1.

(a) Because of transaction ID in the DHCP message, the client machine a DHCP offer message from a DHCP server is meant for it. First, the DHCP discover message sent by the client contains a unique transaction ID, and then the DHCP offer message sent back from the server will have the same transaction ID. Hence the client can know the message is for it.

(b) 255.255.192.0 in binary: 11111111.11111111.11000000.00000000
Since there are 18 consecutive ones, the network prefix of 123.121.139.21 with a 255.255.192 network mask is 123.121.139.21/18 or 01111011.01111001.10.

(c) No, they are not in the same IP subnet.
255.255.128.0 in binary: 11111111.11111111.10000000.00000000
Since there are 17 consecutive ones, the network prefix is 128.101.225.81/17.
128.101.225.81 in binary: 10000000.01100101.11100001.01010001
128.101.81.81 in binary: 10000000.01100101.01010001.01010001
Because the first 17 binary bits of 128.101.255.81 and 128.101.81.81 are different, they are not in the same IP subnet.

(d) The router will have four IP addresses if all the links are active. It can also belong to four IP networks because of this. The main work of a router is to redirect data packets from one interface to another. For each interface it should have an IP address. Since now there are four active interfaces, the router should have four IP addresses and belong to four different subnets at the same time.

(e) We can know this datagram is a fragment of an (originally) larger IP datagram because the “offset” field is 100. The payload size of the original IP datagram is 1780 bytes. Because the “offset” is 100, the payload of previous segments is 100 x 8 = 800 bytes. And the payload of the packet is 1000 - 20 = 980 bytes. Hence the total payload size of the IP datagram is 800 + 980 = 1780 bytes.

2.

(a) CongWin will be set to 24 KB. In this case, since the receiver has received all the segments and CongWin < threshold, the sender can continue on the slow-start phrase.

(b) CongWin = 1 KB and threshold = 12 KB. The congestion window will immediately decrease to 1 MSS after a timeout event and threshold will become half the size of the previous congestion window.

(c) CongWin will be set to 10 KB and the threshold will still be 9 KB. The sender is at a congestion avoidance phrase. Since the receiver has received all the data segments, the congestion window will increase its size by 1 MSS after receiving the correct ACK and the threshold will not be changed.

3.

(a) The VCI no. of the packet will be 4 after it passes through router 1.
Path: host A -> router 1 (VCI no. 1 to 4) -> router 5 (VCI no. 4 to 3) -> router 4 (VCI no. 3 to 4) ->router 2 (VCI no. 4 to 3) -> host B

(b) VC Translation table of Router 1:

Input Port	Input VCI	Output Port	Output VCI
0	4	1	2
0	3	3	2
0	1	2	4
0	2	2	1
3	1	0	1
2	1	0	2

VC Translation table of Router 2:

Input Port	Input VCI	Output Port	Output VCI
0	2	1	1
2	4	1	3
1	2	3	3
3	1	1	2
1	1	2	1

VC Translation table of Router 3:

Input Port	Input VCI	Output Port	Output VCI
0	2	2	1
3	2	2	2
3	3	1	4
1	2	3	1

2	1	3	2
3	1	0	1

VC Translation table of Router 4:

Input Port	Input VCI	Output Port	Output VCI
3	2	2	2
3	1	2	3
0	3	1	4
0	1	2	1
1	1	3	1
2	1	0	1

VC Translation table of Router 5:

Input Port	Input VCI	Output Port	Output VCI
3	4	2	1
0	4	2	3
1	3	3	2
0	1	1	1
2	1	0	1

4.

Prefix match	Next hop
01011011.00011001.0000	eth0
01111111.00010010.10	eth1
01111111.00010010.100	ppp

00010001.01111101	wifi
Other	ppp

i. Destination: ppp
ii. Destination: eth1
iii. Destination: ppp
iv. Destination: ppp
v. Destination: wifi

5.

a.

i) Switch S3 will add an entry mapping E's MAC address to port number 2 in its switch table. Switch S3's forwarding table will look like afterward:

MAC address	Interface
R2's MAC address	1
F's MAC address	3
H's MAC address	4
E's MAC address	2

ii) Yes, switch S4 will also receive this ARP request message. Switch S4 will add an entry mapping E's MAC address to port number 1 in its switch table. Switch S4's forwarding table will look like afterward:

MAC address	Interface
E's MAC address	1

iii) Yes, router R2 will also receive this ARP request message and update its ARP cache. But it will not forward the IP packet to either interface 1 or interface 2 because routers do not forward the broadcast message (ARP request). It is unnecessary: If the destination is present in the same network then ARP will find out the destination MAC address but if it is present in different network then ARP will find out the default gateway MAC address.

iv) No, host G does not need to perform an ARP query in order to find out host E's MAC address because the ARP request message contains the sender MAC address, which is host E's MAC address. As long as host G has received the ARP request message from host E, it should know host E's MAC address and may store it in the ARP cache.

v) Switch S3 will add an entry mapping G's MAC address to port number 3 in its switch table. Then S3 will check its switch table and find out the destination MAC address of the packet is in the switch table and know its next hop is interface 2. Finally, it will forward the ARP response message to interface 2.

b. Host C knows that it can direct forward the packet to host D without the help of router R2 because host C can know host D is in the same network by comparing host D's IP address to its own IP address and subnet mask. Since the IP and MAC address of host D have been already in the ARP cache of host C, the source IP address will be C's IP address and the source MAC address will be C's MAC address; the destination IP address will be D's IP address and destination MAC address will be D's MAC address in the packet.

c.

i) No, host C will not perform an ARP query to find out H's MAC address because host C can know host H is not in the same network by comparing host D's IP address to its own IP address and subnet mask. Instead, it will send the packet to its default gateway (router) in the subnet.

ii) Source IP address: C's IP address
Destination IP address: H's IP address
Source MAC address: C's MAC address
Destination MAC address: R2's MAC address

iii) Yes, router R2 will use interface 3 to deliver the IP datagram from host C to host H because 128.101.100.21 mathes 128.101.100.0/20 in the forwarding table and it will forward the packet via interface 3.

iv) The source MAC address of the new Ethernet frame will be R2's MAC address and destination MAC address will be H's MAC address2.

d. No, switch S3 will not receive the Ethernet frame containing the IP datagram sent by host H to the remote host U. The reason is that the packet will be sent to router R1 first and host H will send the packet via its interface 1. However, switch S3 is connected to host H via H's interface 2 and will not receive the packet in the halfway.

e.

i) Switch S3 will use outgoing interface 1 to forward this Ethernet frame. Because R2's MAC address matches interface 1 in the S3's switch table.

ii) Host H is likely to use interface 2 to deliver this IP datagram to host E. After receiving the former IP datagram from host E, host H will know host E’s IP address. Then host H can find out that host E is in the same network by comparing host E’s IP address to its own IP address and subnet mask. If host E’s MAC address has already been in host H’s ARP cache, host H can directly send the packet to host E without any help from routers. Hence interface 2 is preferable since it is connected to the subnet 128.101.100.0/20.