JUST some examples of questions

You can bring a paper of formulas (only one) JUST FORMULAS
I will check this paper, if it contains more information, I will take my decision regarding that exam.

Topic 0

1. Explain in what consists "data compression" (what is the meaning).
2. Give some examples of lossless data compression methods.
3. Give some examples of lossy data compression methods.
4. Is the "source coding" a subset of lossless data compression methods? (Yes or no), removing which kind of redundancy?
5. Generally, can you obtain more compression with a lossy method or with a lossless method? discuss shortly.

Topic 1

1. Write the condition that an information measure must satisfy.
2. What does $H(X)$ represents? what does $H(X)$ measures?
3. What does $H(X|Y)$ measures?
4. What does $H(Y|X)$ measures?
5. When $H(X)$ reach its maximum and its minimum? and what are its maximum and its minimum values? discuss.
6. When $H(X)$ reach its maximum and its minimum? explain "why" and discuss.
7. Explain differences and connections between the entropy $H(X)$ and the variance of $\text{var}(X)$.
8. Is the KL divergence a true distance? discuss.

9. Why the KL divergence can be very useful in data science/analysis?
10. Why the mutual information can be very useful in data science/analysis?
11. Why does the mutual information measure? when does it reach its maximum and its minimum? and what are its maximum and its minimum values? discuss.
12. Prove that $H(X) \leq H(X|Y)$.
13. Prove that $I(X, Y) = H(X) + H(Y) - H(X, Y)$.
14. Prove that $I(X, Y) = H(X) - H(X|Y)$.
15. Explain and write the relationship between $I(X, Y)$ and KL divergence.
16. When is the KL divergence zero?
17. Prove that $H(X, Y) = H(X) + H(Y|X)$.
18. Explain the relationships between $H(Y|X)$ and $H(Y|X = i)$.
19. Consider the formula $I(X, Y) = H(X) + H(Y)$. Can this formula be "true" in some special case? which one? discuss.
20. Consider the formula $I(X, Y) = 0$. Can this formula be "true" in some special case? which one? discuss.
21. Consider the formula $H(X, Y) = H(X) + H(Y)$. Can this formula be "true" in some special case? which one? discuss.
22. Consider the formula $H(X) = H(X|Y)$. Can this formula be "true" in some special case? which one? discuss.
23. Consider the formula $H(Y) = H(Y|X)$. Can this formula be "true" in some special case? which one? discuss.
24. Consider the formula $I(X, Y) = H(X, Y)$. Can this formula be "true" in some special case? which one? discuss.
25. Consider the formula $I(X, Y) = H(X)$. Can this formula be "true" in some special case? which one? discuss.
26. Consider the formula $I(X, Y) = H(Y)$. Can this formula be "true" in some special case? which one? discuss.
27. Consider the formula $I(X, Y) = H(Y)$ and $I(X, Y) = H(X)$. Can these formulas be "true" JOINTLY (simultaneously) in some special case? which one? discuss.
28. Given a joint probabililty $p(x, y) = ...$ (I will give you a matrix of probability) find the marginal probably mass functions $p(x)$, $p(y)$ and the conditionals $p(x|y)$ and $p(y|x)$.

29. Given a joint probabililty $p(x, y) = ...$, what/which part sums one?
30. Given a joint probabililty $p(x, y) = ...$ (I will give you a matrix of probability) find all the possible entropies $H(X, Y)$, $H(X)$, $H(Y)$, $H(X|Y)$, $H(Y|X)$ and the mutual information.
31. Given a conditional probability $p(x|y)$ (I will give you...again ...a matrix): (a) say what sums one in that matrix, (b) find $H(X|Y)$ and all $H(X|Y = j)$ (what is the differences between $H(X|Y)$ and $H(X|Y = j)$?).

Topics 2 and 3

1. Explain the main idea behind the source coding.
2. Write the lower bound for the expected length of a source code. (I can ask to compute something, giving more information....)
3. I give some examples of source codes and I ask if it is instantaneous or uniquely decodable or etc....
4. Discuss/explain the classification of type of source coding (instantaneous or uniquely decodable or etc....)
5. Show a tree corresponding to a prefix code.
6. Discuss the bounds for an optimal source code.
7. I give you an example....build an Huffman code.
8. I give you an example....build an RLE code.
9. I give you an example....build a Lempel-Ziv code.
10. I give you an example....give the Shannon coding suggestions.
11. I give you an example....build an Shannon-Fano code.
12. I give you an example....build an Arithmetic code.
13. Compute the expected length and variance of a given code.
14. I give you an example....decode considering an arithmetic code approach.

Topics 4

1. Explain why we use channel coding.
2. Discuss/Explain a simple strategy to decrease P_e in any case.
3. Discuss/Explain what is the capacity C of a channel.
4. Give a practical "insight" of the channel capacity C to find easily lower bounds for C.
5. Define the capacity C of a channel and discuss (explain the formula).
6. Discuss/Explain when it is possible to decrease P_e keeping the rate of the code R fixed.
7. Given a channel $p(y|x)$ and a $p(x)$ (given by me) find $p(x, y)$ and $p(x|y)$.
8. Describe the ideal channel.
9. Describe the worst channel.
10. If $H(X|Y) = 0$ but $H(Y|X) \neq 0$, can the channel be considered as ideal one? discuss.
11. If $H(Y|X) = 0$ but $H(X|Y) \neq 0$, can the channel be considered as ideal one? discuss.
12. Say which formula of $I(X, Y)$ is more useful and easy for the practice and which formula of $I(X, Y)$ is more important theoretically.
13. I give a channel (graphically)....find a lower bound for C.
14. I give a channel (graphically)....find a lower and upper bounds for C.
15. I give you two channels in parallel (graphically)....find a lower and upper bounds for equivalent capacity C_{tot}.

Topics 5

1. Say when the use of a channel code makes sense.
2. We want to transmit binary symmetric channel the codeword "00001010". The received sequence is "00100111", passed through the binary symmetric channel with a probability of error p. Find the probability of the received sequence.
3. We want to transmit binary symmetric channel the codeword "00001010". The received sequence is "00100111", passed through the binary *non-symmetric* channel with a probability of errors p_1 (from 0 to 1) and p_2 (from 1 to 0). Find the probability of the received sequence.
4. Considering a repetition code repeating 3 times and binary symmetric channel. find the P_e in detection.

5. Considering a repetition code repeating 2 times and binary symmetric channel. find the P_e in detection.
6. Describe what is a generic channel code (generally, theoretically).
7. Say what is a systematic channel code.
8. Say what is a syndrome.
9. Say what is the Hamming distance.
10. I will give you the matrix G, find H.
11. I will give a k and a matrix G find the codewords c's.
12. I will give all the information needed....build the table b <==> c.
13. I will give all the information needed....build the table e ==> s.
14. How many error vectors e can give you a specific syndrome s?
15. I will give you the matrix G, say which part of G decides the bits of redundancy.
16. Given $b = [00]$ and $c = [00110]$ obtained using a systematic code. Find, k, n, m and the bits of redundancy in c.
17. Explain what the system $cH^\top = 0$ means.