Q1) i) Initial window :-

size $= 2^3 - 1$

$= 7$

6 ¦ 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 ¦ 0

$\xleftrightarrow{\text{size}}$

ii) Frames 0, 1 are sent and acknowlegement is received :

0 ¦ 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 ¦ 2

Sliding window will side along 2 frames and now frame 2 will be ready to be sent.

iii) A timer starts when frame 2 is sent. Then frames 3, 4, 5 are also sent but as frame 2 is lost, the sender does not receive any acknowledgement and timer expires. Hence, the sender resends all the frames

$S_f \longrightarrow S_n$

0 ¦ 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 ¦ 2

iv) Now the acknowledgement of frames 2, 3, 4, 5 will be received by the sender and the sender will be ready to send frame 6

4 ¦ 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 ¦ 6

Q2) a) The sender has to send four data items which are 0x3456, 0xABCC, 0x02BC and 0xEEEE

0x3456 = 0011 0100 0101 0110
0x ABCC = 1010 1011 1100 1100
0x 02BC = 0000 0010 1011 1100
0x EEEE = + 1110 1110 1110 1110

1 1101 0001 1100 1100
1

1101000111001101 ——— (1)

Now taking 1's complement of (1)

$\underbrace{0010}_{2}$ $\underbrace{1110}_{(14)E}$ $\underbrace{0011}_{3}$ $\underbrace{0010}_{2}$

The checksum ~~from~~ the sender's side is as shown above. = 2E32
So from sender's end the bits that will be send which is checksum i.e. along with the four date items.

b) Now since there are no errors at the receiver's end. So at the receiver's end, all the data items will be added along with checksum and it will be

0010 1110 0011 0010
0011 0100 0101 0110
1010 1011 1100 1100
1110 1110 1110 1110
+ 0000 0010 1011 1100

1 1111 1111 1111 1110

1111111111111110

$+\ 1$

1111 1111 11111111

On taking 1's complement, we get all zeros and this verifies that there were no errors in receiving data.

1914078

Q3) Nyquist bit rate formula defines the theoretical maximum bit rate

$$\text{BitRate} = 2 \times \text{Bandwidth} \times \log_2 L$$

Bandwidth : bandwidth of the channel
L : number of signal levels used to represent data
BitRate : in bits per second.

→ Shanon Capacity states that with noise, some bits might be corrupted

Signal to noise ratio: (SNR)

$$SNR = \frac{\text{Signal Power}}{\text{noise power}}$$

Shanon capacity (c) = $B . \log_2 (1 + SNR)$

→ Given,
band width : 20 KHz
$SNR_{db} = 40$

But $SNR_{db} = 10 \log_{10} SNR$

$$SNR = 10^{SNR_{db}/10}$$
$$= 10^4$$

$$\text{Capacity} = B . \log_2 (1 + SNR)$$
$$= 20 \times \log_2 (10001)$$
$$= 265.75 \text{ Kbps}$$