Examination, Science of Environmental Change. FFR 166
Oct 22, 2010, 14.00-19.00 in V-buildings

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: 40, 60, 80 points (of total 100).
A maximum 14 points from hand-ins and oral presentation is 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 *exam code* on every paper.

Note! Your answers should be in *English*.

Evert Ljungström:

1 a/ Which is the name of the element and how many protons, neutrons and electrons do you find in the isotope $^{37}_{17}Cl$? (2)

b/ What is meant by a "strong acid"? (1)

c/ What happens during "oxidation" of an atom or substance? (1)

d/ How is the concept of pH defined? (1)

2 a/ Laughing gas (N_2O) is a common oxidising agent when very hot flames are desired. Write a balanced reaction formula for the process where methane burns with N_2O, forming carbon dioxide, molecular nitrogen and water. (1)

b/ You have 3000 g of the iron ore Fe_2O_3. How much (mass!) pure iron could you produce from this starting material? It is done by reacting the ore with carbon (coke) at high temperature, also producing carbon dioxide. (4)

3 a/ Find out if the gas phase reaction $CF_2Cl_2 + 2\ H_2O$ ---> $CO_2 + 2\ HF + 2\ HCl$ could be spontaneous or not.

$\Delta_r G^0$ (CF_2Cl_2)	-439.4 (kJ/mole)
$\Delta_r G^0$ (H_2O)	-228.6
$\Delta_r G^0$ (CO_2)	-394.4
$\Delta_r G^0$ (HF)	-275.4
$\Delta_r G^0$ (HCl)	-96.3

(3)

b/ Comment on your result and the fact that CF_2Cl_2 belongs to the CFC-group of chemicals, known for its stability. (1)

4/ Describe briefly the main anthropogenic and natural sources to the atmosphere for nitrogen oxides. (3)

5 a/ The sulphur containing compounds that are emitted (anthropogenic and natural) to the atmosphere disappear through transformation into a stable substance – which? (1)

b/ Describe in as much detail as you can how SO_2 is transformed in the atmosphere. (4)

c/ There is one single species that is central to reactions in the atmosphere. It is sometimes known as the "cleaning lady" of the atmosphere. Which is this species (name and formula)? How is it formed? (2)

Sten Karlsson

6. a) - Define *turnover time,* used when dealing with materials fluxes and reservoirs in the environment.
- Why is the turnover time for carbon dioxide in the atmosphere much shorter then the residence time for CO_2 emitted into the atmosphere by humans? (3p)

b) Water is in the atmosphere in the form of gas molecules and clouds (ice or droplets).
- Describe the interaction of long-wave (heat) radiation with these two forms, respectively. (4p)

c) Order from largest to smallest the following four global fluxes of energy: the creation of kinetic energy in the atmosphere, the creation of kinetic energy in the ocean, heat flow from the crust to Earth surface, and the photosynthesis. (3p)

7. a) Give the energy quality (i.e., exergy/energy) for these renewable energy flows:
- wind energy
- energy bound in photosynthesis
- solar energy (3p)

b) The in Sweden very popular air-to-air heat pumps have in tests an energy COP (heat out/electricity in) of 5, when they pump energy from outdoor air of 7 °C to 20 °C indoor. (This value holds for measurement at 50 % of maximum load.)
- Calculate which energy COP an air-to-water heat pump should have, when pumping energy from the same outdoor air (7 °C) to hot water of 60 °C, if it had the *same exergy efficiency* as the air-to-air heat pump described above? (4p)

8 For atmospheric science,

- define the *adiabatic lapse rate* and the *lapse rate,* respectively,
- and explain how these concepts are used when discussing atmospheric stability. (4p)

b) In the ocean there are different inorganic carbon species dissolved.

- Which species?
- In what direction (increase/decrease) will the concentrations of each of these species change as a consequence of an increase in the biomass reservoir in the ocean through enhanced photosynthesis? (4p)

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

10. Describe the *biological pump* and its effect on the carbon fluxes and reservoirs. (5p)

11. NO_x emissions are still a major environmental problem. Identify the three major processes contributing to NO_x emissions in burning of a fuel and the sources of their nitrogen, respectively? (4p)

12. a) Define *global warming potential.* For a specific gas you can calculate a value of the global warming potential. Discuss which factors will influence the value you come up with. (4p)

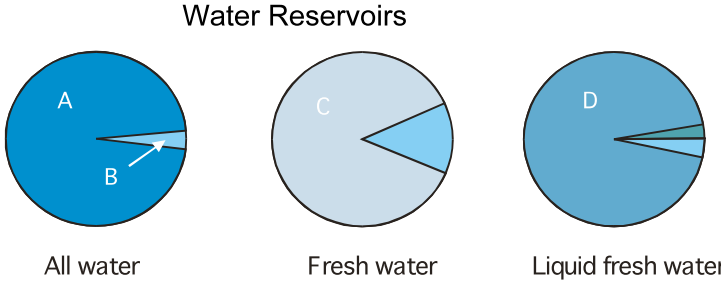
b) Discuss the relation between the concentration of a greenhouse gas in the atmosphere and its radiative forcing. (3p)

Rod Stevens

13.a) Define the following: (5p)

a. *Virtual Water Trading*
b. *Confined aquifer*
c. *Artificial infiltration*
d. *Exogeneous water*
e. *Renewable Fresh Water Resources*

b) In the figures below, identify the water reservoirs indicated by A-D. (2p)



Stefan Wirsenius

14.a)

What is weathering and what important functions does weathering have in the biogeochemical cycles? (2p)

b) What are "secondary minerals"? Describe how they are formed, and specify major categories of secondary minerals. (2p)

15.

Explain the mechanisms of how harvest of biomass may cause soil acidification – describe the mechanisms by making a drawing of the relevant flows in the soil-plant profile. Also describe options for alleviating soil acidification caused by harvest. (4p)

Kjell Wallin

16. (3p)

The process of natural selection can cause the average appearance of a character to evolve. An example of such a character might be body mass in the cod. Such a change will alter the cod's value as a resource for us humans. Three typical changes can be recognized

1. The average body mass change over time.
2. The average body mass does not change, but the population variance decreases.
3. The average body mass does not change, but the population variance increases.

How does natural selection look like in these three cases, respectively, that make such changes to occur?

17. (5p)

An optimal use of a resource depends on the objective of its use. Thus, there is not a single best way of using a resource, independent of the objective. For instance consider open access fishing in the sea. How and why does an optimal solution differ when the objective is just to produce as much food as possible compared to gain as much money as possible?

Thomas Backhaus

For assessing the risks of chemicals in the environment, an evaluation of their hazard and their exposure is necessary.

18) The environmental hazard of a chemical is often described on the basis of the so-called "base set" of data, i.e. data from algae, daphnids and fish. Describe the reasons behind the selection of these test organisms and briefly discuss its limitations. (4p)

19) The exposure to a certain chemical can be evaluated either via modeling approaches or via actual chemical-analytical measurements. Briefly discuss the pros and cons of both approaches. When would you use which? (4p)

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.