Examination, Science of Environmental Change. FFR 166
25 Oct 2007, 8.30-12.30 in M-buildings

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.

Grading scale: 29, 43, 57 points (of total 72).
Maximum 10 points from hand-ins added for grades 4 and 5. (The points are weighted and rounded to nearest halfpoints.)

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 name on every paper.

Note! Your answers should be in *English*.

Evert Ljungström:

1 a/ Any element E in the periodic table may be given in the form ${}^{a}_{b}E$. What is the meaning of a and b? (1p)

b/ If b above equals 13, which is the element E? (1p)

c/ Concentrated sulphuric acid contains 96% (by weight) of H_2SO_4 How many moles of H_2SO_4 do you have in 100 kg? (2p)

2 a/ Write a balanced reaction formula for the process where CFC12 (CF_2Cl_2) reacts with water vapour, forming e.g. hydrochloric- and hydrofluoric acid. (1p)

b/ Judge if the reaction above may take place spontaneously. Use the data given below. Comment on the result – is it what you would expect for a ChloroFluoroCarbon (freon) compound? (3p)

$\Delta_f G^o$ CF_2Cl_2 = - 493 kJ mol^{-1}
$\Delta_f G^o$ H_2O = - 229 kJ mol^{-1}
$\Delta_f G^o$ CO_2 = - 394 kJ mol^{-1}
$\Delta_f G^o$ HF = - 273 kJ mol^{-1}
$\Delta_f G^o$ HCl = - 93 kJ mol^{-1}

3/ You need a hot flame for welding and you burn acetylene C_2H_2 in pure oxygen. You measure an oxygen concentration of 6% (by volume or mole) in your resulting combustion gas. How many % water vapour is there in the same gas? (4p)

4/ Which are the main atmospheric, anthropogenic pollution sources for sulphur, oxidised nitrogen and volatile organic compounds? (3p)

5 a/ Air pollutants very often have to be transformed in order to be removed from the atmosphere. Which is the main species that starts such reactions? How is it produced? (formula please) and what properties does it have. (2p)

b/ Photochemical smog needs 3 "components" to form. Describe briefly, with reaction formulas or words, the contribution of each of these (or as many as you know) to the formation of ground level ozone. (3p)

Sten Karlsson:

4. a/ The maximum energy efficiency of a photovoltaic cell achieved so far (or at least at that time last year) is 40.7 %, according to http://www.news.com/Solar-cell-breaks-efficiency-record/2100-11395_3-6141527.html.

The standard procedure to measure solar cells is at a spectrum AM1, that is, a spectrum corresponding to the solar spectrum at earth's surface when the solar radiation has gone through "1 (one) atmospheric masses" (AM1), which means the spectrum at the earth's surface when the sun is in zenit (perpendicular to the earth surface) and there is no clouds of course.

- Now, estimate and explain roughly the *exergy efficiency* of this cell ? (2p)

b/ The maximum radiance intensity [W/(m^2, μm, sr)] of solar radiation is in the visible part of the spectrum, at ≈ 0.5 μm. Estimate from this and explain the wavelength for the maximum radiance intensity of the heat radiation leaving the Earth. (2p)

5 a/ Describe and explain the average vertical profiles in the troposphere/stratosphere of CO_2 and H_20 respectively. (3p)

b/ What is the ITCZ? Explain why there today is a marked change in concentration of many atmospheric pollutants across the ITCZ. (2p)

6/ In the ocean there is a balance between the different inorganic carbon species

CO2/H2CO3, $HCO3^-$, $CO3^{2-}$

Adding CO2 to the atmosphere will lead to ocean acidification.

- What is the ocean pH today? (1p)
- In what direction (increase/decrease) will each of the species above change with the addition? (2p)
- How is this connected to possible dissolution of corals? (1p)

7/ For the carbon turnover in the ocean, describe the so called biological pump and its contribution to the carbon fluxes. What is the further fate of the carbon transported by this pump? (4p)

8 a/ Describe the principal compounds and processes (including N oxidation number and energy changes) in the biogenic turnover of nitrogen. (4p)

b/ When you burn a fuel, which factors are important for the net addition of reactive nitrogen to the ecosphere? (3p)

9/ Future carbon balance and flows are of great importance.
a/ Define and explain the *buffer factor.* (1p)
b/ What is "the missing carbon sink" (1p)
c/ Define *climate sensitivity.* (1p)
d/ How large is the climate sensitivity according to current knowledge (as suggested by IPCC) ? (2p)
e/ An increase of 2 degrees Celsius has been considered a limit for avoiding dangerous climate change and is also a policy goal put forward by EU. Sketch qualitatively the relation between climate sensitivity and possible future scenarios for CO_2 emissions for stabilising the mean surface temperature change at 2 degree Celsius above preindustrial level (For simplicity, disregard the effect of other greenhouse gases.) (3p)

Rod Stevens:
10/ Define/explain the concepts below, discussed in Oki & Kanae
- Green water and blue water, respectively
- Water scarcity index
- "virtual water trade" (4p)

Stefan Wirsenius:
11/ Small soil particles, soil colloids, carry ionic charges on their surface.
a) Explain how these ionic charges occur (i.e. the source of the charges). (2p)
b) Describe the influence of these charges on the properties of soils. (2p)

12/ In the U.S. and western Europe, reductions in sulphur emissions over the past decades have been much greater than those of nitrogen emissions. Why? Answer by describing the different circumstances of decreasing sulphur and nitrogen emissions. (4p)

Sverker Molander:
13/ The eutrophication of the Baltic Sea is a major environmental problem. Describe the general processes responsible for the main effects *by sketching a conceptual model* that starts with the addition of limiting nutrients and shows the links to three of the main effects. (6p)

14/ What is an environmental indicator, and what are they good for? (2p)