1. In a computer network, what is the difference between a node and a terminal. What is a synonym for terminal?
   Node - Any device in a network.
   Terminal - An "edge device" in a network. A synonym is a "host".

2. The Internet is a network of networks. It is structured as a hierarchy.

   a. What was the main reason for structuring the Internet as a hierarchy?
   Direct from book
   b. Describe the different hierarchical levels of the Internet.
   Direct from book

3. Circuit switching versus packet switching
   i. In a circuit switching network, when Alice wants to communicate with Bob, a physical "circuit" is established between Alice and Bob before any data can be sent.

   a. Why do you think this is necessary?
   This is necessary because in a circuit switching network, resources must be reserved beforehand along the path that will be used to carry data between Bob and Alice.

   b. What is(are) the advantage(s)?
   Circuit switched networks provide predictable performance/quality of service.

   c. What is(are) the disadvantage(s)?
   Circuit switched networks do not always make best use of available resource (i.e. resources may be under-utilized when calls are idle)

   ii. In a packet switching network, when Alice wants to communicate with Bob, no circuit is established and Alice simply starts sending data to Bob.
   a. What is(are) the advantage(s)?
   This fully utilizes the bandwidth available along the path between Alice and Bob. It is also more resilient to faults (e.g. if a link is severed, packets can take alternate paths)

   b. What is(are) the disadvantage(s)?
   Packet switched networks are "best effort" and on demand-- no guarantee about reliability or performance. Unpredictable.

4. In packet switching networks, resource sharing is done through "statistical multiplexing".

   i. Explain what statistical multiplexing is.
   Statistical multiplexing is splitting up the available bandwidth amongst the users who want to use the network at a specific time. As such, network resources are fully utilized when there is demand.

ii. Suppose a scenario where Alice is sending data at 10Mbps and Bob is sending data at 1Mbps. Using your explanation of statistical multiplexing, do you expect to see more packets from Alice or more from Bob on the link they share? Explain.

I would expect to see more packets from Alice.

iii. On average, assuming the network has enough capacity, what would be the ratio between the number of packets from Alice and Bob. 10:1

5. In deep space communication scenarios, the network connection between 2 nodes in space has the following characteristics: it takes 1 minute for information to travel from A to B; between the 2 hosts, there is one router whose queuing delay is 2.5 milliseconds and processing delay 1 millisecond. The link connecting A to B is 10Mbps.

Total Delay = Processing + Queue + Transmission + Propagation

Processing = 1ms
Queue = 2.5ms
Propagation = 60s = 60,000ms

Transmission = Length / Rate
Length = 2MB = 16,000,000 bits
Rate = 10Mbps = 10Mbps = 10,000,000 bits/second
Transmission = 16,000,000 / 10,000,000 = 1.6s

i. What is the total latency to send 2MBytes of information between A and B?

Total Delay = 1ms + 2.5ms + 1.6ms + 60,000ms = 60005.1ms (~1.0051m)

ii. What is the dominating factor causing latency in this scenario?

The propagation delay

6. In so-called "Big Data" applications, very large amounts of data are generated and will be transmitted over the network. Suppose you have 30 terabytes of data to transfer between a data center in Buffalo, New York and another one in Salt Lake City, Utah. You have a 150 Mbps dedicated link available for transferring the data. Is it more efficient to do the data transfer over the link or use an overnight postal delivery service?

30TB = 2.4 * 10^8 Mbps

Transmission = Length / Rate
Transmission = 2.4 * 10^8 / 150 = 1,600,000s = ~2.6weeks

In this situation, it would be much better to use the overnight delivery service. It would take over 2 weeks to transfer the data via the 150Mbps link.

7. Explain encapsulation and de-encapsulation in the context of the Internet's protocol stack. Do they contribute to the cost (or overhead) of transmitting and receiving information over the Internet? Explain and comment on the distinction between communication and processing overhead.

Encapsulation happens at the sender as the application message is processed by the lower layers of the Internet protocol stack on its way to be transmitted. Each layer processes the transmission unit of the layer above and adds its own header. On the receiving end, the inverse process called de-encapsulation is executed, i.e., the message flows up the protocol stack and is processed by each layer. In the process, each layer strips off its corresponding header and passes the resulting transmission unit to the layer above. Note that inside the network, encpasulation/de-encapsulation happens at every hop but only up to the network layer.

Encapsulation results in both communication and processing overhead as it adds additional information that needs be carried by the network (communication overhead) and additional processing that needs to happen at each layer in order to generate or process the layer's header (processing overhead).