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Question 22 (Answer: **D**)

- The electromagnetic spectrum runs from long-wavelength radio to short-wavelength gamma.
- Ultraviolet lies beyond violet and infrared lies beyond red, so ultraviolet has the shorter wavelength.
- Shorter wavelength means higher frequency, since c is the same for both.

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Question 22 (Answer: **D**)

- In a vacuum *every* electromagnetic wave travels at the same speed, 3.0×10^8 m/s.
- So microwaves cannot travel faster than visible light.
- What differs is wavelength and frequency: X-rays have the shortest wavelength of the three and microwaves the longest.

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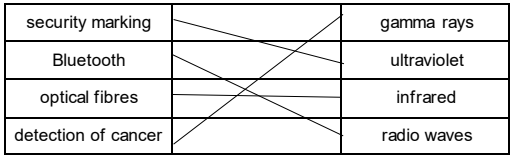
5(a)(i)	all four correct = 2 marks; any two correct = 1 mark 
5(a)(ii)	any **one** from: • only require a short aerial / antenna • can pass through the atmosphere / ionosphere to satellites • can transmit large amounts of data at high speeds / high rate of data transmission
5(b)	any **two** from: transverse: • oscillations / vibrations are at right angles to direction of propagation • medium not required / can travel through a vacuum (for e-m wave) • have crests / peaks and troughs longitudinal: • oscillations / vibrations are parallel to direction of propagation • medium is required • have rarefactions and compressions
5(c)(i)	longitudinal
5(c)(ii)	refraction
	any **one** from: • change in speed of the wave • change in density of the medium
5(d)	increase in carbon dioxide / greenhouse gases (in the atmosphere) **OR** increase in methane / water vapour (in the atmosphere)
	any **one** from: prevents / reduces (re-emitted) radiation escaping (into space) **OR** radiation re-emitted / reflected back to surface (by atmosphere / greenhouse gases) **OR** (amount of) radiation absorbed is greater than (the amount of) radiation leaving the atmosphere

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Question 22 (Answer: **D**)

- A satellite that stays above the same point on Earth is in geostationary orbit.
- That lets a fixed dish stay pointed at it.
- The signals used are microwaves, which pass easily through the atmosphere.

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Question 21 (Answer: **C**)

- Fake banknotes are detected by markings that glow under ultraviolet light.
- Ultraviolet causes fluorescence in certain inks.
- Radio and microwaves have far too long a wavelength, and X-rays are used for looking *through* objects.

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Question 22 (Answer: **C**)

- $\lambda = v/f$, and radio waves travel at 3.0×10^8 m/s.
- $f = 200$ kHz $= 2.0 \times 10^5$ Hz.
- $\lambda = 3.0 \times 10^8 / 2.0 \times 10^5 = 1.5 \times 10^3$ m.

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Question 21 (Answer: **D**)

- $f = c/\lambda$, with $c = 3.0 \times 10^8$ m/s.
- The *longest* wavelength gives the *lowest* frequency: $3.0 \times 10^8 / 7.0 \times 10^{-7} = 4.3 \times 10^{14}$ Hz.
- The shortest gives the highest: $3.0 \times 10^8 / 4.0 \times 10^{-7} = 7.5 \times 10^{14}$ Hz.

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6(a)	(wavelength =) 0.16 m
	$v = f\lambda$ **OR** (λ =) v / f **OR** (λ =) $3 \times 10^8 / 1.9 \times 10^9$
6(b)	(microwaves) only need short aerials / antennas
	(microwaves) penetrate (some) walls
6(c)(i)	labelled diagram of digital (signal) with blocks of high (1) and low (0) **AND** labelled diagram of analogue with continuously variable signal
	digital (signal) consists of <u>two</u> values owtte
	analogue (signal) varies over a range (of values) owtte
6(c)(ii)	any **two** from: • faster (data) transmission rate **OR** data can be compressed • data / signal transmitted over long(er) distances (as signal can be regenerated) • noise easily removed (from signal / data) **OR** signal can be regenerated