra** radium [226]	89-103 actinoids	104 **Rf** rutherfordium [261]	105 **Db** dubnium [262]	106 **Sg** seaborgium [266]	107 **Bh** bohrium [264]	108 **Hs** hassium [277]	109 **Mt** meitnerium [268]	110 **Ds** darmstadtium [271]	111 **Rg** roentgenium [272]							

57 **La** lanthanum 138.905 47(7)	58 **Ce** cerium 140.116(1)	59 **Pr** praseodymium 140.907 65(2)	60 **Nd** neodymium 144.242(3)	61 **Pm** promethium [145]	62 **Sm** samarium 150.36(2)	63 **Eu** europium 151.964(1)	64 **Gd** gadolinium 157.25(3)	65 **Tb** terbium 158.925 35(2)	66 **Dy** dysprosium 162.500(1)	67 **Ho** holmium 164.930 32(2)	68 **Er** erbium 167.259(3)	69 **Tm** thulium 168.934 21(2)	70 **Yb** ytterbium 173.04(3)	71 **Lu** lutetium 174.967(1)
89 **Ac** actinium [227]	90 **Th** thorium 232.038 06(2)	91 **Pa** protactinium 231.035 88(2)	92 **U** uranium 238.028 91(3)	93 **Np** neptunium [237]	94 **Pu** plutonium [244]	95 **Am** americium [243]	96 **Cm** curium [247]	97 **Bk** berkelium [247]	98 **Cf** californium [251]	99 **Es** einsteinium [252]	100 **Fm** fermium [257]	101 **Md** mendelevium [258]	102 **No** nobelium [259]	103 **Lr** lawrencium [262]

Key:

atomic number
Symbol
name
standard atomic weight

Notes

- "Aluminum" and "cesium" are commonly used alternative spellings for "aluminium" and "caesium."
- IUPAC 2005 standard atomic weights (mean relative atomic masses) as approved at the 43rd IUPAC General Assembly in Beijing, China in August 2005 are listed with uncertainties in the last figure in parentheses [M. E. Wieser, *Pure Appl. Chem.*, in press]. These values correspond to current best knowledge of the elements in natural terrestrial sources. For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.
- Elements with atomic numbers 112 and above have been reported but not fully authenticated.