Question 1.
a) t b) f c) f d) f e) t f) f g) t h) f i) f j) t

Question 2.

- CAS (Channel Associated Singling) and CCS (Common Channel Signaling) and subclasses of inter-exchange singling

- CAS includes R1,R2 and SS no: 5 (the old way)
- In CAS voice and signal at the same path
- Divided into Register and Line Singling
- Line Singling: exchange info showing seizure, answer, clear forward, clear back
- Register signaling: exchange routing info: B-number, A-category, B-stsus etc. that is unique info for each call
- Typical methods of CAS of Direct Current (DC9 and VF (Voice Frequency as R2) signaling
- Used in PSTN
- CAS can be used with analog and digital connections (but usually analog)

- CCS includes SS6, SS7
- In CCS signaling has a path of its own (signaling network)
- Used in PSTN, ISDN & PLMN
- Used with digital connections
- Reduces call setup time

2b)

SLIP: (serial Line IP) (the old way)
- Described in RFC 1055 (year 1984)
- Uses raw IP packets with a special flag byte
- RFC 1144 describes header compression that makes this more effective
- No error detection / correction
- Only IP supported (not for example Novel LANs)
- Dynamic IP address assignment not supported
- No authentication (not a problem in leased lines but a big problem in dial-up networking)
- Many versions that not compatible

PPP: (point-to-point protocol)
- Defined in RFC 1661, 1662,1663
- Support for authentication, error detection, multiple protocols, IP address negations,
- Provides: (1) frame format including error detection (2) includes LPC link control protocol (3) Network layer options can be negotiated

2c)

PDH: (Plesio-Synchronous Digital Hierarchy)

- Low in efficiency, highly specialized and inflexible, has problems such as various telecom services (e.g., telephone, data, fax and leased lines) using infrastructure facilities that are totally separated. This results in low communication efficiency, complicated maintenance and management, high cost, and failure to meet new demands of customers (http:// www.telecomn.com/ english/ china_comm/ FOCUS5_20007.htm)
- Sensitive to timing errors
- Awkward disassembly of hierarchy subgroups
- Poor network management

SDH (Synchronous Digital Hierarchy)

- Practically same as SONET (Synchronous Optical Network)
- Enables different carrier to inter-network
- Way to combine USA, Europe & Japn 64 kbit/s PCM systems
- Efficient multiplexing technique
- Support Operations, Administration & Maintenance
- Master clock controlled
- Consists of switched, multiplexers & repeaters
- Basic channel is STS-1 (51.84 Mb/s) and others its multiples

Question 3.

a) QoS (Quality of Service)

QoS is defined by certain QoS parameters which depend on the service in question. The user (subscriber) subscribes to a certain service (on a permanent basis) or negotiates a service contract (on a temporary basis) defined by a number of QoS parameters (maybe also some traffic parameters), such as

- delay, delay variation
- cell loss ratio (ATM), BER
- throughput, bandwidth (these are in fact traffic parameters).

The more the user pays for a service, the higher QoS he/she can expect or demand from the network (operator). In other words the network must fulfill certain QoS requirements (i.e. certain parameter values should not be exceeded, e.g. delay should be less than x ms).
Example: speech requires low delay & delay variation but BER is not so critical. The opposite is true for certain data transmission services.

b) QoS in ATM

=> see lecture notes. Certain QoS classes have been defined by ITU-T (not to be confused with service classes). ATM Forum specifies QoS parameters separately (no

QoS classes). QoS parameters: cell (transfer) delay, cell delay variation, cell loss ratio, cell error ratio, cell misinsertion rate, Severely Errored Cell Block Ratio (SECBR).
If AAL protocols (classes) are described here instead of QoS => 1p

c) QoS in UMTS

In contrast with GSM/GPRS, UMTS can take care of QoS considerations. This can be done using so-called *bearers*, a flexible concept designating a kind of ”bit pipe”

- at a certain network level
- between certain network entities
- with certain QoS attributes and capacity (bandwidth)

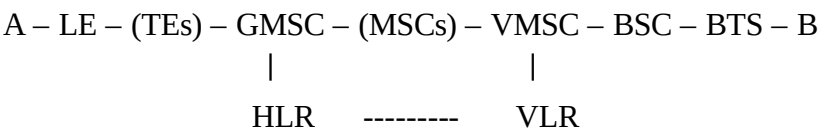
UMTS QoS Classes: conversational, streaming, interactive, background (not necessary for obtaining full points; the bearer concept is more important)

d) Connection admission control is a traffic control mechanism:

Based on a negotiated contract between subscriber and network operator (trade off: stringent requirement on traffic and QoS performance ⇔ higher cost of service), the network decides if a connection request can be accepted. The decision depends on e.g. the current traffic load in the network. If there is a certain probability that the network will not be able to fulfill the traffic or QoS requirements negotiated in the contract (e.g. cell rate, delay, delay variation, cell loss ratio), admission to the network will be refused.

Question 4.

Network nodes involved in setting up connection between A and B:



A = ISDN User A
LE = local ISDN exchange
TE = transit exchange
VMSC = visited MSC

Protocols (not all required for obtaining full points, especially on the GSM side):

A – LE:	DSS1 (ISDN subscriber signaling)
LE – VMSC:	SS7 (MTP + ISUP)
VMSC – BSC:	SS7 (MTP + SCCP + BSSAP + CM & MM)
BSC – B:	GSM signaling (LAPD (+ BTSM) + RR, CM & MM)
GMSC – HLR, HLR – VLR:	SS7 (MTP + SCCP + TCAP + MAP)

Message transactions (could be more detailed, especially on the GSM side):

A – LE:	DSS1 Setup message contains (among others) B number (in this case MSISDN)
LE (and TEs):	MSISDN number analysis for routing to GMSC
LE – GMSC:	ISUP IAM message
GMSC – HLR:	Obtain routing information for connecting to B
HLR:	Translation of MSISDN into routing information
HLR – GMSC:	Routing information provided
GMSC – VMSC:	ISUP IAM message
VMSC – B:	paging message broadcasted
B – VMSC:	B responds
B – VMSC – LE – A:	CM messages routed back (e.g. ACM, ANM in ISUP) and circuit switched connection is established between B and LE
LE:	when ISUP ANM message is received, the circuit switched connection (already existing between LE and B) is established up to A and charging starts

Question 5.

Figures presenting the GSM, GPRS and UMTS network architecture are given in the course material. It should be possible to deduce the following facts from the figures:

GSM:
- A circuit switched connection involves the following network elements: MS – BTS – (BSC) – MSC – GMSC –> PSTN/ISDN network
- Circuit switched connections are *not* routed through HLR (EIR, AC)
- Databases: MS (SIM), VLR, HLR (EIR, AC)
- Access to Internet/X.25 only via established circuit switched connection via GMSC (or using GPRS)

GPRS:
- A packet switched connection involves the following network elements: MS – BTS – (BSC)/PCU – GSGN – SSGN –> Internet/X.25 network
- Packet switched connections are *not* routed through HLR (EIR, AC)

UMTS:
- New radio access network (UTRAN) + old (slightly modified) GSM/GPRS core network
- RNC's can be interconnected (reason why?)

Network elements:

MS: includes database (SIM) which contains among others authentication key, IMSI and latest TMSI, LAI information

BTS, base station: takes care of tasks related to signal transmission over the air (radio) interface (modulation, ciphering) and (small) part of radio resource management

BSC: takes care of *radio resource management* (e.g. allocation of radio channels, handovers, power control)

RNC: same as previous, also connection between two RNC's possible (reason why?)

VLR: involved in *mobility management*, stores temporary data of subscribers roaming within its area (e.g. IMSI, TMSI, LAI)

HLR: stores subscriber data (e.g. permanent subscription information, current VLR serving the subscriber)

MSC: involved in *call management*, switching and routing of circuit switched calls

GMSC: interface to PSTN/ISDN only possible via this network element

SGSN: switching and routing of packet data

GGSN: interface to Internet/X.25 network only possible via this network element

EIR: database containing MS hardware information

AC: database containing authentication keys of subscribers

In addition, various network elements related with charging, security, etc.