1. The problem with John Doe's argument is that he is making one faulty assumption. He is assuming that the receiver knows when the clock of the sender is ticking. However, it is an ASYNChronous connection, not a synchronous one, so the clocks are not synchronized. Thus, if you have two clocks that are out of sync, and they are the same frequency, there is no way to guarantee that you will not lose data. The receiver must be able to observe a change in the state of the signal in order to determine the data bits. The only way a receiver can reliably do this is if its sample frequency is much higher than that of the sender. There is a lot of research into this, and it can be related to a general Signal Processing problem. How can you monitor a signal and be able to reproduce it perfectly? The Nyquist Rate is double the rate of the bandwidth of the signal, and it defines the lower bound. So the minimum rate the receiver clock could be to the sender clock would be 2x. However in practice the sampling will deviate from the nominal bit cell center when attempting to determine a bit, especially with lower quality lines, so 8x is a much better clock ratio. 16x is usually used even though it makes the data rate lower, because it is in general much more reliable.

2. Link Utilization is the ratio of theoretically-available bandwidth to what is actually being used in practice for transmissions. Some factors can make link utilization less than available bandwidth, for example if you are waiting for acks of each packet from the receiver and the propagation delay is very high. The higher you can get your link utilization, the better, because it means your link is being saturated at the highest possible rate. Also, a higher error rate can decrease link utilization (eg. if you have an EMI device near the link). Although, a link that is constantly being utilized fully (that is, its peak and average utilization are the same) may indicate you need more available bandwidth on the link (your traffic load is too heavy for the link so some communications are not at the maximum possible rate.)

3.

a) The bandwidth is 1000 Hz and the SNR is 5dB. The equation for maximum theoretical data rate is C = B * log2(1 + S/N) bps. In this case the equation is C = 1000 * log2(1 + 5) bps = 1000 * 2.584963 = 2585 bps so 2,585 bps is our maximum theoretical data rate.

b) the bandwidth is 3100 Hz and the SNR is 10dB. The equation for maximum theoretical data rate is C = B * log2(1 + S/N) bps. In this case the equation is C = 3100 * log2(1 + 10) bps = 3100 * 3.459432 = 10,724 bps so our maximum theoretical data rate is 10,724 bps.

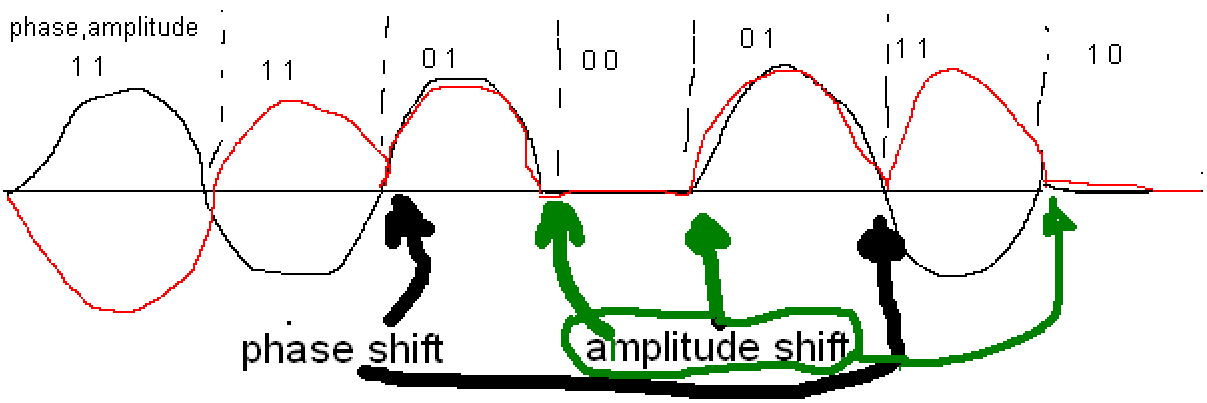
4.

I do not have a copy of the textbook (I asked at the beginning of the semester if it would be required to do homework projects for this reason) so I can't use the diagrams in the book to answer these questions. However, I will attempt to answer them with diagrams found online.

1) an example 4-qam constellation diagram can be found at
http://jre.cplire.ru/koi/jun09/1/text_files/image017.gif

. A constellation diagram represents all of the phase states that a signal could be in at each point in time. In a 4-qam system, there are 2^2 different states that can be represented, so there are 2 bits determined by each state a QAM signal is in. The # of states is determined by the different amplitudes and off-phase amounts that each communication can be in. 4-QAM means that the two carrier waves have either full or no amplitude, and are either completely in or completely out of phase with each other.

Here is a diagram demonstrating how two carrier waves (one black and one red) will send a signal across 4-QAM. I do not know if it is similar to the example in the book but it should be clear.




2) This constellation diagram at http://www.m-indya.com/images/QAM-constellation.JPG is used. 16-QAM can communicate 4 bits at a time, because 2^4 is 16. All of the possible states can be represented by binary numbers, eg. state 0000, state 0001, state 0010, 0011… etc. The state that the signal is in at any point in time's binary value can then be taken to be the 4 bits that the signal is carrying. 16-QAM has the two carrier waves having full, 2/3, 1/3 or no amplitude, and in, 1/3 out, 2/3 out, or completely out of phase with each other.

5. Modulation is the name of the process of mixing or mulitplying a binary signal to be transmitted by a single frequency signal chosen from within the bandwidth used for the analog signal (a "carrier" signal). Modems are devices that MODulate and DEModulate a communication to make and receive a modulated transmission. Modulation is needed because it allows the transmission of binary data

across analog lines. Modulation is not used in ISDN because it is a digital connection that is governed by the telephone company. It still takes place over the same PSTN and cables as regular phones / dial-up internet but it does not modulate the data. PSDN does not use modulation either, it does not take place on a circuit-switched network so it has to have digital communications. Technically you could access a PSDN through a modulated connection, but a PSDN does not need to be modulated itself.