



UNIVERSITY COLLEGE TATI (UCTATI)

FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE : BCE 2174
COURSE TITLE : PLANT OPERATIONS
SEMESTER/SESSION : 2 – 2023 / 2024
DURATION : 3 HOURS

Instructions:

1. This booklet contains **4** questions. **Answer all questions.**
2. All answers should be written in the answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, please raise your hand and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 10 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

- a) The equipment cooling water (ECW) return goes to cooling tower in which the hot water return from the heat exchanger is cooled down by direct contact with air flow.
- Draw a typical diagram of ECW system. (5 marks)
 - Explain how to start the ECW system. (5 marks)
- b) Deionized water produced in boiler water treatment plant is further treated physically and chemically in deaerator before being fed to boiler.
- Draw a simplified schematic drawing of this system. (5 marks)
 - Explain these processes before industrial water can be used in boilers. (5 marks)
- c) Calculate the nominal pipe thickness of a process pipe for the following condition:
- Design $\sigma = 700^\circ\text{F}$.
 - Design $P = 1500$ psig.
 - Pipe outside diameter = 12 in.
 - Material: ASTM A335, Gr. P11 (1¼ Cr - ½ Mo), Seamless.
 - Corrosion allowance = 0.0625 in.

Formula:
$$t = \frac{P \times D}{2(SE + PY)}$$

$$t_m = t + CA$$

$$t_{nom} = \frac{t_m}{0.875}$$

Tables and data are attached in Appendix 1. (5 marks)

- d) Recommend the class rating for a flange for the following parameters:
- Pipe Material: 1¼ Cr - ½ Mo
 - Design Temperature: 300°F
 - Design Pressure: 600 psig

Tables and data are attached in Appendix 2

(5 marks)

QUESTION 2

- a) i. Give two ways to avoid overpressure in a pressure vessel. (2 marks)
- ii. Locate three places where safety or relief valves are mandatory. (3 marks)
- iii. Explain why a safety or relief valve is needed for blocked-in section of cool liquid-filled lines which are exposed to heat such as heat exchanger. (2 marks)
- b) Describe how to ignite the following premix burner as shown in Figure 1.

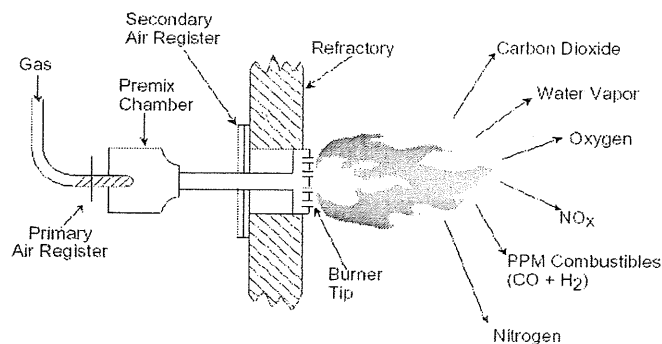


FIGURE 3 – PREMIX BURNER WITH PRODUCTS OF COMBUSTION

Figure 1: Premix burner

(7 marks)

- c) Produce the procedure of hydrostatic test for a pressure vessel in order to determine the ability of the pressure vessel to hold pressure.

(7 marks)

- d) Show the procedure to prepare the pressure vessel for safe entry of personnel. (7 marks)
- e) An operator is going to start up the process heater diagram as shown in Figure 2 below. Explain the procedure to start up the process heater safely.

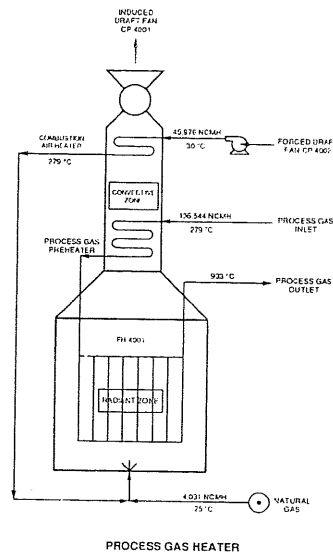


Figure 2: Process Heater

(8 marks)

QUESTION 3

- a) Explain how cavitation may damage a centrifugal pump and suggest three ways to avoid cavitation. (2 marks)
- b) Three important rotating equipment in chemical plants are pump, compressor and turbine. Differentiate pump, compressor and steam turbine. (3 marks)

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- c) Sketch a schematic diagram of a single centrifugal pump with the following fittings and instruments: butterfly valves for suction & discharge pipe, a check valve, drain & vent valves, strainers, flexible joints for suction & discharge pipes, and pressure gauge. (3 marks)
- d) Show the steps to start a standard centrifugal pump. (3 marks)
- e) You are required to start the stand by pump and stop the running pump for repair work. Prepare the procedure to change over the operation of the operating pump without interrupting the rest operation of the chemical process. (3 marks)

QUESTION 4

Figure 3 is a simplified diagram of benzene production plant. The raw material to the plant is hydrogen and toluene. Table 1 shows the start-up schedule of the plant.

- a) O_2 content inside the system must be reduced to less than 0.5% by N_2 purging, before starting-up the plant. The purpose of N_2 purging is to avoid internal explosion hazard. Explain how to carry out this activity. (5 marks)
- b) To eliminate the explosion hazard outside the system, leak test or tightness must be carried out for piping and pressure vessels. Show how to carry out the leak test activity. (5 marks)

- c) All the above are parts of activities prior to start-up. Propose 3 more activities before starting up.

(3 marks)

- d) Prepare the details start-up of this plant.

(7 marks)

V-101	P-101A/B	E-101	H-101	R-101	C-101A/B	E-102	V-102	V-103	E-103	E-104	T-101	E-104	V-104	P-102A/B	E-105
Toluene Storage	Toluene Feed Pumps	Preheater	Reactor	Analysis Gas Separator	Effluent Cooler	High-Press. Phase Sep.	Low-Press. Phase Sep.	Toluene Feed Heats	Benzene Isolate	Benzene Column	Benzene Condenser	Benzene Condenser	Water Drum	Water Pumps	Product Cooler

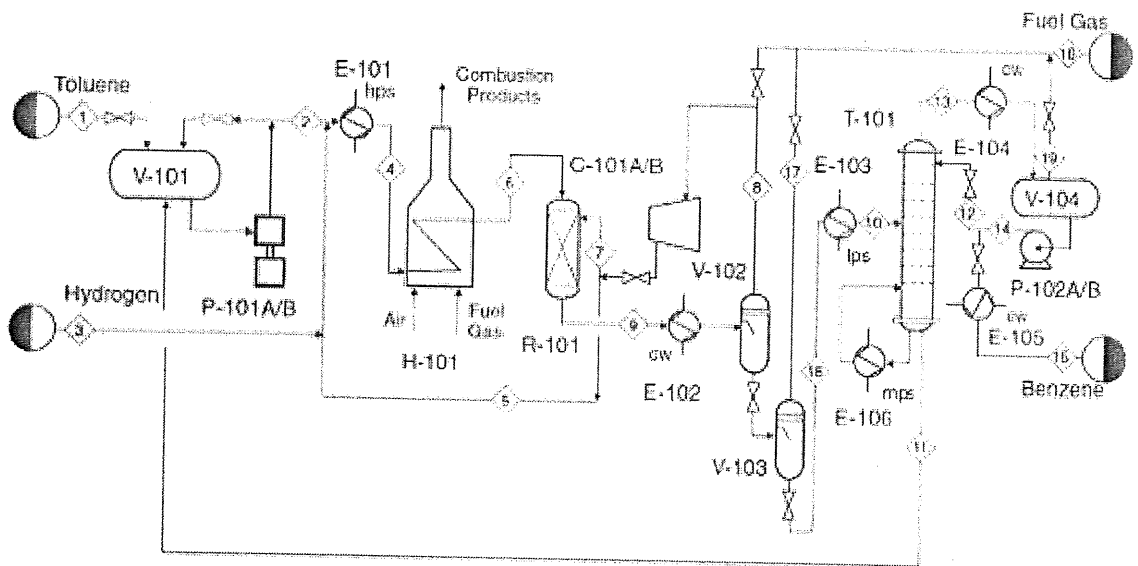


Figure 3: Benzene Production Plant

Table 1: Start-up Schedule of Benzene Production Plant

At the end of time (h)	Radiant Chamber Temperature of H 101, (°C)	Temperature S6, (°C)	Flow S1, (kmol/h)	Flow S3, (kmol/h)	Pressure S6, (bar)	Temperature S13, (°C)	Product, S15 (kmol/h)
0	30			90.3	2.5		
1	80			90.3	2.5		
2	130			90.3	2.5		
3	180			90.3	2.5		
4	210			90.3	2.5		
5	260			90.3	2.5		
6	310			90.3	2.5		
7	360			90.3	2.5		
8	410*	300*		90.3	2.5		
9		350		90.3	2.5		
10		400		90.3	2.5		
11		450		90.3	2.5		
12		500		90.3	2.5	Start T101	
13		550	32.6	90.3	13.8		
14		600	32.6	90.3	25.0	112	31.7
15		600	47.8	132.5	25.0	112	46.4
16		600	63.0	174.7	25.0	112	61.2
17		600	78.2	216.9	25.0	112	76.0
18		600	93.4	259.1	25.0	112	90.7
19		600	108.7	301.1	25.0	112	105.6
20		600	108.7	301.1	25.0	112	105.6

* Approximation only.

-----END OF QUESTIONS-----

Criteria	Marks
All questions answered will be marked according to answer scheme	/100

APPENDIX 1

B31.3 Allowable Stresses in Tension

Material	Spec. No/Grade	Basic Allowable Stress <i>S</i> , ksi. At Metal Temperature, °F.														
		100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Carbon Steel	A 106 B	20.0	20.0	20.0	20.0	18.9	17.3	16.5	10.8	6.5	2.5	1.0				
C - 1/2Mo	A 335 P1	18.3	18.3	17.5	16.9	16.3	15.7	15.1	13.5	12.7	4.	2.4				
1/4 - 1/2Mo	A 335 P11	20.0	18.7	18.0	17.5	17.2	16.7	15.6	15.0	12.8	6.3	2.8	1.2			
18Cr - 8Ni pipe	A 312 TP304	20.0	20.0	20.0	18.7	17.5	16.4	16.0	15.2	14.6	13.8	9.7	6.0	3.7	2.3	1.4
16Cr - 12Ni-2Mo pipe	A 312 TP316	20.0	20.0	20.0	19.3	17.9	17.0	16.3	15.9	15.5	15.3	12.4	7.4	4.1	2.3	1.3

Spec. No.	Class (or Type)	Description	<i>E_t</i>
Carbon Steel			
API	...	Seamless pipe	1.00
5L	...	Electric resistance welded pipe	0.85
	...	Electric fusion welded pipe, double butt, straight or spiral seam	0.95
		Furnace butt welded	
A 53	Type S	Seamless pipe	1.00
	Type E	Electric resistance welded pipe	0.85
	Type F	Furnace butt welded pipe	0.60
A 106	...	Seamless pipe	1.00
Low and Intermediate Alloy Steel			
A 333	...	Seamless pipe	1.00
	...	Electric resistance welded pipe	0.85
A 335	...	Seamless pipe	1.00
Stainless Steel			
A 312	...	Seamless pipe	1.00
	...	Electric fusion welded pipe, double butt seam	0.85
	...	Electric fusion welded pipe, single butt seam	0.80
A 358	1, 3, 4	Electric fusion welded pipe, 100% radiographed	1.00
	5	Electric fusion welded pipe, spot radiographed	0.90
	2	Electric fusion welded pipe, double butt seam	0.85
Nickel and Nickel Alloy			
B 161	...	Seamless pipe and tube	1.00
B 514	...	Welded pipe	0.80
B 675	All	Welded pipe	0.80

Materials	Temperature, °F					
	900 & lower	950	1000	1050	1100	1150 & up
Ferritic Steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic Steels	0.4	0.4	0.4	0.4	0.5	0.7
Other Ductile Metals	0.4	0.4	0.4	0.4	0.4	0.4
Cast iron	0.0

APPENDIX 2

Material Specification List

Material Groups		Product Forms					
Material Group Number	Nominal Designation Steel	Forgings		Castings		Plates	
		Spec. No.	Grade	Spec. No.	Grade	Spec. No.	Grade
1.1	Carbon	A105	--	A216	WCB	A515	70
		A350	LF2	--	--	A516	70
	C-Mn-Si	--	--	--	--	A537	CL1
1.2	Carbon	--	--	A216	WCC	--	--
		--	--	A352	LCC	--	--
	2½ Ni	--	--	A352	LC2	A203	B
	3½ Ni	A350	LF3	A352	LC3	A203	E
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1.9	1Cr - ½Mo	A182	F12	--	--	--	--
	1¼ Cr - ½Mo	--	--	A217	WC6	--	--
	1¼ Cr - ½Mo - Si	A182	F11	--	--	A387	11
1.10	2¼ Cr - 1Mo	A182	F22	A217	WC9	A387	22

Pressure - Temperature Ratings

Material Group No.	1.8			1.9			1.10		
	150	300	400	150	300	400	150	300	400
Classes									
Temp., °F									
-20 to 100	235	620	825	290	750	1000	290	750	1000
200	220	570	765	260	750	1000	260	750	1000
300	215	555	745	230	720	965	230	730	970
400	200	555	740	200	695	885	200	705	940
500	170	555	740	170	695	805	170	665	885
600	140	555	740	140	605	785	140	605	805
650	125	555	740	125	590	785	125	590	785
700	110	545	725	110	570	710	110	570	755
750	95	515	685	95	530	675	95	530	710
800	80	510	675	80	510	650	80	510	675
850	65	485	650	65	485	600	65	485	650
900	50	450	600	50	450	425	50	450	600
950	35	320	425	35	320	290	35	375	505
1000	20	215	290	20	215	190	20	260	345