

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: 09-May-2022

Time: 09:30

Duration: 2 hours

Duration including online upload time: 2 hours 40 minutes

Answer all question fully

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

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Question 1 (Answer all parts, 13 questions worth 4 marks each, total of 52 marks)

- a) State where the legislative concepts “as low as reasonably practicable” ALARP & “so far as is reasonably practicable” SFAIRP are defined. Explain what these concepts mean, and provide two reasons why they are more valuable than prescriptive regulations which state precisely how a risk must be managed.
[4 marks]
- b) State what the acronym REACH stands for? Explain what chemical manufacturers, importers and users are required to do under the REACH legislation.
[4 marks]
- c) Describe three possible modes of exposure to toxic substances and order them in terms of the likely time after exposure that the peak blood plasma concentration is reached explaining why this is.
[4 marks]
- d) Identify three safety critical systems which were non-functional at the Union Carbide Bhopal facility and explain how lack of maintenance led to the Bhopal tragedy.
[4 marks]
- e) Explain the difference between flash point, flame point and auto-ignition temperature and describe how they can be determined experimentally.
[4 marks]
- f) Describe the likely sequence of events leading to a BLEVE incident and explain why this is so catastrophic with reference to one of the incidents studied in the module.
[4 marks]
- g) Explain how a centrifugal pump and a gear pump work and how this difference leads to different consequences when each type of pump is deadheaded i.e. the pump is set to pump into a closed system.
[4 marks]
- h) Explain the concept of hazardous area zoning and how this is used to control ignition sources to prevent fires and explosions in a petrochemical facility.
[4 marks]

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- i) Explain the concept of inherent safety and provide two examples of process changes which demonstrate how this concept is applied. [4 marks]
- j) Outline the concept of layers of protection analysis distinguishing between layers of protection which prevent and those which mitigate. Provide one example of each category drawn for the in-class review of the Buncefield disaster. [4 marks]
- k) Describe the role of equipment reliability information and manufacturers recommended service intervals in setting both planned maintenance schedules. Explain why it is essential to inspect and test safety critical plant systems regularly between planned maintenance intervals. [4 marks]
- l) Explain why isolations are an essential part of plant maintenance procedures. Describe how a liquid transfer line isolation could be accomplished and why valves cannot be relied upon to achieve the isolation. [4 marks]
- m) Briefly explain the hazard posed by a confined space and provide an example of a confined space incident from the incidents studied in class. Explain why it is essential to have a rescue plan and the necessary equipment in place to accomplish a rescue. [4 marks]

Question 2 (Answer all parts, 48 marks)

Figure 1 shows the P&ID for an agitated vacuum filter dryer along with some associated systems. The equipment is to be used to dry a finely divided, combustible, organic solid powder with low toxicity and with a low minimum ignition energy. Previous published studies have shown that the product can be dried safely and in an acceptable time operating with an absolute pressure of 50 mbar and limiting the maximum powder temperature to 40 °C. The particulate material is transferred into the filter dryer in suspension in a medium volatility, highly flammable, non-conductive solvent. The wet filter cake is washed using the same solvent, most of which is removed at the end of the filtration step. Focus your answers on the drying phase of the process.

- (a) Identify and explain three attributes of the materials being processed which present a hazard in terms of the potential for a fire or explosion.

[2 marks for each, total 6 marks]

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- (b) Propose a basis for safety for the drying operation identifying three distinct aspects of the operation which must be addressed to have a sound basis for safety. In each case explain how this may be achieved using three of the features shown in the figure.

[3 marks for each, total 9 marks]

- (c) Considering the following parameter and guide word combinations, use your knowledge of HAZOP to evaluate the drying operation using the filter dryer shown in Figure 1 and hence develop deviations which could jeopardise the safe operation of the unit.

Combination	Parameter	Guide Word	Comments
1	Agitation	More	
2	Temperature	More	Applied to the powder bed
3	Inerting	Other than	In this case air enters the system through an open path to the atmosphere

For each of these three given parameter and guide word combinations, complete a HAZOP table using the following format:

Suggested HAZOP table format:

Parameter & guide word combination:	[no marks, you are given this information]
Deviation:	[1 mark]
Possible cause(s):	[2 marks]
Consequences:	[3 marks]
Existing safeguards:	[2 marks]
Proposed action to further mitigate the risk:	[3 marks]

You need to provide enough detail in each cell in your table to demonstrate that you have understood the deviation, its causes and consequences, and the existing safeguards so that you can make appropriate mitigation recommendations. Writing one word in each cell is unlikely to score a high mark.

[33 marks, 11 marks for each deviation]

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