

ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2012 SESSION

All documentation permitted
Calculators: Only authorized models permitted
Exam duration: 3 hours

Examen 04-ENV-A6 : Génie et gestion des déchets solides

1. Fundamentals (25 points)

- 1.1. (10 points) An average municipal solid waste (MSW) has been analyzed and the empirical chemical formula of its dry part was estimated as being $C_{16}H_{25}O_{11}N_{0.15}S_{0.03}$. Its moisture is 20% w/w. How its heating value (HV) can be calculated? Explain a precise scientific and an empirical method.
- 1.2. (5 points) What is the difference between the lower heating value (LHV) and the higher heating value (HHV)?
- 1.3. (5 points) Apply one of the two methods described in point 1.1 to calculate the LHV.
- 1.4. (5 points) Is it possible to recover all of the energy contained in this MSW? Justify scientifically your answer.

2. Municipal Solid Waste Landfills and Anaerobic decomposition (40 points)

The population of a municipality is 5 500 inhabitants. Each person produces daily 1.2kg of residual materials (annual mean); 20% of them are recycled. The rest is sent in a sanitary landfill. The average composition of the landfilled material is 70% putrescible organics and 30% inorganic on a mass basis. The putrefaction takes place under quasi-anaerobic conditions because only 5% of the stoichiometric oxygen reaches the landfilled material. The following data are available:

- The composition of the organic part can be approximated by the following formula: $C_{17}H_{27}O_{12}N_{0.15}S_{0.03}$.
- The organic material is decomposed anaerobically in CO_2 , CH_4 , H_2O , H_2S and NH_3 . The molar ratio of $CO_2(\text{total})/CH_4$ is equal to 0.7.
- It can be assumed that the 5% of the stoichiometric oxygen is used to convert only the H into H_2O .

Estimate the annual quantity and the composition of the so produced biogas at a barometric pressure of 750mmHg at 15°C. If the methane (CH_4) combustion heat at these conditions is 890 MJ/kmol CH_4 and it is possible to recover this energy as electricity with an efficiency of 25%, calculate the electric power potential in MW.

3. Municipal Solid Waste Management (20 points; 4 per sub-point)
 - 3.1. Give a typical composition of MSW in North America.
 - 3.2. Present briefly the MSW management methods.
 - 3.3. Give a list of the characteristic steps of operation of a sanitary landfill.
 - 3.4. Give all the known technologies of the MSW energetic valorization.
 - 3.5. What are the differences between incineration and gasification?

4. Dangerous solid waste and site contamination (15 points; 5 per sub-point)
 - 4.1. What are the objectives of the methods of solidification and stabilization? Present the techniques of stabilization and solidification. Describe the Pozzolan-Portland solidification technique.
 - 4.2. If you are the engineer responsible of a dangerous liquid materials storage, what are the measures you will establish to prevent and eventually contain an accidental spill.
 - 4.3. Describe the method of Bioreclamation used for site decontamination. What are the two alternatives and give a brief description of their operational steps. Donnez une brève description de chacune d'elles en termes d'étapes opérationnelles. Which one is faster?