

4. (a) Explain the purpose of the *physical* and *data link* layers in the OSI reference model. [4]
- (b) (i) Consider a communication channel of bandwidth 2MHz and signal to noise ratio (S/N) of 251 (24dB). How many signal levels are required for 50% of the maximum possible data rate to be achieved? [4]
- (ii) Explain the difference between *quadrature phase shift keying* (QPSK) and *quadrature amplitude modulation* (QAM). [4]
- (iii) What is the maximum transmission rate in bits per second (bps) that a modem can achieve if the baud rate is 9600 and (1) QPSK, and (2) QAM-64, signalling methods are used? [4]
- (iv) A modem constellation diagram has data points at (0,1) and (0,2). What type of modulation does the modem use? [2]
- (c) (i) Four stations have the following bi-level chip sequences (Walsh codes):  
A = (-1 +1 -1 -1 -1 -1 +1 -1)                      B = (-1 +1 -1 +1 +1 +1 -1 -1)  
C = (-1 -1 +1 -1 +1 +1 +1 -1)                      D = (+1 +1 -1 +1 -1 -1 -1 +1)
- A CDMA receiver obtains the following bi-level chip sequence:  
S = (-1 +1 -3 +1 -1 -3 +1 +1). Which of the four stations transmitted, and which bits did each one send? [4]
- (ii) Most 3G mobile phone systems use a form of Wideband Code Division Multiple Access (WCDMA). It is impossible for all phones to be synchronised such that the chip sequences transmitted are exactly orthogonal. How is this problem overcome in practice? [3]