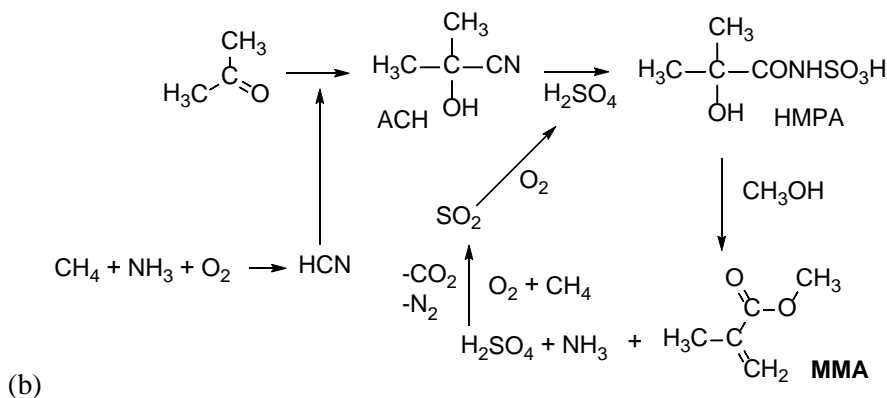
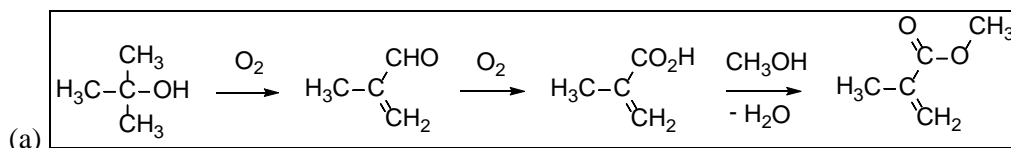


COURSE "Introduction to Green and Sustainable Chemistry"

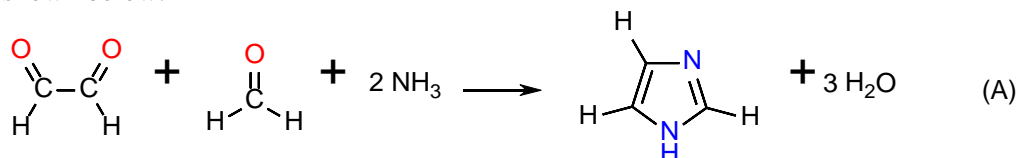
Written exam - 14 January 2019 (part I)

- 1) (a) After providing a brief explanation of the terms, write down one example for each of the 4 Rs (Refuse, Reduce, Reuse, Recycle) that could be implemented easily but has not been done yet. (b) Which of the following is not included in the hierarchy of pollution prevention techniques: i) maintain in place less raw materials/products, ii) treatment, iii) landfilling, iv) sources reduction, v) recover energy? What is missed?
- 2) Which of the following is not one of the 12 Principles of Green Engineering? i) Design for Commercial "Afterlife", ii) Conserve Complexity, iii) Circumstantial Rather than Inherent, iv) Minimize Material Diversity, v) Process Miniaturization. Correct the uncorrected principle(s) and give specific example(s) of how industry can apply this(them) successfully.
- 3) Can ADI and TDI indexes be applied to endocrine disruptors? What is true about compounds causing endocrine disruption? (Indicate all that apply with a brief explanation).
 - Originate from a very narrow class of chemical compounds.
 - Are present in our food and environment.
 - Are toxic to one of the hormone producing organs.
 - Can be a risk factor for cancer incidences.
 - May cause developmental toxicity.
 - Are corrosive agents
- 4) * Methylmethacrylate (MMA) can be prepared following two different processes: (a) from tert-butanol (TBA) and (b) from acetone cyanohydrin (ACH) following the sequences and with the information reported in the table. Devise the basis of your preference for one of the two processes, taking in exam i) the atom economy and RME, ii) the wastes, iii) the toxic compounds used and the toxicity indices.

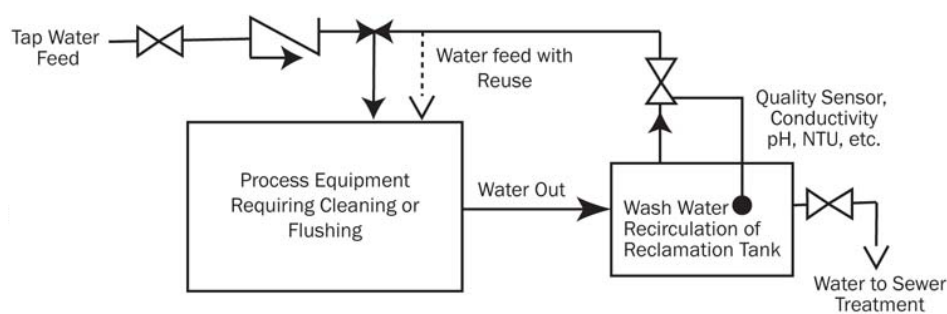


Route/ Step	Reactants	Products	Reaction Phase	T (°C)	P (bar)	Yield (%)	ΔH _r kJ/kg
ACH Acetone cyanohydrin (ACH) based							
1	CH ₄ , NH ₃ , O ₂	HCN	Gas	1200	3.4	64	-3757
2	Acetone, HCN	ACH	Liquid	29 - 38	1	91	-458
3	ACH, H ₂ SO ₄	HMPA	Liquid	130 - 150	7	98	v.exo
4	HMPA, CH ₃ OH	MMA	Liquid	110 - 130	7	100	small
5	H ₂ SO ₄ , NH ₃ , O ₂ , CH ₄	SO ₂ , CO ₂ , N ₂	Gas	980 - 1200	1	100	-1520
6	SO ₂ , Oxygen	SO ₃	Gas	405 - 440	1	99.7	-1229
TBA Tertiary butyl alcohol (TBA) based							
1	TBA, O ₂	Methacrolein	Gas	350	4.8	83	-1165
2	Methacrolein, O ₂	Methacrylic acid	Gas	350	3.7	58	-1656
3	MAA, CH ₃ OH	MMA	Liquid	70 - 100	6.8 - 7.5	75	490

- 5) Comment the sentence: “We can revolutionise our interaction with the fundamental elements of nature, switching from dispersing elements throughout our environment to concentrating them in synthetic ores for useful applications”. In which sense a similar project deals with the Green Chemistry and the Green Engineering?
- 6) (* and **) Imidazole can be synthesized by a process whereby glyoxal and formaldehyde are added to 30% ammonia solution (which we can consider both the solvent AND a reagent in this process - 10 mol for mol of glyoxal and formaldehyde) with a yield of 20% and disappearance of carbon reagents. The process is shown below:



- (a) calculate the % atom economy (EA), the SF factor, the % RME and E_m for this process.
 (b) are in the process present co-products and/or by-product?
- 7) With reference to the coffee process (in capsules), allocate the main stages of the life cycle of this food and the main impact associated to each stage, including the waste categories: water, air, solids, toxic, energy.
- 8) Describe briefly with examples the 5 different types of eco-industrial parks (EIP) in term of the location, role of actors, and the types of material exchanges and relationships between them.
- 9) What are important cancer inducing factors? What are important classes of cancer inducing chemicals? What techniques are expected to contribute to development of alternatives for animal testing for carcinogenicity?
- 10) Which physical and chemical treatments are applied to waste plastics when their recycle is addressed? Provide appropriate examples of related industrial technologies. Why thermosetting resins are so hardly recycled, whereas thermoplastic materials are commonly recycled, even if not all types?
- 11) (* and **) What is your opinion about the correctness of the following treatment plant for equipment cleaning and water reuse?



- 12) **Polysaccharides are natural polymers widespread in nature ensuring quite different functions. By using as references cellulose, glycogen and pectin, illustrate the main structural factors which originate this diversity, despite the similarity of functional groups present and their polarity.

- 13) **Complete the annexed table, related to the main component of polluted air, suggesting the possible solutions to be proposed for each component.

Table – Components of polluted air (sources, effects, and proposed solutions).

Pollutant	Major sources	Health Effects	Environmental Effects	Proposed solutions
SO ₂				
NO _x				
PM 2,5				
PM 10				
CO				
Lead				
Ozone				
VOCs				

* Chem. Eng.

** Env. Eng.