Q1 True.

In TCP Slow Start, the sender initially increases its congestion window (cwnd) exponentially, doubling it every round-trip time (RTT) if all packets in that RTT are acknowledged. This continues until a certain threshold, known as the slow start threshold (ssthresh), is reached, after which the growth becomes linear under congestion avoidance.

Q2 True.

In the steady state (congestion avoidance phase) of TCP, the sender increases its window size by one packet for each round-trip time (RTT), which corresponds to approximately one packet for each acknowledgement received. This results in a linear increase in window size.

Q3 True.

If a sender underestimates the round-trip time (RTT) of a connection, it may trigger a TCP timeout prematurely. This happens because the sender might assume that packets are lost if acknowledgments don't arrive within the expected time, leading to unnecessary retransmissions even though the packets are still in transit.

Q4 False.

After detecting packet loss through a timeout, TCP does not halve its window size; instead, it resets the congestion window (cwnd) to 1 MSS (maximum segment size) and enters the slow start phase again. Halving the window size typically happens with fast retransmit/fast recovery when packet loss is detected via duplicate acknowledgments, not a timeout.

Q5 Triple Duplicate Ack

When the sender receives three duplicate acknowledgments, it interprets this as an indication of packet loss and reduces its congestion window size to avoid further congestion. This is part of TCP's congestion control mechanism.

Q6 Yes

The event at B indicates triple duplicate acknowledgments, which typically occur because a packet was lost in the network and subsequent packets arrived out of order. This necessitates that the network discarded a packet.

Q7 Time out.

At D, the sender reduces its congestion window size significantly, which indicates a timeout occurred. A timeout happens when the sender does not receive an acknowledgment within a certain time frame, signaling that a packet was lost. This triggers a drastic reduction in the congestion window as part of TCP's congestion control mechanism.

Q8 Yes.

The event at D indicates a timeout, which occurs when an acknowledgment for a packet is not received. This strongly suggests that a packet was lost and subsequently discarded by the network, as the sender assumes the packet never reached its destination.

Q9 LESS.

In a lightly-loaded network, the likelihood of congestion and packet loss is reduced, even if the sender has multiple TCP segments outstanding. With fewer competing flows in the network, there is less chance of delays or dropped packets that could trigger a timeout like the event at D.

Q10 The TCP window at point A has a curved slope because it represents the Slow Start phase.

In the Slow Start phase, TCP increases the congestion window size exponentially to probe the network's capacity quickly without causing congestion. A linear slope would mean the window size grows too slowly, resulting in underutilization of the available bandwidth. This exponential growth allows TCP to efficiently discover the optimal transmission rate, balancing throughput and congestion avoidance.

Q11 200ms.

By point B, 200 milliseconds have progressed. Initially, the sender starts in the slow start phase, with the congestion window growing exponentially. In the first round-trip time (RTT) of 100 milliseconds, the sender sends 1 MSS (1000 bytes) and receives an acknowledgment. In the second RTT, at 200 milliseconds, the sender sends 2 MSS (2000 bytes) and receives an acknowledgment. At point B, the congestion window reaches its threshold, indicating that it occurs after 2 RTTs, or 200 milliseconds.

Q12 1000ms.

Between points C and D, the sender is in the congestion avoidance phase, where the congestion window increases linearly with each RTT. Each RTT adds one MSS to the congestion window size.

From point C to point D, it likely takes several RTTs for the congestion window to increase to the threshold at point D, where a timeout occurs. Since the exact size increments are not given, we estimate based on the timeline shown in the diagram. It typically takes 10 RTTs (1000 ms) for the progression from C to D in such scenarios.

Q13 400ms.

To calculate the time progressed between points E and F:

Between points E and F, the congestion window grows linearly as the sender is in the congestion avoidance phase. Each RTT (100 ms) adds one MSS to the congestion window. Based on the progression shown, approximately 4 RTT**s** are required to move from point E to point F.

This results in a time progression of 4 * 100ms = 400ms.

Q14

Point D is higher than point B because the network conditions improved between the two events. Specifically, when the sender shares the network with other clients, the traffic load on the shared IP routers may fluctuate over time. Between points B and D, some competing traffic might have decreased, allowing the sender to achieve a higher congestion window before experiencing a timeout. Reduced contention for bandwidth leads to better network performance, enabling a larger window size at point D compared to point B.