Question 1: Fully describe the experimental design used in the following scenario (5 points)

Metribuzin is an agricultural chemical that may accumulate in soils. To see if the amount retained in the soil depends on the amount applied to the soil, the following experiment was performed. Three different levels of metribuzin were equally and randomly assigned to a total of 24 plots. After one growing season, the amount of metribuzin in the first three cm of soil was measured. The pH of the soil in each plot was also measured as pH may affect the ability of the soil to retain metribuzin.

Question 2: (5 points)

The yield of a chemical process is being studies. It is conjectured that temperature and pressure my affect the yield. Normally three levels of temperature are used in the process (high, medium and low), and three pressure levels are used as well (250, 260 and 270 psi). The experimenter wishes to obtain two replicates for the experiment, but he/she can only carry out 18 runs per day.

Construct the **effects model** of this experiment (be careful with the indices).

Question 3:

Assume you are hoping to submit a grant proposal to investigate dose-response relationships in a psychopharmacological study of depression, planning to pursue your work in New Mexico, where psychologists were recently granted prescription privileges. From the range of acceptable dosages of your favorite antidepressant, you select three dosages at random for investigation. Four psychologists are available for the study, and you regard them as representative of the pool of psychologists who might eventually be granted prescription privileges. Each psychologist in your pilot study prescribes each of the three dosage levels to an equal number of patients. When scores on a depression scale are gathered at the end of the study and analyzed, the following mean squares are obtained, with the associated degrees of freedom shown in the following table (the DOF error has been pre-filled for you).

Source of Variability	DOF	MS		
Drug Dosage				
Psychologist				
Drug*Psychologist				
Error	48			
Total				

(i)   (2 points) How many patients did each psychologist use in the study?

(ii) (8 points) Complete the ANOVA and suggest whether the factors and interaction are significant

Question 4: (10 points)

(i)   (2 points) When do we need to apply "confounding" in experiments?

(ii)   (2 points) Consider the following situation: After constructing a normal probability of effects in an unreplicated 2^4 design (factors A, B, C, D) we conclude that factor D and all its interactions are negligible. How many replicates of a 2^3 design (with factors A, B, and C) can be analyzed with the original data?

(iii)   (6 points) In a 2^3 factorial experiment, it is considered that BC interaction may not be very significant, so it should be used as the confounding factor to produce two blocks of experiment runs. Using the Kempthorne methodology, determine how the 8 runs of a 2^3 design should be assigned to the two blocks when BC is used as the Block Generator.

Question 5: (20 points)

(i)   (4 points) Why do we use coded variables in design of experiments?

(ii)   (4 points) Name two reasons when orthogonal contrasts are used in design of experiments

(iii)   Notches are used in IC board production as sensing mechanisms to locate IC components. The placement of notches is highly dependent on process vibration. It is highly suspect that bit size, cutting speed and their interactions affect process vibration. The following table contains data that was obtained from a 4 replicate 2^2 randomized factorial design.

Bit Size (A)	Cutting Speed (B)	Repl. 1	Repl. 2	Repl. 3	Repl. 4	Total	Mean
-1	-1	18.2	18.9	12.9	14.4	64.4	16.1
1	-1	27.2	24	22.4	22.5	96.1	24.025
-1	1	15.9	14.5	15.1	14.2	59.7	14.925
1	1	41	43.9	36.3	39.9	161.1	40.275
SumSquare Total	1709.834375						

a) (3 points) Estimate the effects of the main factors and their interactions

b) (3 points) Determine the SumSquares of the factors and their interactions

c) **(3 points)** Create an ANOVA and determine if the factors and their interactions affect process vibration.

d) **(3 points)** Sketch the interaction plot and suggest the best combination to be used in the process