Q1 (10 points).

Answer: *Use UDP* ***(1 point)*** *and build requirements in application layer* ***(1 point).***
Elements: Sliding Window ***(1 point)*** *for flow control* ***(1 point).***
ACKs, Retransmits, timeouts ***(3 points)*** *for reliable transfer* ***(1 point).***
Pipelining ***(1 point)*** *for high performance* ***(1 point).***

Q2 (5 points).

Answer: *Client contacts local DNS* ***(1 point)***
local DNS contacts root DNS ***(1 point)***
root DNS contacts TLD DNS ***(1 point)***
TLD DNS contacts authoritative DNS ***(1 point)***
IP for www.cnn.com is propagated back on the same route ***(1 point)***

Q3 (3 points).

Answer: *There is not enough information to tell* ***(1 points)***

Because both GBN ***(1 point)*** *and SR* ***(1 point)*** *will ACK each of the first two messages as they are received correctly, and there is not enough behaviour information for other scenarios.*

Q4 (3 points).

Answer: *There 40 terabytes = 40 * 10^{12} * 8 bits* ***(1 point)****.*

*So, if using the dedicated link, it will take 40 * 10^{12} * 8 / (100 *10^{6}) = 3200000 seconds = 37 days* ***(1 point)****.*

But with FedEx overnight delivery, you can guarantee the data arrives in one day ***(1 point)****.*

Q5 (5 points).

Answer: *The queueing delay is 0 for the first transmitted packet* ***(1 point****).*

L/R for the second transmitted packet ***(1 point)***

and generally, (n-1)L/R for the nth transmitted packet ***(1 point)****.*

Thus, the average delay for the N packets is ***(2 points)****:*

$(L/R + 2L/R + ... + (N-1)L/R)/N$
$= L/(RN) * (1 + 2 + ... + (N-1))$
$= L/(RN) * N(N-1)/2$
$= LN(N-1)/(2RN)$
$= (N-1)L/(2R)$

Note that here we used the well-known fact:

$1 + 2 + ... + N = N(N+1)/2$

Q6 (6 points).

Answer: *Trudy can pretend to be Bob to Alice and vice versa* ***(1 point)***

Trudy can partially or completely modify the messages being sent from Bob to Alice and from Alice to Bob ***(1 point)*** *Trudy can even drop the packets that are being sent by Bob to Alice* ***(1 point)****. The latter can be done even in case of encryption. Attack based on the content of messages can be prevented by encryption* ***(1 point)***

Q7 (5 points).

Answer: *An overlay network is a network that is using another network as a platform. The overlay network in a P2P system consists of the nodes participating in the (e.g. file sharing) system* ***(1 point)*** *and the logical links between the nodes* ***(2 points)****.*

There is edge in graph from node A to node B if there is a (TCP) connection between A and B ***(1 point).***

An overlay network does not include routers ***(1 point)****.*

Q8 (5 points).

Answer: *An advantage of using the earlier values of* `cwnd` *and* `ssthresh` *at t_2 is that TCP would not have to go through slow start* ***(1 point)*** *and congestion avoidance to ramp up to the throughput value obtained at t_1* ***(1 point).*** *A disadvantage of using these values is that they may be no longer accurate* ***(1 point).*** *In particular, if the path has become more congested between t_1 and t_2, the sender will send a large window's worth of segments into an already more congested path* ***(2 points)****.*

Q9 (10 points). Please refer to the figure below, and answer the following questions.

(a) **(1 point)**

Answer: *Slow start (2xMSS every RTT)*

(b) **(1 point)**

Answer: *Window size reached* `ssthresh`

(c) **(2 points)**

Answer: *8 (before congestion) and 6 (after congestion)*

(d) **(1 point)**
Answer: *Congestion avoidance (MSS+1 every RTT)*

(e) **(1 point)**
Answer: *Reaction to Congestion*

(f) **(1 point)**
Answer: *TCP 2*

(g) **(1 point)**
Answer: *TCP 1*

(h) **(2 points)**
Answer: *Window size and window maintenance mechanism after congestion*

Q10 (5 points).

Answer: *Persistent HTTP connections can send multiple objects over one TCP connection.*

1. Reduces the TCP handshaking overhead ***(2 points).***
2. Reduces the repeated TCP slow starts ***(1 points).***
Very effective if multiple objects come from the very same server ***(1 point),*** *but not if they come from different servers* ***(1 point).***

Q11 (10 points).

(a) (5 points)

Answer: *Two different ways of managing the transmission resources in communication network* ***(1 point).***

Circuit switching: *explicit call setup phase; allocates an end-to-end path and resources; all data flows on same path* ***(1 point).***
Example: *classic telephony* ***(1 point).***
Packet switching: no end-to-end setup; data divided into chunks called packets; each packet independently addressed and routed through network ***(1 point).*** *Example: Internet* ***(1 point).***

(b) (5 points)

Answer: *(transport) protocols* ***(1 point)***
Connection-oriented: *a protocol with explicit phases for setup, data transfer, and teardown afterwards; involves state information at nodes* ***(1 point).*** *Example: TCP.* ***(1 point)***

Connection-less: *a protocol with no advance setup or release of resources, and minimal or no state information involved* ***(1 point).*** *Example: UDP* ***(1 point).***

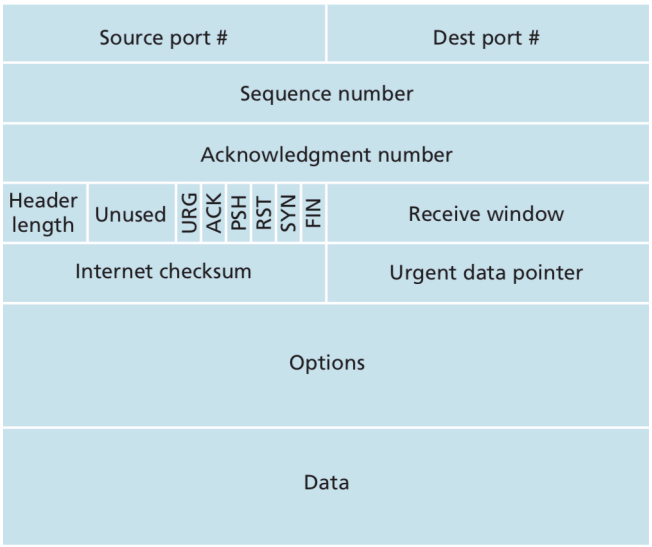
Q12 (5 points).

Answer: *Since the link capacity is only 100 Mbps, so host A's sending rate can be at most 100Mbps* ***(1 point)****. Still, host A sends data into the receive buffer faster than Host B can remove data from the buffer. The receive buffer fills up at a rate of roughly 50Mbps* ***(1 point)****. When the buffer is full, Host B signals to Host A to stop sending data by setting RcvWindow = 0. Host A then stops sending until it receives a TCP segment with RcvWindow > 0* ***(1 point)****. Host A will thus repeatedly stop and start sending as a function of the RcvWindow values it receives from Host B* ***(1 point)****. On average, the long-term rate at which Host A sends data to Host B as part of this connection is no more than 50Mbps* ***(1 point)****.*

Q13 (10 points).

Answer: *Electronic Mail Application* ***(1 point)***
POP3 (Mail Access) IMAP (Mail Access) SMTP (Mail Transfer) ***(6 points)***
POP3 and IMAP are both mail access protocols. IMAP provides more functionalities ***(1 point),*** *including folders and saved mailbox* ***(2 points)***

Q14 (10 points).



Q15 (10 points).

Answer: *Throughput = min {Rs, Rc, R/M}*