COURSE "INTRODUCTION TO GREEN AND SUSTAINABLE CHEMISTRY"
Written exam - January 29, 2018 (part II)

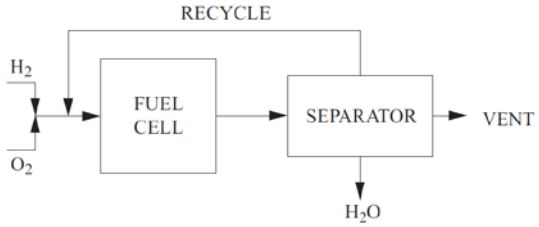
PLAGIARISM. The Course takes plagiarism very seriously. Cutting and pasting from an article or any another person's work is plagiarism, even if you cite them (the exception to this is quotations).

1) Process intensification (PI) was defined in 2007 by the European Roadmap of Process Intensification as "a set of often radically innovative principles (paradigm shift) in process and equipment design, which can bring significant benefits in terms of process and chain efficiency, capital and operating expenses, quality, wastes, process safety." Is this definition again valid ten years later or more details on the principles are now more clear so that were successfully applied? Provide examples to support your opinion.

2) In a recent survey of the concept of inherently safer processes (ISPs), the following definition was introduced: "ISP is best described as a philosophy for engineering design of material processing plants, rather than a specific set of technologies or processes. The ISP philosophy can be applied at all stages in the life cycle of a manufacturing plant, from early process invention and research, through development, plant design, operation, and eventual shutdown and demolition, and at all levels of design detail." Do you agree with this sentence or some details, especially on chemical processes, were omitted? Provide examples which support your opinion and clarify how the Layer of Protection Analysis (LOPA) methodology can be useful in the process industries for simplified, rule-based risk analysis.

3) State one major direct and one major indirect way two pollutants significantly affect the health of humans or the environment. Describe briefly the effect on humans or other species. Describe a specific strategy that has reduced the risk of the pollutant affecting human health and the environment. Evaluate how effective this risk reduction strategy has been and how the risk can be managed. Describe the ways this risk reduction strategy can be improved.

4)* Hydrogen (H_2) and oxygen (O_2) are reacted in a fuel cell to produce energy. The product of the reaction is water, and any excess gases are vented after the fuel cell, as shown in the figure below. The H_2 and O_2 tanks are maintained at the same temperature and pressure, and they feed at the same volumetric flow rate. The reaction goes to 60% completion in the fuel cell (H_2 basis). If all of the unreacted H_2 and a portion of the unreacted O_2 are recycled, then what is the molar ratio of O_2 in the vent to O_2 in the fresh feed? If the efficiency of the electric energy recovery in the fuel cell is 55%, which must be the volumetric flow rate of the two gas in the feed to provide an power of 200 kw for 1 hour ($\Delta H°_{combust.}$ (H_2) = -484 kJ·mol^{-1}). What is the value of Atom Economy and E parameter for this system?



5) Biotechnologists prefer stable enzymes but often this stabilization comes at the cost of reduced efficiency. Moreover, understanding the complex role of protein flexibility in biocatalysis can help in designing biotechnological processes. Explain in which ways gene modification can be applied in the development of engineered enzymes more adapt to develop a wide range of processes from chemical synthesis to generating new biofuels starting from C-4 building blocks.

6) Process understanding, process control, and risk based decisions are goals of PAT and QdB. Which are the elements of these two approaches and in what they differ. Explain why is important to define a design space (DS) for analytical methods to be applied in processes focused on pharmaceutical quality based products.

7) Sketch how hydrogen gas is at present produced and which are the main uses of this dangerous compound. Explain briefly why, despite the fact that this compound is not a source of energy, it is dangerous and the energy conversion from its sources are well below 50%, there is interest in developing a hydrogen economy for energy uses.

8) Bioethanol is considered by some people to be 100% carbon neutral, other people argue that bioethanol can never be completely carbon neutral if the life-cycle costs of the fuel are considered? Explain why these conclusions can depend on the raw material and the technologies adopted to produce this biofuel and why Europe and USA have

laws which impose the use of definite amount of a biofuels as an additive to unleaded gasoline, with preference for bioethanol.

9) Biotechnology can have different complemental views. Explain with examples which are the aims, the successes, and the defeats of white, green and yellow biotechnologies,

*10) Which strategies has been adopted to reduce the VOC solvent used in the chemical industry? Select appropriate example which emphasize the more or less easy possibility to substitute a list of specific solvents or to reduce the use of different solvents in multistage chemical processes.

**11) (I) Which of the following statements about hormones is correct? a) most hormones are secondary metabolites; c) all hormones are lipid soluble; c) all hormones regulate metabolic pathways; d) most hormones are primary metabolites; e) Hormones are relatively unstable and work only in the area adjacent to the gland that produced them.. (II) Examples of biomimicry are: a) Sun---sunflower; b) Whale---turbine; c) Gecko----sticky tape; d) Elephant trunks---robotic arm; e) Horse---car. Discuss your answer.

**12) List the main metabolic pathways and provide a minimum of details for glycolysis (steps, intermediates, enzymes, cofactors, energy requirements or production as ATP).

**13) Examine the structure of phosphoenolpyruvate and ATP and explain why they have such a high phosphoryl group transfer potential. Draw relevant metabolic pathways in which these molecules are used.

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* Eng. Chem. students

** Environmental students