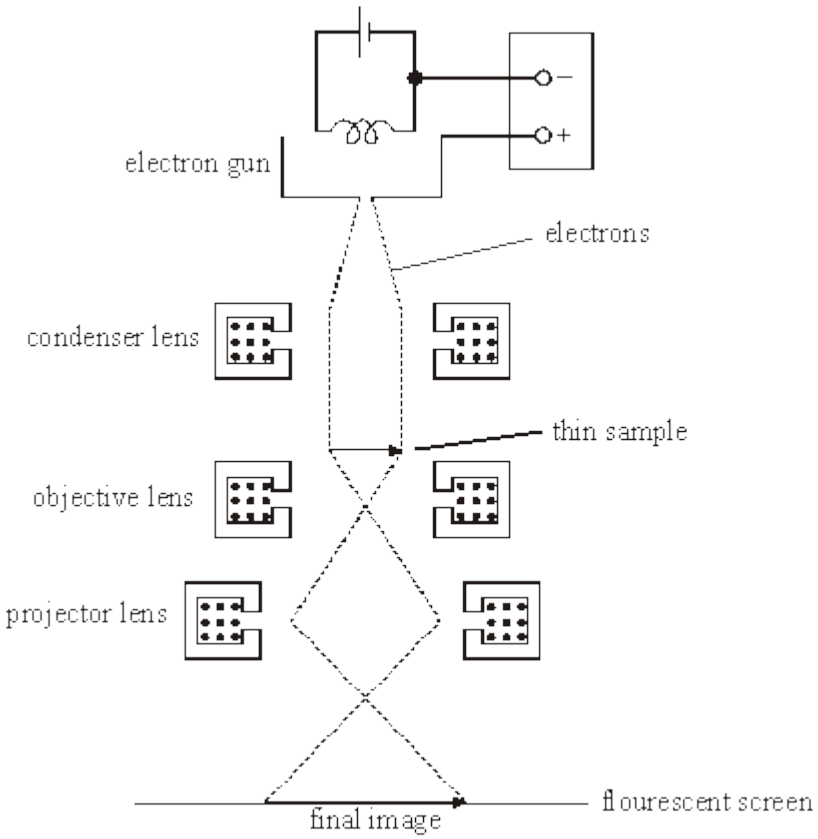
1 In a transmission electron microscope, electrons from a heated filament are accelerated through a certain potential difference and then directed in a beam through a thin sample. The electrons scattered by the sample are focused by magnetic lenses onto a fluorescent screen where an image of the sample is formed, as shown in the figure below.



(a) State and explain **one** reason why it is important that the electrons in the beam have the same speed.

.....

.....

.....

.....

(2)

(b) When the potential difference is increased, a more detailed image is seen. Explain why this change happens.

.....

.....

.....

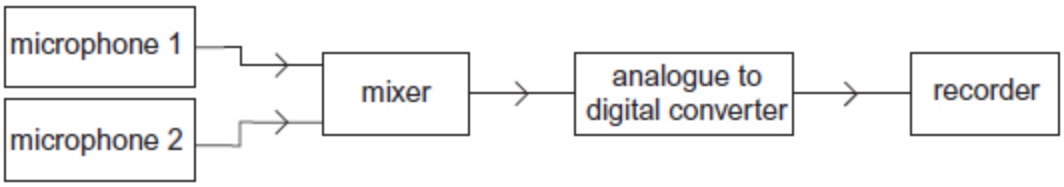
.....

.....

.....

(3)
(Total 5 marks)

2 The diagram shows a block diagram of an audio recording system.



(a) Explain the purpose of the mixer in this system.

.....

.....

(1)

(b) Suggest a type of recorder that may be used in this system.
Give **one** reason for your answer.

.....

.....

.....

.....

(2)

(c) Explain **one** advantage of including the analogue to digital converter in the system.

.....

.....

.....

.....

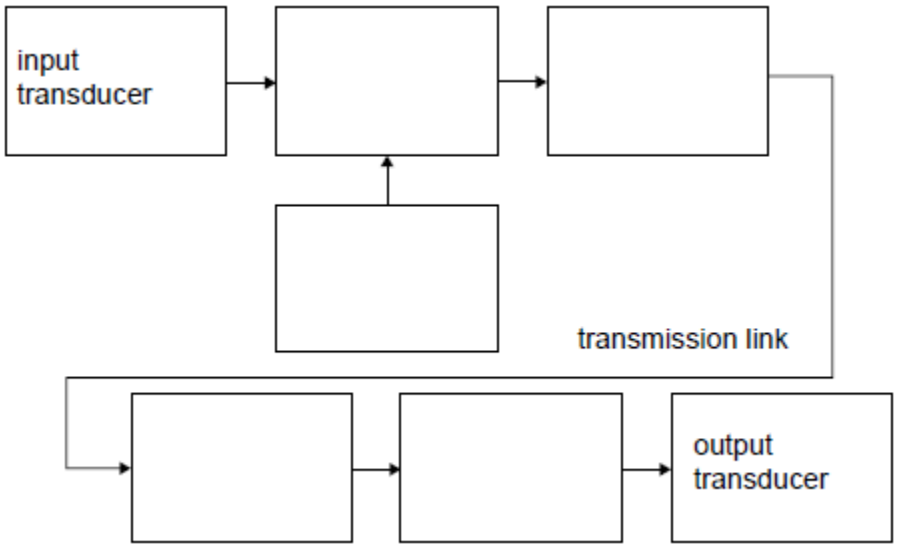
(2)
(Total 5 marks)

3 **Figure 1** shows a block diagram of a generalised communications system.

(a) Complete the labelling of the block diagram, using the following terms:

carrier wave generator **demodulator** **modulator** **receiver** **transmitter**

Figure 1



(2)

(b) Name **three** different media suitable for the transmission link.

1.....

2.....

3.....

(3)

(c) (i) State the function of the modulator.

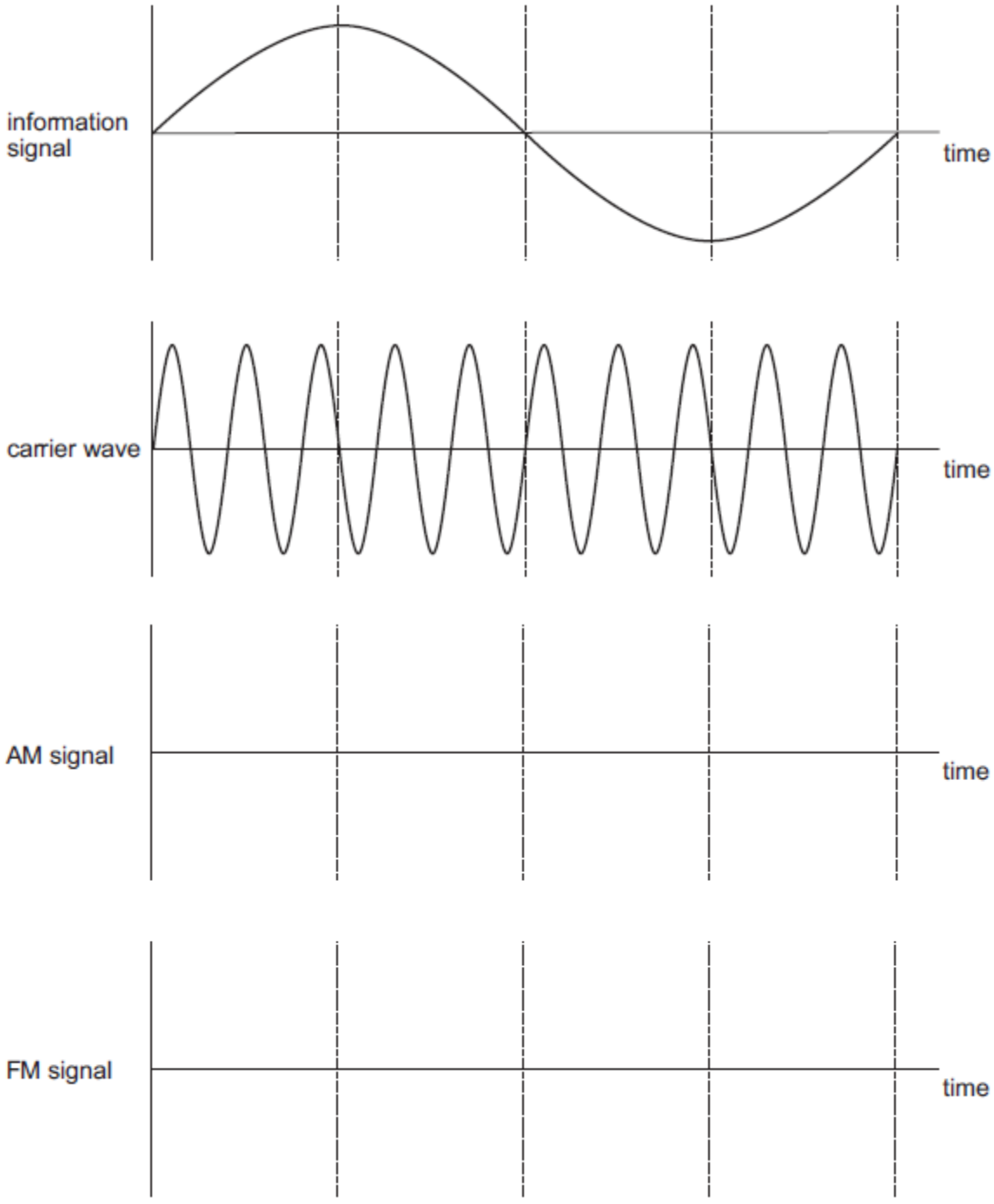
.....

(1)

(ii) AM and FM are two types of modulation.
An information signal and a carrier wave are shown on the upper axes of **Figure 2**.

Draw on the lower axes the AM signal and the FM signal that these would produce.

Figure 2



(4)
(Total 10 marks)

4 (a) Name **three** different types of medium that a modulated carrier signal could travel through.

1 .....

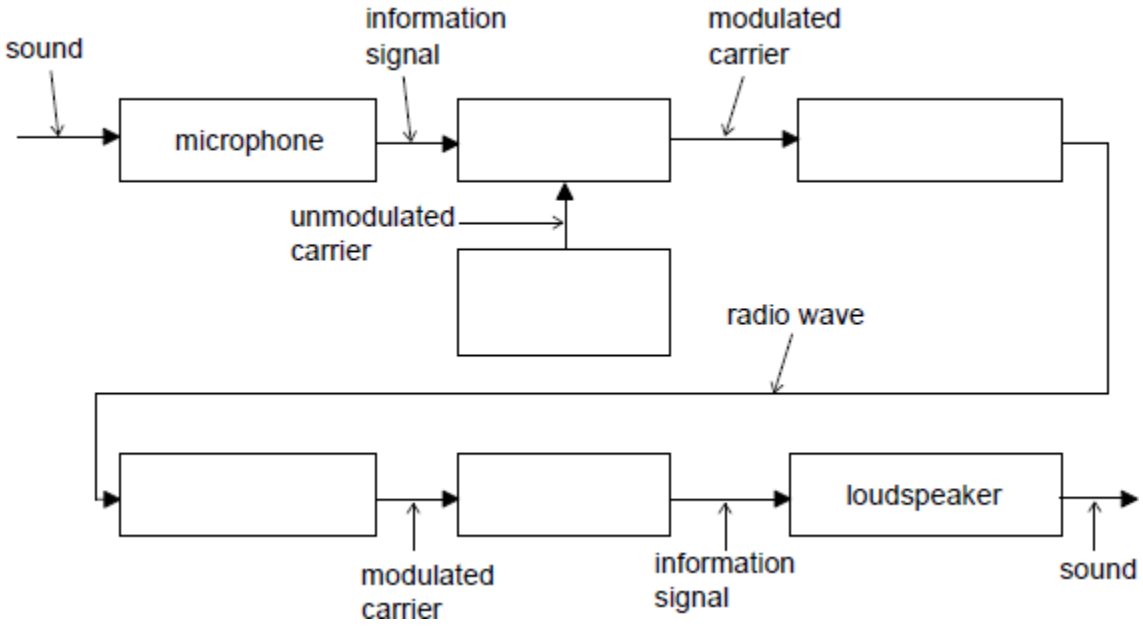
2 .....

3 .....

(3)

(b) A block diagram of a radio communication system is shown below. The signals between subsystems are shown.

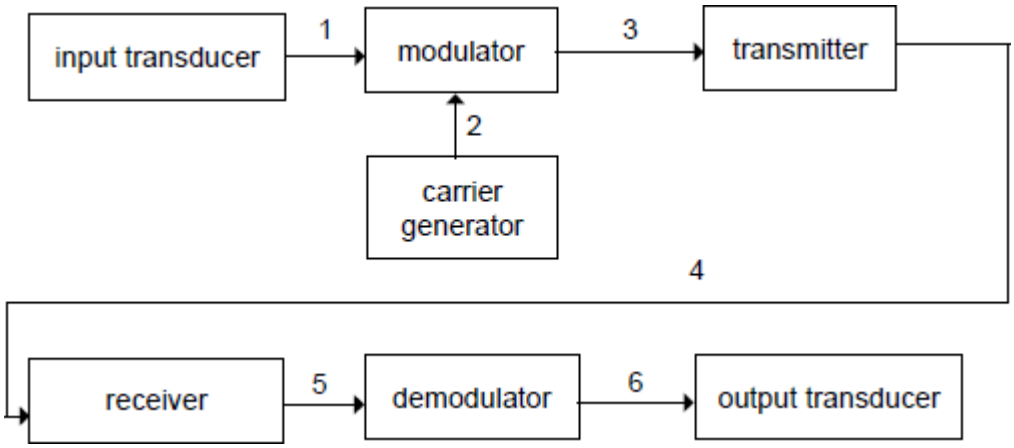
Label the blank boxes.



(5)

(Total 8 marks)

5 A block diagram of a generalised communication system is shown below.
The signals between subsystems have been numbered.



(a) The type of signal at number 1 is an information signal and at number 3 it is a modulated carrier wave.
State the type of signal that could be at

(i) 2 .....
(1)

(ii) 4 .....
(1)

(iii) 5 .....
(1)

(iv) 6 .....
(1)

(b) Name a subsystem in the diagram above which could contain

(i) a diode .....
(1)

(ii) an oscillator .....
(1)

(iii) a loudspeaker .....
(1)

(iv) a tuned circuit .....
(1)

(Total 8 marks)

6 (a) A simple radio receiver system consists of the following subsystems.

af amplifier **aerial** **detector** **loudspeaker** **tuned circuit**

Label the diagram below with the subsystems in the correct order.

(5)

(b) Which subsystem has an input that is

(i) a narrow range of modulated radio frequency signals .....

(1)

(ii) a wide range of modulated radio frequency signals .....

(1)

(iii) a large amplitude audio frequency signal .....

(1)

(iv) a small amplitude audio frequency signal? .....

(1)

(c) Describe the function of the detector.

.....

.....

.....

(2)

(Total 11 marks)

7 Part of a communication system has the following subsystems:

carrier generator **input transducer** **modulator** **transmitter**

(a) Draw a labelled block diagram to show how these subsystems are connected.

(3)

(b) Describe the operation of each of the subsystems in part (a), stating for each one its action on its input signal(s) and the form taken by its output signal.

(i) carrier generator .....

.....

.....

(2)

(ii) input transducer .....

.....

.....

(2)

(iii) modulator .....

.....

.....

(3)

(iv) transmitter .....

.....

.....

(2)

(Total 12 marks)

8 (a) Describe what is meant by amplitude modulation (am).

.....

.....

.....

(1)

(b) A radio wave has an unmodulated frequency of 120 kHz. It is amplitude modulated by a signal from an audio transducer of frequency 2.2 kHz.

Calculate the bandwidth of the modulated wave.

bandwidth = ... kHz

(1)

(c) Explain why frequency modulation (fm) is not used for commercial radio transmissions in the medium and long wave bands.

.....

.....

(1)

(d) State and explain **one** advantage of transmitting digital signals using frequency modulation (fm) rather than amplitude modulation (am).

.....

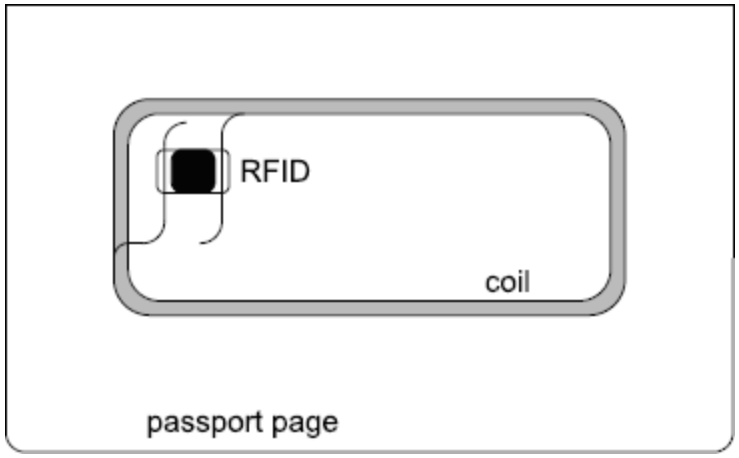
.....

.....

.....

(2)
(Total 5 marks)

9 Modern UK passports contain a Radio Frequency Identification Device (RFID) chip connected to a coil of wire.



(a) The RFID chip operates at a frequency of 13.56 MHz. The RFID chip has an effective capacitance of 20 pF in parallel with the coil.
Calculate the required inductance of the coil.

.....

.....

.....

.....

.....

(4)

(b) Calculate the length of a half wave dipole aerial for this frequency. Explain why a coil of wire is used at the immigration control desk for reading the data on the RFID instead.

.....

.....

.....

.....

(3)

(c) The quality factor, Q, of a tuned circuit is $\frac{f}{\Delta f}$.

If the bandwidth, Δf, of the tuned circuit in a passport is 100 kHz, calculate the quality factor of the tuned circuit.

.....

(1)

(d) Assume the bandwidth given in part (c) represents the highest bit rate that can be used to transfer data from the RFID. Estimate, using a calculation, the length of time it would take to read 1 KB of data.

.....

.....

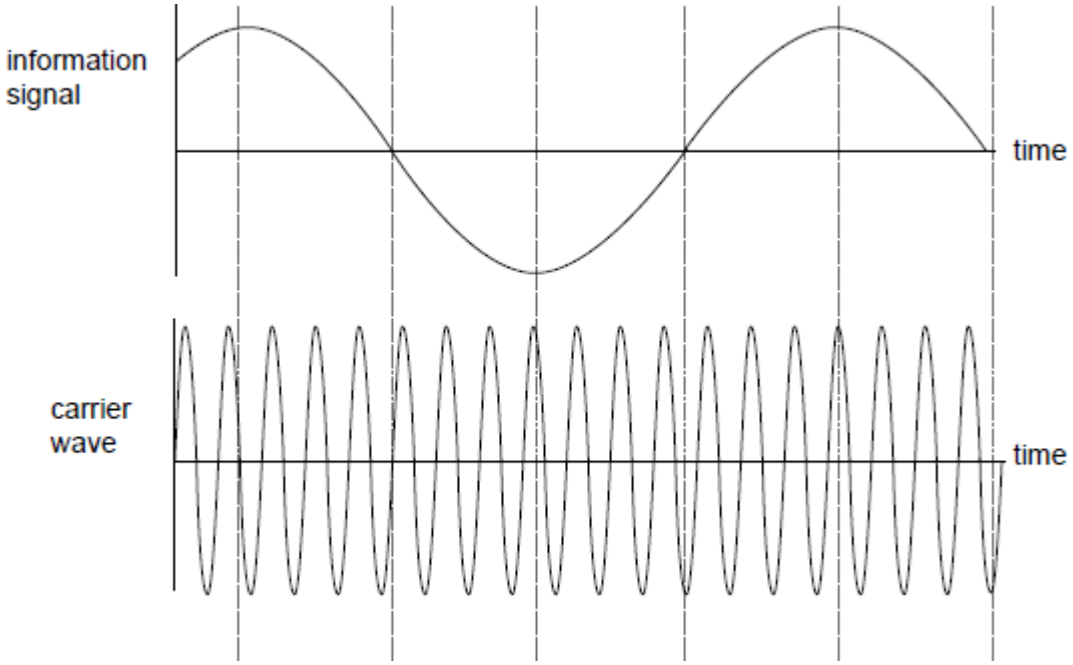
.....

(2)
(Total 10 marks)

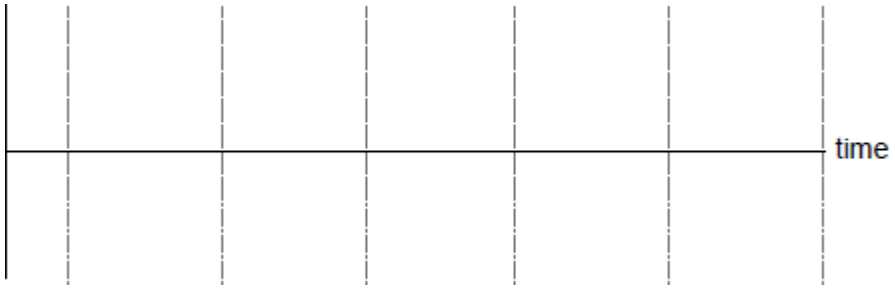
10 (a) An information signal and a carrier wave are shown on the axes below.
Show how these can be combined to form

(i) an AM signal

(ii) an FM signal.



(i) AM signal



(3)

(ii) FM signal

(3)

(b) The information signal has a maximum frequency of 3 kHz.

(i) Calculate the bandwidth of the resulting AM signal.

.....

(1)

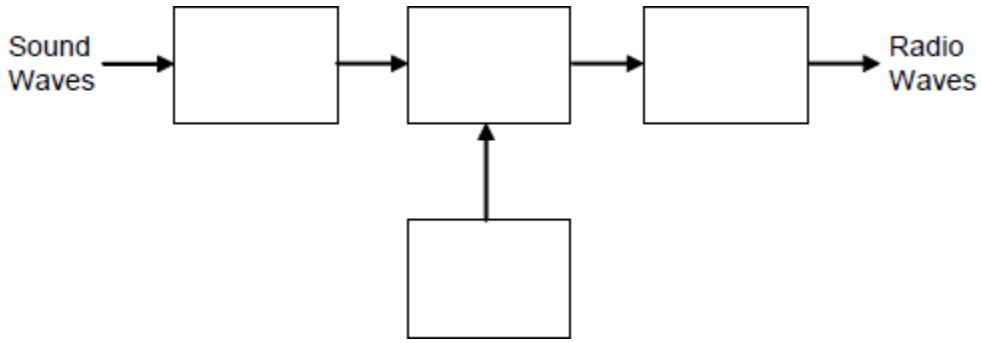
(ii) The maximum frequency deviation of the FM carrier is ± 5 kHz. Calculate the practical bandwidth of the resulting FM signal.

.....

(2)
(Total 9 marks)

11 (a) A radio transmitter system consists of the four subsystems.

Label the diagram below with the names of each subsystem.



(4)

(b) (i) Which **one** of the subsystems above produces an unmodulated rf signal and may contain a tuned circuit?

.....

(1)

(ii) The tuned circuit contains a 5 pF capacitor and a 0.1 μH inductor. Calculate the frequency of the signal that the subsystem produces.

.....

.....

.....

(3)

(c) A DAB transmitter has a frequency of 227.36 MHz. Calculate the length of a half-wave dipole that would be suitable for use as an aerial for this transmitter.

.....

.....

.....

(2)
(Total 10 marks)

1

(a) force on an electron in a magnetic field depends on speed **(1)**
electrons at different speeds would be focussed differently so image would be blurred **(1)**
[or electrons at different speeds would have different (de Broglie) wavelengths
therefore resolution would be reduced]

2

(b) increase in pd increases speed **(1)**
increase in speed/momentum/E_k causes reduction of (de Broglie) wavelength **(1)**
reduced (de Broglie) wavelength gives better resolution **(1)**

3

[5]

2

(a) Balances the relative
strength / voltages / currents / intensity / signal / loudness / output from the two microphones / combines the signals to form one signal

Condone power

Not 'sorts the relative strengths'

Allow merges

B1

1

(b) CD or named digital recorder

Only allow magnetic media if clear mention of digital

B1

(A to D converter means) digital recorder is needed

Computer / mobile phone / ipad / MP3 because it processes digital data

B1

2

(c) Noise reduction
When recovering of original digital signal during playback
or
Less storage per file or shorter download time per file
due to compression of digital signal

Allow for 1 mark

- *concept of restoring the original signal more easily*
- *'faithful' multiple copies*
- *ease of manipulation of data*

<u>Not</u> easier to store

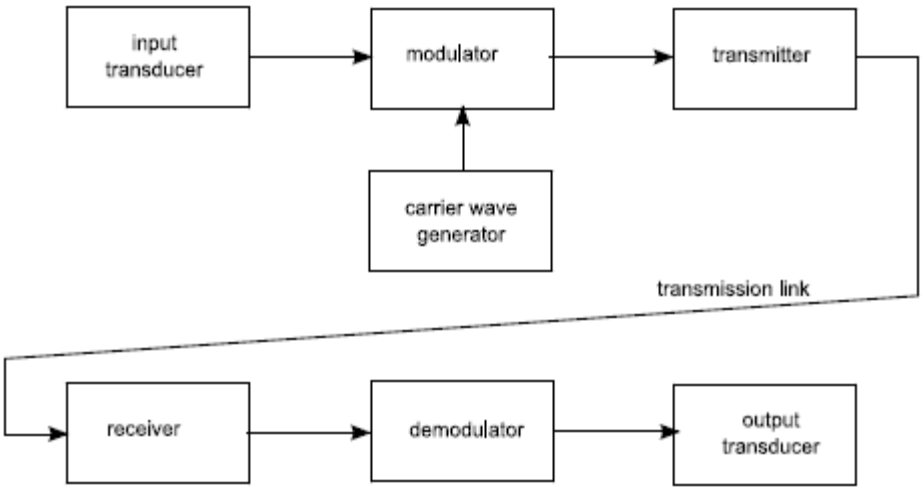
B1

B1

2

[5]

3 (a)



transmitter & receiver, carrier wave gen ✓
demodulator & modulator✓

2

(b) e.g. free space
optical fibre
twisted pair
coax cable (any 3 ✓✓✓)

3

(c) (i) superimpose the information signal onto the carrier wave ✓

1

(ii) AM − constant frequency sinusoidal wave matching carrier wave ✓
amplitude varies in phase with information signal ✓
FM − constant amplitude sinusoidal wave ✓
frequency varies in phase with information signal ✓

4

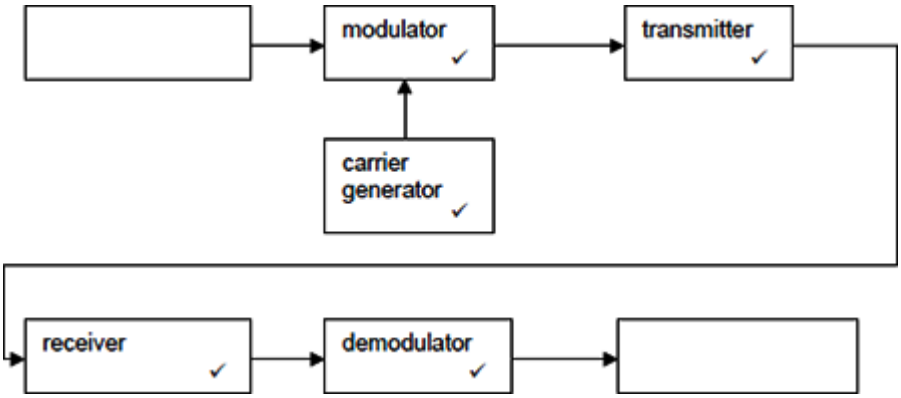
[10]

4

(a) (any order)
1 free space✓
2 wires (twisted pair, coaxial etc.) ✓
3 fibre✓

3

(b)



5

[8]

5

(a) (i) unmodulated carrier wave / sine wave / blank carrier etc✓

1

(ii) electromagnetic signal / modulated radio wave / ray in fibre etc✓

1

(iii) modulated carrier wave✓

1

(iv) information signal / recovered information signal / baseband signal etc✓

1

(b) (i) demodulator (could also be modulator)✓

1

(ii) carrier generator(may also be demodulator)✓

1

(iii) output transducer✓

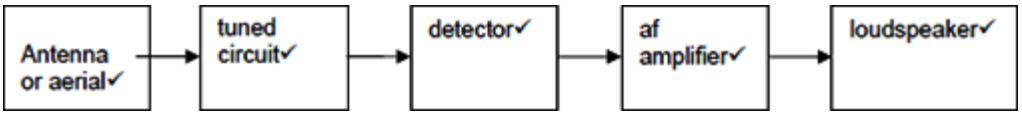
1

(iv) carrier generator / transmitter / receiver✓

1

[8]

6 (a)



5

(b) (i) detector✓

1

(ii) tuned circuit✓

1

(iii) loudspeaker✓

1

(iv) af amplifier✓

1

(c) obtains af signal from modulated wave OR
rectifies modulated carrier wave
filters out rf signal
passes af signal Max 2 ✓✓

2

[11]

7 (a) input transducer to modulator✓
carrier generator to modulator✓
modulator to transmitter✓

3

(b) (i) no input, produces an oscillating signal✓
at desired frequency✓

2

(ii) takes a signal from the environment✓
and converts it to an electrical signal✓

2

(iii) uses the signal from the input transducer✓
to change some property of the signal produced by the carrier generator✓
to carry the information signal and feeds it to the transmitter✓

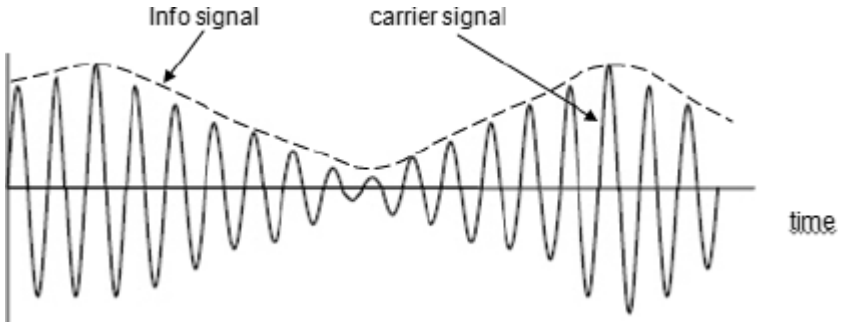
3

(iv) converts the modulated carrier signal✓
into a radio wave✓

2

[12]

8 (a) amplitude of carrier varies in phase with information / audio signal ✓
accept labelled diagram in support



1

(b) 2 x 2.2 kHz = 4.4 kHz ✓

1

(c) requires a large bandwidth so would limit the number of channels / stations if low frequency carriers were used✓

1

(d) Noise distorts the amplitude of signals which is difficult to reduce in am✓
In fm the original signal can be recovered as long as the frequencies in the BW are detectable since no information in the amplitude. ✓
In AM receivers signals and noise are amplified equally.
ANY TWO

2

[5]

9 (a) use of $f = 1 / 2\pi\sqrt{LC}$, change subject to $L = 1 / 4\pi^2 f^2 C$
substitute values, calculation , leading to 6.9μH ✓✓✓✓

4

(b) use of $\lambda = c / f$, substitute values leading to 22.1m ✓
dipole = 11.05m ✓
too large for desk operation ✓

3

(c) 13.56 / 0.1 = 136✓ (could be rounded down to 135)

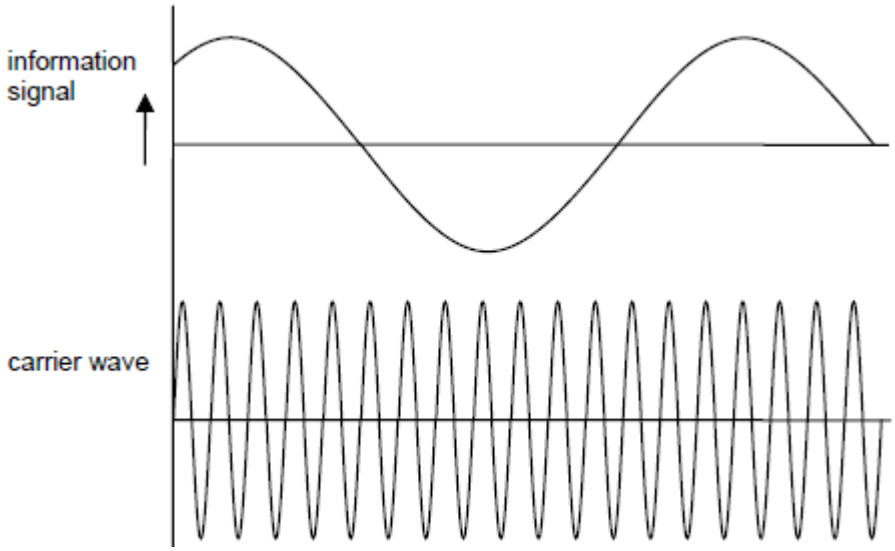
1

(d) 1KB = 8192 bits (allow 8000)✓
8192 / 100000 = 0.082s
(or allow values based on 8000, 0.08s) regardless of these variations, time to download centres on 80ms✓

2

[10]

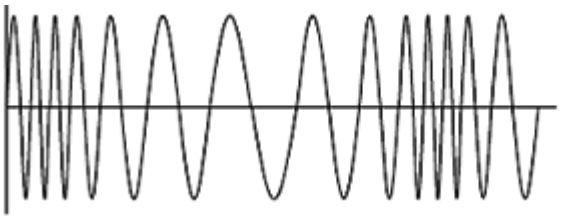
10 (a)



(i) AM signal

const freq✓
amplitude varies✓
in phase with info sig✓

(ii) FM signal



const ampl✓
frequency varies✓
in phase with info sig✓

6

(b) (i) 2 × 3 kHz = 6kHz✓

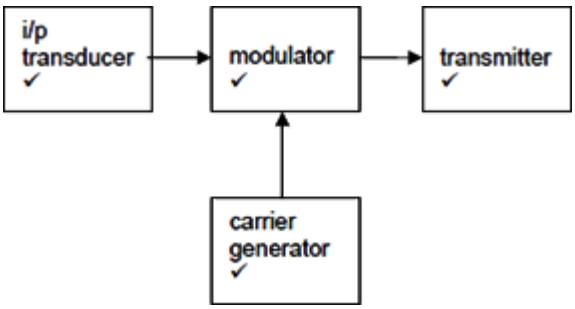
1

(ii) 2(3 + 5)✓ = 16kHz✓

2

[9]

11 (a)



4

(b) (i) carrier generator✓

1

(ii) use of $f = 1 \div 2\pi \sqrt{LC}$✓

$1 \div 2\pi\sqrt{10^{-7} \times 5 \times 10^{-12}}$ ✓

225 MHz✓

3

(c) calc leading to $\lambda = 1.32$m✓

$1.33 \div 2 = 0.66$m✓

2

[10]