Q1a. Maximum value for L is $2^{32} = 4,29,49,67,296$ bytes
Q1b. Time per segment = (Segment size + Header size)/Link speed
Number of segments = $(2^{32})/1400 = 3,06,78,833.78$ bytes
Adding header (66 bytes) to each segment = $((2^{32})/1400)$ x 66 = $20,24,77,029.67$ bytes

Total Bytes   = (2^{32}) + $(((2^{32})/1400)$ x 66)
              = $4,29,49,67,296 + 20,24,77,029.67$
              = $4,49,74,44,325.67$ bytes

10 Mbps = (10 Mbps) x ((1,000,000 bps)/(1 Mbps)) = 10,000,000 bps
Time = (4497444325.67 x 8)/(10000000) = 3597.955460 sec

Q2.

a) The slow start phase of TCP is active during transmission rounds [1,6] and [23,26]
b) The congestion avoidance phase of TCP operates over the intervals [6,16] and [17,22]
c) After round 16, packet loss is inferred from the receipt of triple duplicate ACKs, not a timeout event which would have reset the congestion window to 1.
d) Packet loss after the 22nd round is detected by a timeout, causing the congestion window size to drop to the initial value of 1.
e) The slow start threshold is initialized to 32 at the first round, since it is at this window size that slow start stops, and congestion avoidance begins.
f) At the 18th round, the slow start threshold holds a value of 21, which is half of the congestion window size of 42 when loss was detected after round 16.
g) The slow start threshold value for the 24th round is 14, determined as half of the 29 window size when loss occurred after round 22. Hence the threshold is 14 (taking lower floor of 14.5) during the 24th transmission round.
h) During the 1st transmission round, packet 1 is sent; packets 2-3 are sent in the 2nd transmission round; packets 4-7 are sent in the 3rd transmission round; packets 8-15 are sent in the 4th transmission round; packets 16-31 are sent in the 5th transmission round; packets 32-63 are sent in the 6th transmission round; packets 64-96 are sent in the 7th transmission round. Thus, the 70th segment is sent during the 7th transmission round.
i) The threshold will be set to half the current value of the congestion window (8) when the loss occurred, and congestion window will be set to the new threshold value +3 MSS . Therefore, the new values of the threshold and window will be 4 and 7 respectively.

Q3 TCP waits for three duplicate ACKs before triggering a fast retransmit because there's a possibility of networks delivering packets out of order. If the sender retransmitted after just the first duplicate ACK, it could lead to unnecessary retransmissions when packets simply arrived out of sequence rather than being lost. Requiring three duplicate ACKs provides more confidence that a packet was dropped before retransmitting it. This prevents the sender from prematurely injecting redundant packets into the network due to reordering delays alone.

Q4. Yes, it is possible for a TCP sender to transfer an enormous file between routers A and B over a 10 Mbps link without any packet loss, even if the routers' buffer sizes are much smaller than the file size. This can be achieved through TCP's congestion control mechanisms, such as slow start, congestion avoidance, and receiver feedback via acknowledgments (ACKs). By carefully adjusting the congestion window size and sending rate based on the available bandwidth and lack of competing traffic, the sender can effectively utilize the link capacity without overwhelming the routers' buffers, leading to a lossless file transfer. Additionally, TCP's retransmission mechanism can recover any potential packet losses caused by buffer overflows or other transient issues.