1	1	**2 marks AO2 (analyse) and 2 marks AO1 (knowledge)** Award **1 mark** for each correctly named protocol, up to a maximum of **2 marks** and **1 mark** for each correct explanation of what a protocol will be used for, if linked to the correct protocol. **A.** if correct initialism used but then the full term is incorrect eg "SMTP – Special Mail Transfer Protocol" as **BOD** **A.** other protocols that achieve the same purposes as those listed above **R.** non-application layer protocols eg TCP, IP	**4**

Protocol (AO2)	**Use (AO1)**
SMTP // Simple Mail Transfer Protocol	To send/transmit/receive emails (to/from another email server/client).
POP(3) // Post Office Protocol (3) // IMAP // Internet Message Access Protocol	(So that clients can) retrieve/manage emails on the server. **TO.** sending emails **A.** receiving emails as BOD but **TO.** receiving emails if answer suggests that this is done as the email is sent.
SSH // Secure Shell // Telnet // RDP // Remote Desktop Protocol	So that technicians can execute commands on the server // to give access to command line // provides a secure/encrypted connection for remote management (only award for secure protocols) **NE.** to login remotely
HTTP / HTTPS	So users can access email via the web / a web browser // so that technicians can access web-based control panels.

1	2	**Mark is AO1 (understanding)** (The transport layer will) use the port number to (determine which server / software should deal with the request) // by adding a port number to the request/data/packet; **A.** examples of specific port numbers and which server / software they would be directed to.	**1**

1	**3**	**Mark is AO1 (knowledge)** Adds source IP / destination IP address(es) (to datagrams/packets); **R.** MAC address **NE.** Adds IP address **NE.** Uses destination IP address Performs routing // selects the next host / hop to transmit a datagram/packet to; **A.** determines where to send data to using destination IP address **NE.** determines where to send data to Creates checksum for datagram/packet header // performs error detection on the datagram/packet header; **NE.** error detection on its own Encapsulating/splitting data into datagrams // reassembling data from datagrams; **R.** packets for this mark point only **Max 1**	**1**

2	**1**	**Mark is for AO1 (knowledge)** D; **R.** if more than one lozenge shaded	**1**

2	**2**	**Mark is for AO1 (understanding)** B; **R.** if more than one lozenge shaded	**1**

2	**3**	**2 marks are for AO1 (understanding)** More compact; **A.** facilitates faster transmission, smaller file size, uses less memory Quicker (**A.** easier) to parse; Structure understood directly in some languages (eg Javascript); (Native) support for arrays; Easier <u>for humans</u> to read/write/understand; **Max 2**	**2**

3	**1**	**Mark is for AO1 (understanding)** Reduces the need for expert knowledge when configuring a host; **A.** No requirement to manually assign IP addresses / other values **A.** Automatic assignment of IP addresses Reduces the time required to configure hosts; Facilitates efficient use of a limited pool of IP addresses; **A.** Example of how this is facilitated eg reuse Avoids errors - with a relevant example such as duplicating IP addresses or programming incorrect subnet mask; **NE.** "avoiding errors" without an example **Max 1**	**1**

3	**2**	**2 marks for AO1 (understanding)** The computers have private/non-routable IP addresses // 192.168.2.3 is a private/non-routable IP address; **NE.** The computers can have the same IP addresses as they are on different networks NAT/Network Address Translation will be performed (so that the computers can communicate on the Internet) // as data passes onto Internet, private IP address replaced with public IP address of router/gateway;	**2**

3	3	**12 marks for AO1 (understanding)**	**12**

Level	Description	Mark Range
4	A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. The response covers all three areas indicated in the guidance below and in at least two of these areas there is sufficient detail to show that the student has a good level of understanding. To reach the top of this mark range, a good level of understanding must be shown of all three areas.	10–12
3	A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response which shows a good level of understanding of two areas indicated in the guidance below.	7–9
2	A limited attempt has been made to follow a line of reasoning and the response has a mostly logical structure. A good level of understanding has been shown of at least one area or a reasonable understanding has been shown of at least two areas.	4–6
1	A few relevant points have been made but there is no evidence that a line of reasoning has been followed. The points may only relate to one or two of the areas from the guidance. There is insufficient evidence of a good understanding of any of the three areas.	1–3

Guidance – Indicative Response

Determining if on LAN:

- AND operation of subnet mask with Computer A's IP address
- AND operation of subnet mask with Computer B's IP address
- result (of each AND operation) is the network/subnet ID
- network/subnet IDs compared
- as they are different, then packet must be sent via router/gateway/Internet // Computer B is not on the same subnet
- if they were the same, then packet can be sent directly to Computer B // Computer B is on the same subnet.

If no other points made, then a very basic understanding could be shown by recognising that the subnet mask is used with the IP addresses to determine if the two computers are on the same network/subnet.

Good level of understanding = most of the key elements listed above are covered.

Routing across Internet:

- hierarchical organisation of routers
- example of hierarchical organisation of routers eg passed up to a national router, transferred internationally and then passed back down a hierarchy
- path to take selected by each router (not determined at start) **NE.** passed from router to router

		• route may change as a result of eg congestion, technical problems • (possible) repackaging of packet to use different protocol (eg gateway may change protocol) • route determined using the (Network ID part of the destination) IP address (**Note:** can infer "IP address" if just "address" is stated, if previously candidate has written about an IP address) • use of router tables / criteria to determine next hop / (step of) path • router decrementing "time to live" of packet • source and destination MAC addresses changed at each router // MAC addresses used for each "hop" • IP address of Computer A will be replaced with IP address of Router A3 // NAT / Network Address Translation will occur at router(s). *Good level of understanding = most of the key elements listed above are covered.* **Checksum:** • checksum produced when packet transmitted // by computer A • (hash) value / checksum calculated from packet contents • MOD operation (often) used to limit magnitude of checksum // fit value to specific number of bits • this value / checksum transmitted with packet // appended to packet • computer B recalculates checksum // performs same calculation on data • received and calculate checksum compared • if these match packet contents/data are accurate // if these differ the data has been changed // if these differ there is an error in the data. *Good level of understanding = most of the key elements listed above are covered.*	

Qu	Pt	Marking guidance	Total marks
4		**1 mark AO1 (knowledge) and 2 marks AO1 (understanding)** **What it is (1 mark):** Processing is carried out // applications/programs are executed on an application server (**A.** server); **NE**. Resources are stored on the server **Why selected (Max 2 marks):** Clients are cheaper to purchase // clients can have lower hardware specification; **NE.** cheaper without further explanation Less configuration of clients is necessary // easier to configure/add a new client // easier to replace a client; Simpler installation/updating of software (as only done on server); **R.** if implication that software is on client Impossible to install unauthorised software on workstations // more secure as fewer settings can be changed; Workstations consume less electricity/power; Licensing can be cheaper (as licence per active user not per client); Longer MTBF for workstations // workstations do not fail/break as often // workstations need less maintenance; **Max 3**	**3**

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking guidance</th><th>Total marks</th></tr>
<tr><td>5</td><td>1</td><td>All marks AO2 (analyse)

1 mark per valid IP address

<table>
<tr><td>The Router 1 port labelled A</td><td>192.168.x.y
where:
• x is in range 192 to 207
• y is in range 0 to 255
R. 192.168.192.0
R. 192.168.207.255</td></tr>
<tr><td>The Router 1 port labelled B</td><td>192.168.x.y
where:
• x is in range 64 to 79
• y is in range 0 to 255
R. 192.168.64.0
R. 192.168.79.255</td></tr>
<tr><td>The computer labelled C</td><td>192.168.x.y
where:
• x is in range 64 to 79
• y is in range 0 to 255
R. 192.168.64.0
R. 192.168.79.255
R. same response as for part B</td></tr>
</table></td><td>3</td></tr>
</table>

Qu	Pt	Marking guidance	Total marks
5	2	**Mark is AO2 (analyse)** **C**; (255.255.240.0) **R.** more than one lozenge shaded	**1**

Qu	Pt	Marking guidance	Total marks
5	3	**Mark is AO1 (understanding)** There are not enough (unique) addresses in IPv4 // IPv4 addresses are running out // to provide more addresses; Eliminate need for NAT / network address translation // facilitates true end-to-end connectivity; Simplified / more efficient routing is possible; Improved facilities for multicasting; Automatic configuration possible without DHCP; Allows bigger packet sizes; Devices can move / roam between location and keep the same IP address; Improved support for prioritising traffic by type; **Max 1**	**1**

Qu	Pt	Marking guidance	Total marks
5	4	**Mark is AO1 (understanding)** Star; **A.** physical star, star topology, star network	**1**

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking guidance</th><th>Total marks</th></tr>
<tr><td>5</td><td>5</td><td>

2 marks for AO1 (knowledge) and 4 marks for AO1 (understanding)

<table>
<tr><th>Level</th><th>Description</th><th>Mark Range</th></tr>
<tr><td>3</td><td>A detailed, coherent, description of CSMA/CA that includes the use of RTS / CTS and that conveys good understanding of how the protocol works. Whilst there may be some omissions from the description it contains no misunderstandings.</td><td>5–6</td></tr>
<tr><td>2</td><td>An adequate description of CSMA/CA, including at least three points from the list below. The description is logically organised so that it makes sense when read as a whole and therefore demonstrates a reasonable understanding of how the protocol works. The description may or may not include the use of RTS / CTS.</td><td>3–4</td></tr>
<tr><td>1</td><td>A small number of points relevant to of CSMA/CA have been recalled (in this case award one mark per point, up to a maximum of two from lists below). However, the structure of the response, or lack of it, demonstrates only a very limited understanding, if any, of the protocol used.</td><td>1–2</td></tr>
</table>

Indicative Content

- Computer with data to send monitors / listens for (data signal).
- If (data) signal present / another transmission in progress then continue to wait.
- When no (data) signal present computer sends a Request to Send / RTS. **A.** if no valid points made about RTS / CTS in response then accept ‘when no data signal is present computer starts to transmit data’, but since no marks awarded for RTS / CTS then marks are limited to max Level 2.
- Two computers could start transmitting simultaneously <u>if they both detect there is no data signal.</u>
- <u>Receiver / WAP</u> responds (to RTS) with a Clear to Send / CTS signal. **A.** router
- RTS / CTS signal blocks any other transmissions from nodes in range (for a specified time).
- If / when CTS received then start to transmit. **A.** by implication as **BOD** if the student states that the computer will begin to transmit after the receiver sends the CTS.
- If CTS not received continue to wait (until transmission ends).
- Receiver sends acknowledgement / ACK <u>after (all) data received</u>
- After transmitting (the transmitter) waits to receive acknowledgement packet (to confirm data received and not corrupted).
- If no acknowledgement / ACK received (within reasonable time period) then:
  - wait a time period.
  - then listen again / retransmit.
- The acknowledgement / ACK also notifies other computers that they can transmit again // after the time specified in the CTS passes, other nodes can transmit.
- Waiting periods are (often) random. **A.** an example waiting period that is random.
- Collisions cannot be detected by transmitter.

</td><td>6</td></tr>
</table>

Question			Marks
6		**All marks AO1 (understanding)** **For a thin-client system…** **Network (Max 1):** Higher bandwidth network connection required; **A.** examples of how high bandwidth might be achieved eg use of fibre optic cables, gigabit switches **Client (Max 2):** • Slower (clock speed) processor needed • Reduced RAM needed • No / small HDD / SSD / secondary storage required in workstations **A.** "storage" for "secondary storage" **A.** other examples of reduced hardware requirements **Server (Max 2):** • Multiple processors needed / processor with many cores / high clock speed • A lot of RAM needed • Many HDD/SSD/ secondary storage drives needed **A.** "storage" for "secondary storage" **A.** other examples of increased hardware requirements **NE.** more powerful / less powerful, higher performance / lower performance, cheaper / more expensive Accept the opposite of points if a student has written from the point of view of a thick client system instead eg for "Slower (clock speed) processor needed in client" accept "a thick client system would need a faster processor in the client".	**3**

Qu	Pt	Marking guidance	Total marks
7	1	**Mark is AO1 (knowledge)** **B**; (GET→SELECT, POST→INSERT, DELETE→DELETE, PUT→UPDATE) **R.** If more than one lozenge shaded	1

Qu	Pt	Marking guidance	Total marks
7	2	**All marks AO1 (understanding)** More compact; **A.** facilitates faster transmission, smaller file size, uses less memory Quicker (**A.** easier) to parse; Structure understood directly in some languages (eg JavaScript); (Native) support for arrays; Easier <u>for humans</u> to read/write/understand; **Max 2**	2

Qu	Pt	Marking guidance	Total marks

8	1	**All marks AO1 (understanding)**
		
		Establish an end-to-end connection (between email servers);
		A. end-to-end path
		NE. virtual path, virtual circuit
		
		Perform error detection // correction // request that corrupted segments (**A.** packets, data) are resent // add error detection/correction information to the data // sending acknowledgement packets // ensuring packets are delivered;
		A. Add checksum/CRC to data
		
		(Use the port number to) pass the data on to the correct // email server application software in the application layer (when it is received) // add port number (to segment to identify the application to associate with the data);
		A. socket for port number as BOD
		
		Split data up into segments (and adds header information) // assembles segments in correct order to rebuild message // adds segment numbers;
		A. “packets”, “frames”, “datagrams” for segments
		
		Perform flow control // matches speed of sender and receiver;
		
		Manage congestion;
		
		Max 3
			3

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking guidance</th><th>Total marks</th></tr>
<tr><td>8</td><td>2</td><td>2 marks AO1 (knowledge) and 2 marks AO1 (understanding)

Award 1 mark for each correctly named protocol, up to a maximum of 2 marks and 1 mark for each correct explanation of what a protocol will be used for, if linked to the correct protocol.

<table>
<tr><th>Protocol (knowledge)for</th><th>Purpose (understanding)</th></tr>
<tr><td>SMTP // Simple Mail Transfer Protocol</td><td>To send/transmit/receive email (to/from another email server/client).</td></tr>
<tr><td>POP(3) // Post Office Protocol (3)</td><td>(So that clients can) retrieve emails on the server.
R. Sending emails
A. Receiving emails as BOD but R. Receiving emails if answer suggests that this is done as the email is sent.</td></tr>
<tr><td>IMAP // Internet Message Access Protocol</td><td>(So that clients can) retrieve/manage emails on the server.
R. Sending emails
A. Receiving emails as BOD but R. Receiving emails if answer suggests that this is done as the email is sent.</td></tr>
<tr><td>HTTP/HTTPS</td><td>So users can access email via the web/a web browser.</td></tr>
</table>

A. If correct initialism used but then the full term is incorrect eg “SMTP – Special Mail Transfer Protocol” as BOD
A. Other protocols that achieve the same purposes as those listed above
R. Non-application layer protocols eg TCP, IP

Note: Marks can be awarded for both IMAP and POP(3) protocol names, but to award the mark for purpose, two marks can only be given for the purpose of IMAP and POP(3) if the purposes given are different.</td><td>4</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking guidance</th><th>Total marks</th></tr>
<tr><td>8</td><td>3</td><td>1 mark AO1 (knowledge) and 1 mark AO1 (understanding)

What is (knowledge): A (reserved) port (number) that has a specific purpose // a port that has a reserved number // a port assigned by the Internet Assigned Numbers Authority (IANA);

Why used (understanding): The communication is initiated by the sender/client (therefore the port number must be the same for all initial email communications);</td><td>2</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking guidance</th><th>Total marks</th></tr>
<tr><td>9</td><td>1</td><td>

All marks AO1 (understanding)

<table>
<tr><th>Level</th><th>Description</th><th>Mark Range</th></tr>
<tr><td>4</td><td>A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically-structured response. The response covers both areas indicated in the guidance below and, in each area, there is sufficient detail to show that the student has a good level of understanding.</td><td>10–12</td></tr>
<tr><td>3</td><td>A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response which shows a good level of understanding of at least one area indicated in the guidance below and some understanding of the other area or a reasonable understanding of both areas.</td><td>7–9</td></tr>
<tr><td>2</td><td>A limited attempt has been made to follow a line of reasoning and the response has a mostly logical structure. A reasonable level of understanding has been shown of one area or some understanding of both areas.</td><td>4–6</td></tr>
<tr><td>1</td><td>A few relevant points have been made but there is no evidence that a line of reasoning has been followed.</td><td>1–3</td></tr>
</table>

Guidance – Indicative Content

Area 1: How data is stored on and read from a magnetic hard disk drive

<table>
<tr><th>Key Points</th><th>Additional Points</th></tr>
<tr><td>Disk is coated in a magnetisable material // iron / cobalt-based material

Magnetising a spot in one direction could represent 0 and the other direction could represent 1 A. any plausible way of representing two values

Disk divided into rings called tracks

Tracks divided into sectors / blocks

Read/write head moves in / out (radially) (to correct track)

Wait until correct sector / block passes under read/write head

Disk spins at high speed

Read/write head senses magnetic field and converts to 0s and 1s</td><td>Whole block read together

Data stored in buffer while being read

Can be many disks inside drive known as platters

Disk and drive are a sealed unit

Data near outside edge of disk stored less densely // disk has constant angular velocity

Files stored in hierarchical structure / directories

Free / used space indicated in file allocation table

Mirroring / striping / RAID may be used for automatic backup // to protect against drive failure</td></tr>
</table>

</td><td>12</td></tr>
</table>

A good understanding could be demonstrated by covering many of the points in the 'Key Points' column of the table, conveying the fundamental method by which magnetic hard disks work, but may omit some detail. Referencing points in the 'Additional Points' column could compensate for any omissions in the 'Key Points' column, but is not required.

Area 2: How the TCP/IP stack is used in the file server

- Four layers of stack are Application, Transport, Network/Internet and Link/Physical.
- File will be passed down/through each layer in turn.

Layer	Key Points	Additional Points
Application	File server software will operate in the Application Layer File transfer may use FTP protocol	Alternative protocols are SMB, NFS
Transport	Establishes end-to-end connection between file server and computer Receives file / data on a port from the application layer // adds source and destination port numbers to segment Splits file / data into segments Adds checksum to segment // adds error detection information to segment // deals with transmission errors // retransmits lost / corrupted segments **A.** packet for segment	Performs flow control Performs congestion control Adds sequence number to segment May use TCP or UDP protocol
Network / Internet	Adds source and destination IP addresses to datagram **R.** routes data across network **A.** packet for datagram	Encapsulates each TCP/IP segment into an IP datagram Add time to live Uses subnet mask to determine if destination is on same subnet
Link / Physical	Physical interface to network communications medium // writes (encoding of) data to communications medium (**A.** cable for medium) Uses device drivers // uses network interface card Adds hardware / MAC address of destination / router / gateway / source	

Points cannot be credited unless they are linked to the appropriate layer.

		A good understanding could be demonstrated by covering many of the points in the 'Key Points' column of the table, including naming all four layers and making a range of accurate points about at least three of them. Referencing points in the 'Additional Points' column could compensate for any omissions in the 'Key Points' column, but is not required.	

Qu	Pt	Marking guidance	Total marks
10	1	**All marks AO1 (understanding)** Computers (outside the LAN) will use the (public) IP address of the router / 186.7.2.31 (to access the web server); **NE.** no reference to IP address (The router will perform) port forwarding; Router maintains a port mapping table // router uses rules for converting port numbers and IP addresses; **A**. NAT table for "port mapping table" Router must identify traffic arriving on the HTTP port // the port used for web services // port 80/8080 (from outside the network) // HTTP traffic (from outside the network); **A.** HTTPS / port 443 (Relevant traffic) must be forwarded (by the router) to the IP address of the Web Server // IP address 192.168.0.2; **NE.** the non-routable IP address without reference to web server **Max 3**	**3**

Qu	Pt	Marking guidance	Total marks
10	2	**Mark is AO1 (understanding)** The IP address of the web server might be changed (by the DHCP server); If the IP address of the web server changes the router will not be able to forward data to it // port forwarding will no longer work; **A.** DHCP server / router would need to be configured to allocate a fixed / static IP address to the web server **A.** just "IP" for "IP address" as **BOD** **NE.** "settings" for "IP address" **Max 1**	**1**

Qu	Pt	Marking guidance	Total marks
10	3	**All marks AO1 (understanding)** **When request sent** (When the router receives the FTP request from the computer), it will replace the IP address of the computer / the source IP address / 192.168.0.4 (**A.** the private IP address) with the (public) IP address of the router / 186.7.2.31 / (**A.** the public IP address); **NE.** references to a public IP address The router replaces the (source) port number with a port number it generates; The router adds the mapping (port number to IP address and port number / socket) it has created to its NAT translation table (**A.** list, dictionary or similar); **NE.** router adds mappings without reference to some sort of structure that they might be stored in **I.** incorrectly stated contents of table **When reply received** When a reply is received from the FTP server, it is recognised by its destination port number // the (destination) port number is looked up in the NAT translation table; (If the port number is present in the NAT translation table) the reply is forwarded to the computer that made the original request / computer with IP address 192.168.0.4 // the student's computer (and the destination port number is replaced with the one stored in the NAT translation table / the original source port number) // (If the port number is present in the NAT translation table) the router replaces its IP address / the (public) IP address of the router / 186.7.2.31 / (**A.** the public IP address) with the IP address of the student's computer / 192.168.0.4 (**R.** the private IP address); **A.** private and non-routable as equivalents and public and routable as equivalents **Accept the use of the term "NAT" instead of "router" but Max 2 for overall response** **Max 4**	**4**

Qu	Pt	Marking guidance	Total marks
10	4	**Mark is AO1 (understanding)** There are enough (IPv6) addresses for every device (in the world) to have a unique/public/routable (IP) address; **NE.** there are more IPv6 addresses	1

Qu	Pt	Marking guidance	Total marks
10	5	**Mark is AO1 (knowledge)** **D**; (The protocol establishes a full-duplex communication channel) **R.** if more than one lozenge shaded	1