CORSO DI "ELEMENTI DI CHIMICA VERDE E SOSTENIBILE"
Verifica scritta del 06 Febbraio 2015 (prima parte)

1) *List four ways in which the chemical industry can be made more sustainable.

2) CFCs were invented in 1928. They were widely used in the 20th century and are now being phased out.
   a) What are the useful properties of CFCs? Name three typical uses for these compounds.
   b) Why was the use of CFCs banned by the Montreal Protocol?
   c) Write out the reactions of CCl_3F which lead to ozone depletion.

3) Calculate the atom economy, E factor and RME for the following stoichiometric vs. catalytic oxidation of 1-fenylethylalcohol (if the yield is 95% in both cases with stoichiometric amount of reagents).

   $3\ Ph\text{-}CH(OH)CH_3 + CrO_3 + 3\ H_2SO_4 \rightarrow 3\ Ph\text{-}COCH_3 + Cr_2(SO_4)_3 + 6\ H_2O$

   $Ph\text{-}CH(OH)CH_3 + ½\ O_2 \rightarrow Ph\text{-}COCH_3 + H_2O$

4) Bioenergy policies: Legislation, EU directives and agreements concerning biofuels.

5) Discuss briefly the benefits, properties and bottlenecks of Hydrogen as a fuel.

6) Pollution prevention is an integral component of waste management practices. Which of the following is not included in the hierarchy of pollution prevention techniques?
   a) recycling/reuse/recovery, b) storing less material on-site, c) treatment, d) land disposal, e) source reduction, f) all of the above

7) *An accident-prevention program must include:
   a) regular monitoring, b) formal and regular procedures, c) procedures that ensure proper disposal of waste chemicals, d) regular safety inspections, e) all of the above. Give examples of the correct answers.

8) What an LD50 of 20 in mice indicates? What the label CORROSIVE on a chemical container indicates? Which are the major factors in toxicity?

9) (a) On the basis of LCA (Life Cycle Assessment - reported in the table and figure) list the following organic solvents in order of decreasing greenness: butyl acetate ($CH_3COOn\text{-}C_4H_9$); acetonitrile (CH_3CN); acetone (CH_3COCH_3); pentane (C_5H_{12}); and diethyl ether ($C_2H_5OC_2H_5$)
   (b) Combining EHS (Environmental, Health and Safety) and LCA methods, which of the five is greenest?

10) Which is Your opinion on the following statement: "Approximately 50% of the elements we use can be obtained from agriculture, provided that we develop biorefineries that optimise biomass utilisation through advanced extraction and other separation techniques."

11) Hydrogen is considered to be an energy vector and not an energy source. Why? What is the hydrogen economy and which are the main challenges in this context?

12) Hydrogen is considered an energy vector and not an energy source. Why?. Briefly discuss benefits, properties and limits of this energy vector.

Table – CED and EHS data for common solvents.

* Chem. Eng.

Solvent	CAS-No	Solvent production per kg solvent / MJ-eq.	CED Solvent distillation per kg solvent/MJ-eq.	CED Solvent incineration CED per kg solvent/MJ-eq.
Acetic acid	64-19-7	55.9	-34.9	-15.5
Acetone	67-64-1	74.6	-53.6	-33.9
Acetonitrile	75-05-8	88.5	-79.6	-29.7
Butanol(1)	71-36-3	97.3	-74.6	-39.9
Butyl acetate	l23-86-4	121.6	-95.9	-34.1
Cyclohexane	110-82-7	83.2	-63.4	-53.5
Cyclohexanone	108-94-1	124.7	-99.7	-40.4
Diethyl ether	60-29-7	49.8	-31.9	-40.2
Dioxane	123-91-1	86.6	-63.8	-27.6
Dimethylformamide	68-12-2	91.1	-67.6	-25.9
Ethanol	64-17-5	50.1	-31.2	-31.7
Ethyl acetate	141-78-2	95.6	-72.0	-27.6
Ethylbenzene	100-41-4	85.1	-64.9	-49.8
Formaldehyde	50-00-0	49.3	-28.8	-15.9
Formic acid	64-18-6	73.9	-50.1	-4.7
Heptane	142-82-5	61.5	-43.7	-54.5
Hexane	110-54-3	64.4	-46.7	-55.2
Methylethylketone	108-10-1	64.2	-44.6	-37.6
Methanol	67-56-1	40.7	-21.7	-22.2
Methyl acetate	79-20-9	49.0	-29.2	-22.8
Pentane	109-66-0	73.2	-54.5	-55.3
Propyl alcohol (n-)	71-23-8	111.7	-87.3	-36.5
Propyl alcohol (i-)	67-63-0	65.6	-46.1	-36.5
Tetrahydrofuran	109-99-2	270.8	-230.7	-37.5
Toluene	108-88-3	80.0	-60.0	-49.3
Xylene	1330-20-7	72.5	-53.1	-49.9

*CED = Cumulative Energy Demand

Fig. 1 - EHS assessment of organic solvents

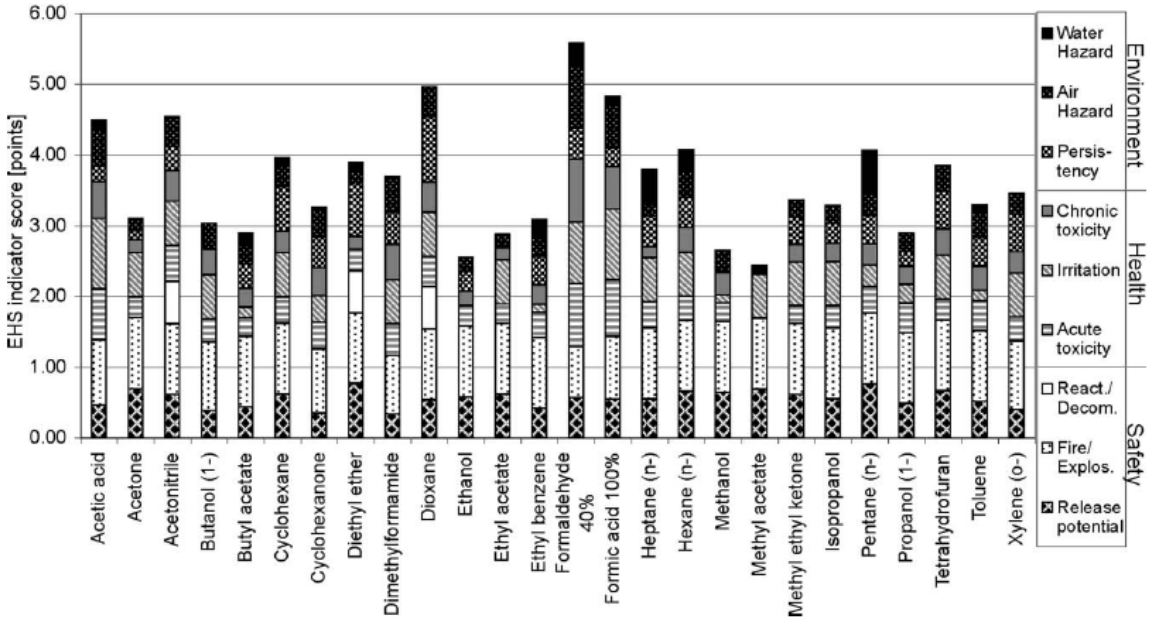

Fig. 2 Results of the EHS method for the 26 pure organic solvents (step (1) in the framework for the assessment of green solvents). The EHS result score is composed of environmental indicators (water and air hazard, persistency), as well as indicators for health (chronic and acute toxicity and irritation) and safety (reaction/decomposition, fire/explosion, release potential) hazards. The results were calculated using the EHS-Tool.[14]