

**Degree of BEng/MEng in Chemical Engineering
CP212 and CP319 Chemical Engineering:
Process Safety Fundamentals**

**Degree of MSci in Applied Chemistry & Chemical Engineering
CH218: Practical Organic, Inorganic and Physical Chemistry and
Safety: Process Safety Fundamentals**

Date: Monday 10th May 2021

Time: 09:30

Duration: 2 hours

Answer all questions

**PLEASE PAY CAREFUL ATTENTION TO INSTRUCTIONS ON
MYPLACE FOR UPLOAD OF YOUR ANSWERS**

Plagiarism statement: By submitting answers to this paper I declare that these answers are entirely my own work and have not been shared, in part or in whole or in any draft form, with any other student, or disseminated in any other way. I understand that infringing this statement would represent a serious academic offence subject to disciplinary action according to the University Regulations and Procedures regarding Plagiarism, with significant consequences for degree progression and final degree outcome.

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Question 1 [26 marks]

- a) List three attributes of the atmosphere within the vapour space of a confined space which could cause a fatality and explain how this might arise.
[3 marks]
- b) Describe three actions which, in addition to monitoring, are necessary to minimise the risk of a fatality when authorising work in a confined space and explain how each of the actions reduces or eliminates a particular risk.
[6 marks]
- c) The flash point is an important attribute of a flammable liquid. Define it and explain its significance in the context of a spill of flammable liquid.
[3 marks]
- d) Define auto-ignition temperature and explain its significance in the context of fighting a fire in an open top vessel of flammable liquid.
[2 marks]
- e) Explain the concept of limiting oxygen concentration and describe how this is exploited in preventing the lower explosive limit being reached in the vapour space inside solvent storage vessels.
[2 marks]
- f) Describe how the Control of Major Accident Hazards Regulations 2015 (COMAH) regulations require the duty holder to work with the off-site emergency services.
[2 marks]
- g) Describe a rupture disk and explain how it functions as a pressure relief device.
[2 marks]
- h) Explain how a spring loaded pressure relief valve works.
[2 marks]
- i) Outline the advantages and disadvantages of rupture disk over a spring loaded pressure relief valve
[2 marks]
- j) Explain how a spring loaded pressure relief valve and a bursting disk might be used in series to protect a vessel handling a process where the contents are both toxic and corrosive.
[2 marks]

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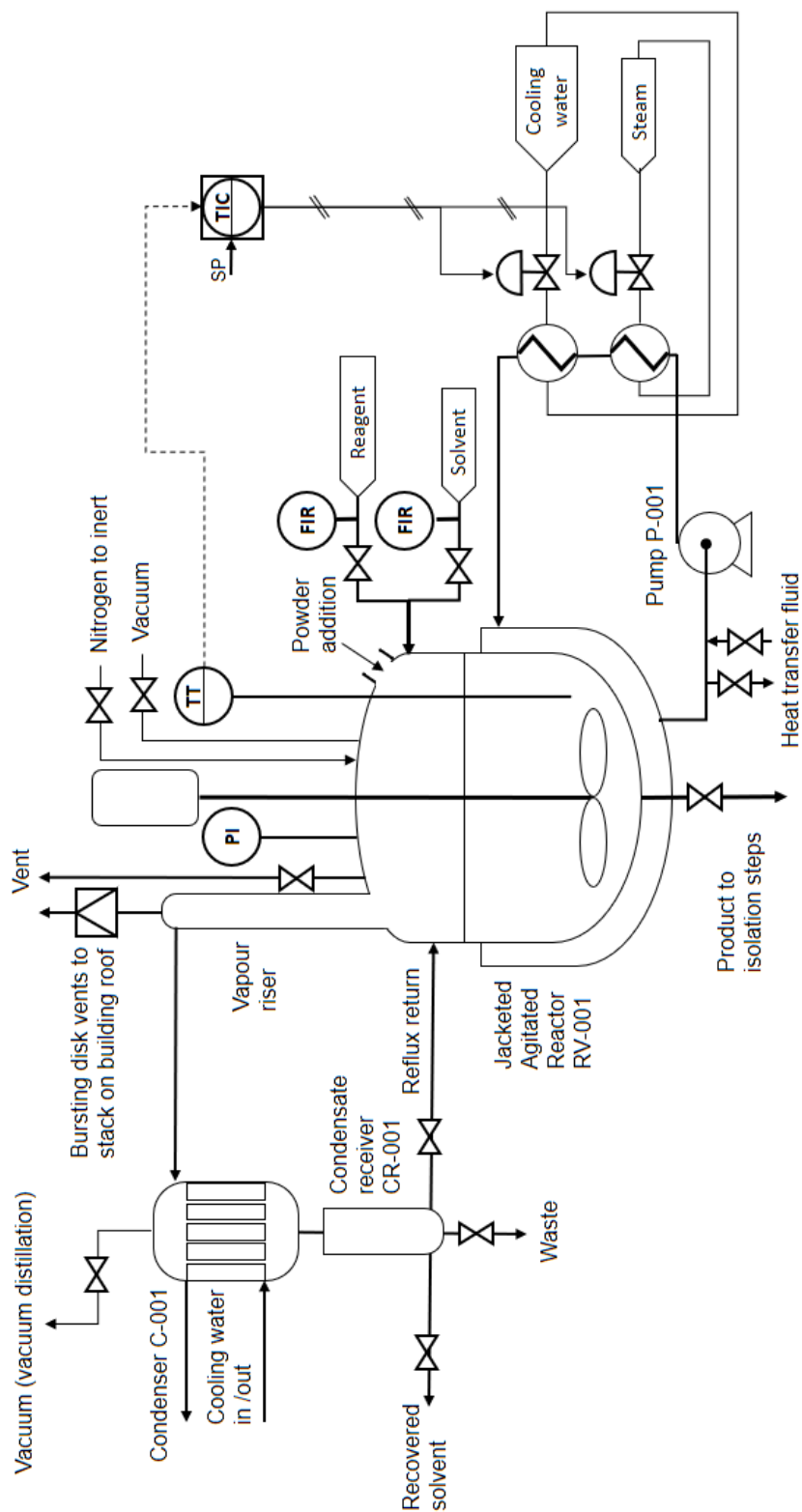
Question 2 [40 marks]

You are the only process engineer in a small contract chemical manufacturing company. The company has received a request to perform an exothermic synthesis involving a solid starting material and a reactant which is a liquid, the reaction is to be conducted in a flammable solvent. This new synthesis will require improvement of the cooling capabilities of the reactor shown in Figure 1 (shown on the next page).

- a) Describe the likely consequences of operating an exothermic synthesis without sufficient cooling capacity. [2 marks]
- b) You decide to use a HAZOP as a tool to systematically evaluate the weaknesses of the current reactor cooling arrangement shown in Figure 1. For the cooling loop you select the parameters; **flow** and **temperature**, and the deviation guide words; for **flow**; **less** and **none** and for **temperature** just **higher**. For the vessel agitator you select the parameter, **mixing**, and the deviation guide words **less** and **none**. For each of these given parameter and deviation guide word combinations complete a standard HAZOP table showing; parameter & guide word, deviation, possible cause, consequence, safeguard / protection, and proposed action. [24 marks (8 marks per parameter)]
- c) Describe four plant modifications which you would recommend explaining how they will improve the cooling capability of the unit to make it suitable for undertaking exothermic chemical syntheses. [8 marks (1 mark per recommendation and 1 mark per explanation.)]
- d) Identify three layers of protection which are present in the system as currently configured. For each layer of protection you identify, indicate how it might be compromised, making reference to the industry case studies examined in this course module to demonstrate how this might occur. [6 marks]

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Figure 1 P&ID for multi purpose batch reactor working volume 2000L



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[Compiler: Prof C J Price, 0141 574 5303]