1. (a) The DTD element declarations are as follows:

```xml
<!ELEMENT article (author+, title, (journal | book | conference), year, pages?)>
<!ELEMENT journal (title, volume?, number)>
<!ELEMENT book (title, editor*)>
<!ELEMENT conference (title, venue)>
```

(b) The main difference is that a broadcast channel is a shared resource while a point-to-point channel is used exclusively by the two parties communicating. The consequence is that access to a broadcast channel must be coordinated. Three different types of protocols used on broadcast channels are channel partitioning protocols, random access protocols, and taking-turns protocols.

(c) Routers by definition have one IP address for each network they are connected to. Other machines may have multiple network interfaces (e.g. WiFi and wired Ethernet), each with their own IP address.

2. (a) An IP address of all-zeroes is used during boot-up for “this computer”. An IP address of all-ones is used for broadcast on the local network. An address with the network prefix and all-zeroes for the suffix is used to identify a network. An address with the network prefix and all-ones for the suffix is used for broadcast on the local network. There are also address ranges reserved for private internets as well as the so-called loopback addresses used for testing.

(b) Each form field has a name attribute whose value is used to identify the field. These names and their values are sent in the HTTP GET or POST message. PHP has built-in associative arrays whose keys are the field names.

(c) The XMLHttpRequest object allows a script to send an HTTP request back to the server from which the page was loaded, potentially in an asynchronous manner. The open method specifies the HTTP method to be used and whether the request should execute asynchronously. The send method sends the request. The responseXML and responseText properties provide the response in DOM
or text form, respectively. The `onreadystatechange` property stores the name of a callback function. (Any two will do.)

(4 marks)

3. (a) The string `xs1:` is a namespace prefix. It does not appear in the `<h2>` start and end tags because they are not in the XSL namespace.

(2 marks)

(b) The start tag is `<div class='slide'>`.

(3 marks)

(c) The `variable` construct declares a variable named `section` and assigns it a number which is the position of the current `div` element (with class attribute value of 'slide') within all such `div` elements.

(4 marks)

(d) The elements selected by `*` are all child elements of the `div` element matched by the template rule.

(3 marks)

(e) If the name of the current element is `<h1>`, then an `<h2>` element is output with contents equal to the value of the `section` variable, followed by a period, followed by the contents of the `<h1>` element. If not, then the current element and all its descendants are copied to the output unchanged.

(8 marks)

4. (a) i. They are parameter entities. They are distinguished syntactically from general entities by the use of `%` both in their declarations and when referencing them.

(2 marks)

ii. They are considered useful as a shorthand notation for common parts of a DTD, and also to provide more meaningful names for some components.

(2 marks)

iii. The declaration for the `BR` element is:

```xml
<!ATTLIST BR
  id ID #IMPLIED
  class CDATA #IMPLIED
  style CDATA #IMPLIED
  title CDATA #IMPLIED>
```

(3 marks)

(b) i. The root servers receive DNS requests containing a DNS name and return the IP address of a DNS server for the top-level domain name appearing in the address.

(3 marks)
ii. The root servers are not used for every DNS lookup since caching is used extensively, e.g., in browsers as well as by local DNS servers. Even after expiry of the time-to-live of a cached entry, a request will probably be satisfied by a cached entry lower in the hierarchy than a root server.

(c) Protocol port numbers are represented by 16-bit integers. Each port number is used to denote a service (i.e., a running process) available on a machine on the Internet, e.g. DNS. The first 1024 port numbers are reserved for common services such as web servers, each of which has a default port number (e.g. 80). Source and destination port numbers are stored in transport-layer headers.

5. (a) TCP uses a window mechanism to control the flow of data. When a connection is established, each end of the connection allocates a buffer to hold incoming data, and sends the size of the buffer to the other end. As data arrives, the receiver sends acknowledgements together with the amount of buffer space available, called a window advertisement. If the receiving application can read data as quickly as it arrives, the receiver will send a positive window advertisement with each acknowledgement. However, if the sender is faster than the receiver, incoming data will eventually fill the receiver’s buffer, causing the receiver to advertise a zero window. A sender that receives a zero window advertisement must stop sending until it receives a positive window advertisement.

(b) i. The router looks up the destination port number 5001 in its table. Finding an entry in the table, it then replaces the destination port number in the TCP header by 3345 and replaces the destination IP address in the IP header by 10.0.0.1.

ii. The router first searches its table to see if there is a matching entry in the LAN column. Since there is not (the port number is different), it creates a new entry in the table with 10.0.0.1, 7668 in the LAN column, along with its IP address and a random port number (larger than 1024) in the WAN column. It then replaces the source port number and source IP address by these entries.

(c) Manchester encoding uses rising and falling edges to encode bits because it is easier for hardware to recognise a change in voltage rather than a constant voltage.
6. (a) IP fragmentation arises when an IP datagram is larger than the maximum amount of data that can be accommodated by a link layer frame (the maximum transmission unit or MTU). The IP datagram is divided into fragments, each with the original destination and identification field, but with a flag set to indicate that each is a fragment, along with its position in the original datagram specified using a fragmentation offset. The fragments are reassembled at the final destination using the identification, fragmentation offset and flag fields. (10 marks)

(b) Persistent connections can send multiple request and response interactions over a single TCP connection. This results in improved performance over HTTP 1.0 since multiple TCP connections do not have to be established and terminated, each of which requires computational expense. Pipelining means sending multiple requests before waiting for a response, rather than being limited to request-response pairs of interactions. The server needs to send responses back in the same order in which they were sent. This also improves performance and network utilisation. (10 marks)

7. (a) i. The string **goodbye** would appear in the righthand text box. (3 marks)

ii. The string **unknown** would appear in the righthand text box. (2 marks)

(b) When TCP sends data, a timer is started. If the timer expires before an acknowledgement is received, TCP retransmits the data. The length of the timeout is determined as follows. For each active connection, TCP generates a sequence of round-trip estimates and produces a weighted average. It also maintains an estimate of the variance, and then uses a linear combination of the estimated mean and variance as the value of the timeout. (7 marks)

(c) i. `//p//p` (3 marks)

ii. `//.[not(name()=ul or name()=ol)]/li or //li[not([name()]^ul or name()^ol)]` (3 marks)