1. What is the need for the fields a) sequence number and b) age in packets that are flooded?

Sequence number prevents uncontrolled flooding. (A node will flood a packet only once)
Age addresses issues created by wrapping around of sequence numbers

2. Match each statement below to one of the following four: DV, LS, Both, or None

1. Always finds the best path to any destination BOTH
2. Small amount of routing data flooded throughout the network LS
3. Large amounts of routing data sent only to neighbors DV
4. Determines complete network topology LS
5. Determines sink-tree LS
6. Susceptible to count-to-infinity problem DV
7. Used in RIP DV
8. Used in TCP NONE
9. Used in OSPF LS
10. Used in BGP NONE

3. What is an IP Prefix? What does the prefix 128.5.6.0/23 represent?

A chunk of consecutive IP addresses with the same MSBs (23 in this case).
Addresses 128.5.6.0 to 128.5.7.255

4. What is the main difference between classful and classless inter-domain routing?

Classful addressing supports only three different network sizes: $2^8$ hosts, $2^{16}$ hosts and $2^{24}$ hosts. CIDR supports any power of two.

5. An IP packet with a payload size of 2400 bytes (hereinafter, the original packet) is fragmented into 3 packets of the same size. In what ways will the contents of the IP header in each fragment be similar to, or different from, the header in the original IP packet?

All 3 fragments will have 800 bytes payload size. Let 12345 be the 16 bit identity field in the original packet (with 2400 byte payload).

<table>
<thead>
<tr>
<th>Original</th>
<th>Fragment 1</th>
<th>Fragment 2</th>
<th>Fragment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identity</td>
<td>12345</td>
<td>12345</td>
<td>12345</td>
</tr>
<tr>
<td>Offset</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>MF</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total Length</td>
<td>2420</td>
<td>820</td>
<td>820</td>
</tr>
</tbody>
</table>

6. What are the contents of a NAT table? Explain the purpose of each field.

Source (private) IP, Source port, Protocol, Assigned port, Time stamp
Assigned port is chosen to be unique for every source IP and source port.
The time stamp field helps identification of stale connections which can be removed to free up the assigned port number for another connection.
7. Explain the role of the flags SYN, ACK and FIN in the connection establishment, and connection termination process.

SYN and ACK used during connection establishment:
- A to B: SYN flag set, sequence number S_A
- B to A: SYN and ACK flag set, sequence number S_B, acknowledgment number S_A+1
- A to B: ACK, acknowledgment number S_B+1

FIN and ACK flags used for connection termination:
- A to B: FIN set, sequence number S (S vs last acknowledgement number from B)
- B to A: ACK set, acknowledgement number S+1.
- B to A: FIN, sequence number Y (Y vs last acknowledgement number from A)
- A to B: ACK, acknowledgement number Y+1.

8. What are the two main purposes of the field window size in the TCP header? Why is the window scaling factor a frequently used TCP option?

- Size of TCP buffer (to store data bytes sent by the other side until the data is read by the application)
- Large window size permits the sender to send several packets back to back before receiving an acknowledgement (Window size is thus the number of bytes that can be sent during one round-trip interval)
- TCP window size is a 16-bit number. The option Window scaling factor enables scaling the window size by left shifting from 1 to 14 bits. Large window sizes are necessary to take advantage of high speed connections with high round trip times.

9. What are the three timers used by TCP? Explain their purpose.

- Retransmission Timer: Started every time a packet is sent. If ACK is not received before the retransmission timer fails the packet is retransmitted. Typically set to 1.5 times the estimated RTT
- Persistence timer: To prevent dead-lock. Whenever a non zero window size is advertised following a zero-window size advertisement, the persistence timer is started. Some response is expected from the other side before the timer fires. Else the non-zero window size will be advertised again.

10. State TRUE or FALSE

1. TCP connection establishment uses a 3-way handshake  TRUE
2. TCP connection termination uses a 4-way handshake  TRUE
3. Sequence number and acknowledgment numbers can be seen as the number of bits of data sent over the connection so far. FALSE (number of bytes)
4. The sequence number in the TCP header indicates the number of TCP connections created by a host. FALSE
5. The acknowledgment number indicates the next byte expected  TRUE
6. The optional fields in IP headers are frequently used FALSE
7. The optional fields in TCP headers are frequently used TRUE (window scaling, MTU size)
8. IPV6 uses 6 byte IP addresses instead of four byte addresses used in IPV4 FALSE (16 byte)
9. In IP protocol fragmented packets are reassembled only by the final destination TRUE
10. In the IP header, the source and destination IP addresses are modified at every hop. FALSE