Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	DESIGN OF EXPERIMENT
COURSE CODE	:	BWB 21803
PROGRAMME CODE	:	BWQ
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**.

THIS EXAMINATION PAPER CONSISTS OF **FOUR (4)** PAGES

Q1 A study is conducted to evaluate the efficiently factors influencing the adsorption capacity of activated carbon in treating textile dyes. Activated carbon is usually used to treat wastewater effluents from textile industries to remove textile dyes before discharge into the environment. Most treatment facilities, particularly large industrial or wastewater treatment facilities use continuous flow reactors or packed columns to treat the dye. Due to the limited residence time in these types of reactors, adsorption equilibrium is not necessarily reached, and the absorption rate becomes an important factor in this treatment process. Other factors influencing the capacity of activated carbon used in this study included pH, ionic strength, the type of the dye and the type of carbon (Alkhatib *et al.*, 2017).

(a) Identify the response variable and factors involved in this study.

(3 marks)

(b) Suggest the suitable design for this problem and explain why you choose that design.

(3 marks)

(c) **Table Q1(c)** shows the ANOVA table for this study. Determine the significant factors that affecting the adsorption capacity of activated carbon in treating textile dyes. Discuss your answers using 0.05 level of significance.

Table Q1(c)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F_o	P
Carbon	2	2632.40	1316.2	287.91	0.000
Dye	1	55.15	55.15	12.06	0.001
pH	2	12.95	6.47	1.42	0.245
Salinity	1	19.26	19.26	4.21	0.042
Time	2	840.63	420.32	91.94	0.000
Carbon*Dye	2	101.14	50.57	11.06	0.000
Carbon*pH	4	7.52	1.88	0.41	0.800
Carbon*Salinity	2	38.95	19.47	4.26	0.016
Carbon*Time	4	148.6	37.15	8.13	0.000
Dye*pH	2	65.33	32.67	7.15	0.001
Dye*Salinity	1	14.43	14.43	3.16	0.077
Dye*Time	2	115.15	57.58	12.59	0.000
pH*Salinity	2	16.78	8.39	1.84	0.162
pH*Time	4	80.28	20.07	4.39	0.002
Salinity*Time	2	6.98	3.49	0.76	0.468
Error	182	832.01			
Total	215	4987.56			

(6 marks)

(d) The residual plot of the analysis is given in **Figure Q1(d).** Interpret the results of each plot.

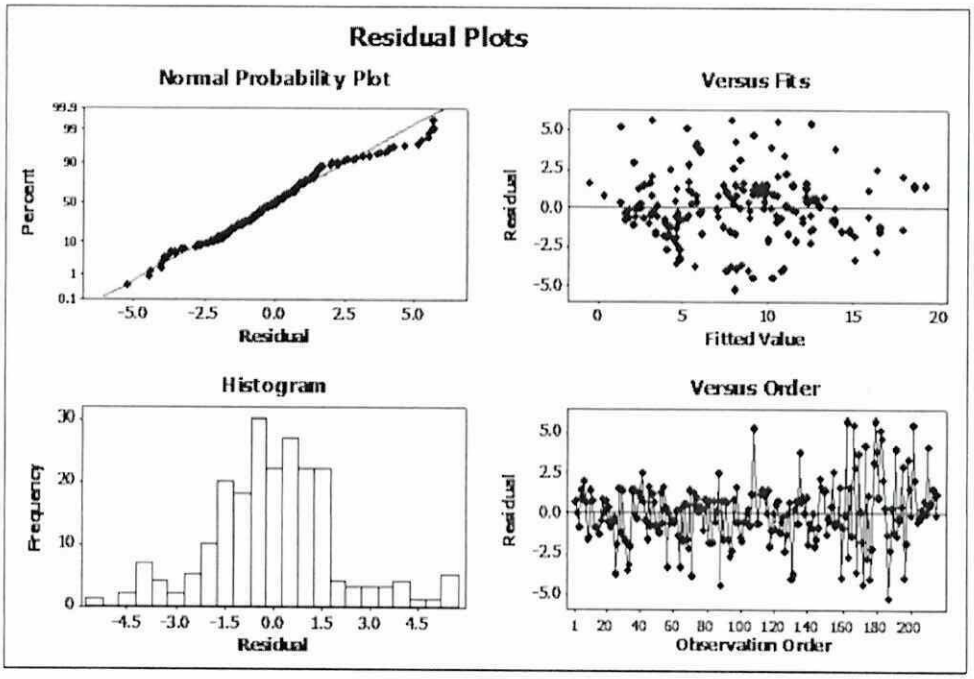

Figure Q1(d)

(8 marks)

Q2 Rahman is interested in obtaining more uniform fill heights in the bottles produced by his manufacturing process. The filling machine theoretically fills each bottle to the correct target height, but in practice, there is variation around this target, and the bottler would like to understand the sources of this variability better and eventually reduce it. The process engineer, Nathan, can control three variables during the filling process: the percent carbonation (A), the operating pressure in the filler (B), and the bottles produced per minute or the line speed (C). The pressure and speed are easy to control, but the percent carbonation is more difficult to control during actual manufacturing because it varies with product temperature. However, for purposes of an experiment, the engineer can control carbonation at two levels: 10, and 12 percent. He chooses two levels for pressure (25 and 30 psi) and two levels for line speed (200 and 250 bpm). The data is given as in **Table Q2(i).**

Table Q2(i)

Factors	Factors Level	
	Low (-1)	High (+1)
A (%)	10	12
B (psi)	25	30
C (b/m)	200	250

Nathan decides to run two replicates of a factorial design in these three factors, with all 16 runs taken in random order. The response variable observed is the average deviation from the target fill height observed in a production run of bottles at each set of conditions. The data is given as in **Table Q2(ii).**

Table Q2(ii)

	Coded Factors			Fill Height Deviation	
Run	A	B	C	Replicate 1	Replicate 2
1	-	-	-	-2	-3
2	+	-	-	0	-1
3	-	+	-	1	2
4	+	+	-	-2	2
5	-	-	+	-1	1
6	+	-	+	2	0
7	-	+	+	2	1
8	+	+	+	5	4

(a) Conduct an analysis of variance at 0.05 level of significance.

(28 marks)

(b) Help Nathan to explain the results of the experiment to Rahman, based on the factors that significantly affect the fill height deviation.

(7 marks)

(c) **Table Q2(c)** show the ANOVA results after removing the interaction term. Compare the results in the ANOVA table with **Q2(a)**.

Table Q2(c)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F_o	P
A	1	5.062	5.062	2.36	0.150
B	1	22.562	22.562	10.51	0.007
C	1	18.063	18.063	8.42	0.013
Error	12	25.750	2.146		
Total	15	71.438			

(5 marks)

- END OF QUESTIONS -