For the following multiple-choice questions, each of which has ONE correct answer. Please CIRCLE the letter of the correct answer. You must CLEARLY identify your SINGLE selection. If two or more answers are marked, that question will be counted as wrong. Each multiple-choice question is worth 4 points.

1) Fragmenting large packets into small packets enhances error control because:
   a) It reduces the error rate on the channel
   b) X It reduces the amount of data retransmitted due to error
   c) It reduces the propagation delay on the channel
   d) It enables the transmitter to transmit at a higher bit rate
   e) None of the above

2) Which one of the following is true?
   a) Best-effort connection less communications protocols never use error detection.
   b) X A communication service can be circuit-switched and unreliable
   c) Connection-oriented protocols always reserve bandwidth along the route from source to destination.
   d) Connectionless communication services always reserve bandwidth.
   e) None of the above

3) Assuming no errors occur, what is returned by the \texttt{socket()} system call?
   a) X File descriptor
   b) Port number
   c) IP address
   d) Address of a socket data structure
   e) None of the above

4) Which Internet protocol layers execute on hosts outside the network core?
   a) Transport and application only
   b) Physical, link, and network only
   c) X Application, transport, network, link, physical
   d) Application, transport, and network only
   e) Application, transport, network, and link only

5) Complete the following sentence to make it true: When messages are transmitted using circuit switching, …
   a) X Bandwidth is reserved along the route prior to message transmission
   b) Messages are often delayed due to queueing at routers and switches
   c) Bandwidth is allocated dynamically to messages as they are transmitted
   d) Message transmission on each link is guaranteed to be reliable
   e) All the above

6) When a UDP datagram arrives at a computer, the operating system inspects the destination port number in the header. If that number is not associated with any existing socket, then:
   a) An error message is returned to the sender.
   b) X The received datagram is discarded
   c) The UDP connection is torn down
   d) The sending process is terminated
   e) All the above
7) Compared to circuit switching, a disadvantage of packet switching is:
   a) Waisted network capacity due to bandwidth reservation for packets.
   b) **X** Possible delays due to packet queueing
   c) Overhead due to connection setup time.
   d) Lower degree of sharing among transmitting nodes.
   e) None of the above.

8) A major benefit of circuit switching compared to packet switching is:
   a) Circuit switching does not incur any overhead for call setup, as in packet switching.
   b) **X** Once the connection is established, data transfer will not be delayed due to network congestion
   c) For bursty traffic like data, circuit switching makes more efficient use of network capacity
   d) Individual chunks of a data stream can follow different paths through the network
   e) None of the above

9) Which protocol is used to determine the MAC of another node on the same LAN if its IP address is known?
   a) DNS
   b) **X** ARP
   c) DHCP
   d) HTTP
   e) SMTP

10) What percentage of burst errors can a single parity bit catch?
    a) 0%
    b) 25%
    c) **X** 50%
    d) 75%
    e) 100%

11) As a packet travels through the Internet it passes through many different routers. These routers look at information in portions of the packet to determine where to send it next. In doing this, each router modifies some of the fields in the various layer headers. Which fields are typically modified?
    a) IP source and destination addresses
    b) TCP/UDP Source and destination ports
    c) **X** IP time to live (TTL), Link source and destination MACs
    d) IP source and destination addresses as well as Link source and destination MAC
    e) Nothing gets modified

12) UDP has some advantages over TCP, what are they?
    a) **X** No connection setup delay, no state stored, no congestion control
    b) It is more reliable
    c) Less prone to packet loss
    d) It can handle larger data packets
    e) All the above
13) TCP utilized fast retransmit to speed up sending lost packets after an error. When is this used?
   a) After a timeout
   X b) After receiving three duplicate ACKs
   c) When ever any error is detected
   d) When cwnd is less than thresh
   e) When cwind >= thresh

14) Your organization has been assigned an address block of 195.35.84.0/23 by ICANN. What does the /23 indicate?
   a) The number of bits in the host portion of the IPV4 address
   b) How many public IPV4 addresses are available to your organization
   c) X The number of bits in the network portion of the IPV4 address
   d) It’s just number used by ICANN to track which organization has the address block
   e) It has no special meaning

15) Consider a UDP datagram that is sent across an Ethernet local area network. The frame contains an application header, an Ethernet header, an IP header, a UDP header, data payload and an Ethernet trailer. Which of the following statements is true?
   a) The IP header will arrive before the UDP header
   b) The Ethernet header will arrive before the IP header
   c) The IP header will arrive before the data payload
   X d) All of a), b) and c)
   e) None of a), b), and c)

16) Consider the reliable transmission of a packet across a link. The sender will repeatedly transmit the packet until it receives and acknowledgement. Assume $L_{pkt}$ is the probability that a packet is lost or damaged, and $L_{ack}$ is the probability that an acknowledgement is lost or damaged. If $L_{pkt}$ and $L_{ack}$ are both equal to 0.2, what is the probability that exactly two attempts will be needed to successfully deliver the packet and receive the acknowledgement?
   a) 0.6400
   b) 0.0400
   c) X 0.2304
   d) 0.4096
   e) None of the above

   
   $P_{success} = (1 - 0.2)(1 - 0.2) = 0.64$
   $P_{Fail} = 1 - P_{success} = 1 - 0.64 = 0.36$
   $P_2 = 0.46 * 0.64 = 0.2304$

17) Consider a 10 Mbps (10,000,000 bits per second) channel on a copper coaxial cable. If the propagation speed of signals is $2 \times 10^8$ meters per second, how long (in meters) is the signal for one bit when transmitted on the channel?
   a) 0.05 meters
   b) 2.00 meters
   c) 0.5 meters
   d) X 20.0 meters
   e) 50.0 meters

   \[ D_{bit} = \frac{2 \times 10^8}{(1 \times 10^7)} = 20 \text{ meters} \]
18) Which of the following describes the setup of a TCP connection?
   a) Channel capacity is reserved along the route between the endpoints
   b) X State information is established at the endpoints of the connection
   c) Buffer space is reserved at routers along the route between endpoints
   d) All of a), b), and c)
   e) None of a), b), and c)

19) Domain Name service (DNS) maps domain names to IP addresses. Which of the following is true of DNS?
   a) Since its service must be reliable, DNS always uses TCP for all requests and responses.
   b) DNS is defined as part of the IP protocol standard
   c) DNS is defined as part of the TCP protocol standard
   d) X DNS is an application-level protocol that uses UDP protocol for requests and responses
   e) None of the above

20) During the Apollo space program, NASA established a 50 Kbps (50,000 bits per second) communications link between the Earth and the Moon. The distance between the two bodies is approximately 384,000 kilometers. The propagation speed of signals in space is 3 X 10^8 meters per second. Assume that data frames were 1000 bytes long. What is the propagation delay across this link?
   a) 600 seconds
   b) 1280 microseconds
   c) X 1.28 seconds
   d) 781 milliseconds
   e) None of the above

   \[ T_{\text{delay}} = \frac{3.84 \times 10^8}{3 \times 10^8} = 1.28 \text{ s} \]

   \[ T_{\text{frame}} = \frac{8000}{50000} = 0.16 \text{ s} \]

21) Using the same information as Question 20), how long does it take to transmit an individual frame on the link?
   a) 0.02 seconds
   b) X 0.16 seconds
   c) 0.625 seconds
   d) 6.25 seconds
   e) None of the above

22) Consider a packet-switching scenario with seven users sharing a 100 Mbps link, where each user again requires 25 Mbps when transmitting, but only needs to transmit 10 percent of the time. What is the probability that any 4 users (of the total 7 users) are transmitting and the remaining users are not transmitting?
   a) 0.02296
   b) X 0.00255
   c) 0.00018
   d) 0.0000729
   e) None of the above

   \[ P(n=4) = \binom{7}{4} \times (0.1)^4 \times (0.9)^3 = 0.00018 \]
   \[ P(n=4) = 35 \times 0.0001 \times 0.729 = 0.00255 \]
23) Suppose that TCP's current estimated values for the round-trip time (estimatedRTT) and deviation in the RTT (DevRTT) are 400 msec and 37 msec, respectively. Suppose that the next two measured values of the RTT are 220 and 250 msec respectively. What will the TCP timeout value be after the second RTT? Use the values of \( \alpha = 0.125 \) and \( \beta = 0.25 \)

<table>
<thead>
<tr>
<th>Sample RTT</th>
<th>Est Rtt</th>
<th>Est Dev</th>
<th>Timeout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>400.0</td>
<td>37.0</td>
<td>548.0</td>
</tr>
<tr>
<td>220.0</td>
<td>377.5</td>
<td>67.1</td>
<td>646.0</td>
</tr>
<tr>
<td>250.0</td>
<td>361.6</td>
<td>78.2</td>
<td>674.5</td>
</tr>
</tbody>
</table>

a) 646 ms  
b) X 674.5 ms  
c) 548 ms  
d) 623.5 ms  
e) None of the above

24) Consider the following network router. Packets arrive at the router at 400 pps and the average time it takes a router to process a packet is 1.5 ms. Assuming an M/M/1 model, what is the average queue length in the router?

| L = 400 | M = 1/(1.5 * 10^{-3}) = 666.67 | R = 400/666.67 = 0.6 | N = \rho/(1 - \rho) = 0.6/(1- 0.6) = 0.6/0.4 = 1.5 |

a) 0.27 packets  
b) 0.6 packets  
c) X 1.5 packets  
d) 3 packets  
e) None of the above

25) The following frame was received 10111001 which contains a CRC in the right most bits. If \( r=3 \) and \( G=1101 \), is this a valid frame?

| 11000  
---
1101 | 10111001 | 1101 | ---- | 1101001 | 1101 | ---- | 000001 |

a) Yes, because the remainder is 0 when the crc is validated  
b) X No, because the remainder is 001 when the crc is validated  
c) No, because the remainder is 101 when the crc is validated  
d) Yes, because the remainder is 111 when the crc is validated  
e) None of the above