1a) Seven layers of ISO-OSI model are as follows:

i) Physical, ii) Data-link, iii) Network, iv) Transport, v) Session, vi) Presentation, and vii) Application

Among these layers transport, session, presentation, and application layers are end-to-end.

1b) Range of frequency in a spectrum is defined as bandwidth of the spectrum.

1c) According to Fourier theory, any waveform can be represented by a summation of a (possibly infinite) number of sinusoids, each with a particular amplitude and phase. Such a representation is referred to as the signal's spectrum (or it's *frequency-domain representation*).

1d) Attenuation refers to any reduction in the strength of a signal.

If Ps is the signal power at the transmitting end (source) of a communications circuit and Pd is the signal power at the receiving end (destination), then Ps > Pd. The power attenuation Ap in decibels is given by the formula:

$Ap = 10 \log_{10} (Ps / Pd)$

1e) A subnet is an identifiable sub part of an organization's network. It contains routers and the connection between routers which might be either wired or wireless. In terms of a wide area network, the local area networks that it contains can be considered as separate subnets.

1f) TCP and UDP

1h) Frequency ranges used to transfer data in optical network:

O band	original	1260 to 1360 nm
E band	extended	1360 to 1460 nm
S band	short wavelengths	1460 to 1530 nm
C band	conventional ("erbium window")	1530 to 1565 nm
L band	long wavelengths	1565 to 1625 nm

U band	ultralong wavelengths	1625 to 1675 nm

1i) In Simplex communication, data transmission is possible in only one direction. For example transmission in television systems.

In Half-duplex mode of communication, data transmission is possible in both directions, however they can not occur at the same time. For example in case of hand held transceivers or walkie-talkie.

In Full-duplex mode of data transmission, it is possible from both end and at the same time. Communication in telephone systems.

1j) Data rate can be increased while using the same bandwidth, by using a quantization scheme which uses higher number of signal levels to encode more bits in the same signal.

1k) Types of transmission impairments:
 i) Delay, ii) Jitter, and iii) Attenuation.

1l) Types of noise:
 i) Thermal noise or white noise
 ii) Shot noise
 ii) Transit time noise

1m) Parameters that need to be known to interpret a signal:
 i) Angular frequency, and ii) phase

1n) Shortcomings in channel that lead to the necessity of Data Link Layer
 1) Error detection, 2) error correction, and 3) flow control

1o) Three contingencies taken care by Go-Back N ARQ:
 1) Damaged frame, 2) Damaged RR, and 3) Damaged REJ

2a)

$N_o = kT$,
k = Boltzman's constant ($k = 1.38 \times 10^{-23}$ joules/kelvin)
$N_o = 4.002 \times 10^{-21}$

2b)

(1 + 0.5 Cos 5t) Cos 100t
= Cos 100t + 0.25 (2 Cos 5t Cos 100t)
= Cos 100t + 0.25 (Cos 105t + Cos 95t)
= Sin(100t +π/2) + 0.25 Sin(105t + π/2) + 0.25 Sin(95t + π/2)

1st comp: Amp A =1, ω = 2πf = 100 → f = 50/π, φ = π/2
2nd comp: Amp A = 0.25, ω = 2πf = 105 → f = 105/2π, φ = π/2
3rd comp: Amp A = 0.25, ω = 2πf = 95 → f = 95/2π, φ = π/2

2c) Nyquist Capacity: $C= 2B \log_2 M$
where C is capacity, B is bandwidth. and M is number of levels.

Shanon's Capacity: $C = B \log_2 (1 + SNR)$
where C is capacity, B is bandwidth. and SNR is signal to noise ratio.

For a given spectrum, B= 1 MHz.
$SNR_{db} = 24$ db
$SNR_{db} = 10 \log_{10} SNR$
$SNR = 10^{SNRdb/10}$
$SNR = 10^{2.4}$
SNR = 251.1

$C = 1MHz \log_2(1 + 251.1)$ (using Shanon's capacity) ---(i)
$C = 2\ 1MHz \log_2 M$ (using Nyquist capacity) ---(ii)
$2 \log_2 M = \log_2(252.1)$ (comparing i and ii
$M = (252.1)^{0.5}$
$M \approx 16$

2d) Interlaced scan refers one method for "painting" a video image on an electronic display screen by scanning or displaying each line or row of pixels. This technique uses two fields to create a frame. One field contains all odd lines in the image, the other contains all even lines.

A PAL-based television set display, for example, scans 60 fields every second (30 odd and 30 even). The two sets of 30 fields work together to create a full frame every 1/30 of a second (or 30 frames per second), but with interlacing create a new half frame every 1/60 of a second (or 60 fields per second). To display interlaced video on progressive scan displays, playback applies de-interlacing to the video signal (which adds input lag).

There are 483 rows and 483 x 3/4 columns.
So the required bandwidth is:

483 x 483 x 3/4 x 60 bits/second. = 10498005 bits/second.

3c) Multiple frequency-shift keying (MFSK) is a variation of frequency-shift keying(FSK) that uses more than two frequencies. MFSK is a form of M-ary orthogonal modulation, where each symbol consists of one element from an alphabet of orthogonal waveforms. M, the size of the alphabet, is usually a power of two so that each symbol represents $\log_2 M$ bits.

fc = 2500 Khz, fd = 25 Khz, No of bits/signal = 4, M = 2^4 = 16

fi = fc + (2i -1 -M) fd

f1 = 2125 Khz, f2 = 2175 Khz, f3 = 2225 Khz, f4 = 2275 Khz,
f5 = 2325 Khz, f6 = 2375 Khz, f7 = 2425 Khz, f8 = 2475 Khz,
f9 = 2525 Khz, f10 = 2575 Khz, f11 = 2625 Khz, f12 = 2675 Khz,
f13 = 2725 Khz, f14 = 2775 Khz, f15 = 2825 Khz, f16= 2875 Khz

3e) In signal theory, a signal element is a part of a signal that is distinguished by its: duration, magnitude, nature (the modulation technique used to create the element), relative position to other elements, transition from one signal state to another.

4a) A framing error is the result of starting to read a sequence of data at the wrong point. Normally it happens due to the presence of start/stop bit in the information data part.

4b) There are 8 data bits, 1 even parity bit, and 2 stop bits. So there are total 11 bits.

Let us assume that Q% clock inaccuracy can be tolerated. Hence total error may result in is 11 x Q /100.

As sample is taken at the midpoint, so less than 1/2 bit error is fine with system.

$11 Q / 100 < ½$
$Q < 4.54$

4d) Number of frames per day
= Number of frames per second x 24 x 60 x 60
= 64000 / 1000 x 24 x 60 x 60
= 5529600

Probability of frame error = 1 / 5529600 = 1.8×10^{-7}
Hence with 1.8×10^{-7} probability a erroneous frame may be received.

Successful frame transmission probability
= $(1 - BER)^{\text{number of bits in frame}}$

$1 - 1.8 X 10^{-7}$
= $(1 – BER)^{1000}$

Hence, BER = $1.8 X 10^{-10}$

4e) BER: The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage.

5a) Distance between any two valid code is at least 2t + 1. So if even t bit of a valid code got flipped we can identify the nearest valid code and accordingly correct the error. However if t + 1 bits got flipped then modified code will be closed to other valid code and hence error correction will not be possible.

5c) Sampling rate = 7000 samples/sec
Number of bits in each sample = 8
Data rate = 7000 x 8 bits/second = 56 Kbps

5d) 10% of channel is idle
Hence, Po = 0.1, $e^{-G} = 0.1$
Hence, channel load G = 2.3

Throughput, $S = G \times e^{-G} = 0.23$
Channel is overloaded as $G > 1$.