Solutions

Each answer shows the steps, then the **result**.

2.1

- radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays

2.2

- 3.0×10^8 m/s

2.3

- any one use of infrared: remote controls, thermal imaging, grills, optical fibres
- ultraviolet: skin cancer or eye damage

2.4

- an analogue signal varies continuously and can take any value
- a digital signal has only two values, on or off, 1 or 0

2.5

- a higher rate of data transmission
- a greater range, because the signal can be regenerated without the noise

2.6

- microwaves
- any one of: they pass through the atmosphere and ionosphere; only a short aerial is needed; they carry a large amount of data at high speed

2.7

- $\lambda = v / f$

$$\lambda = \frac{3.0 \times 10^8 \text{ m/s}}{1.5 \times 10^8 \text{ Hz}} = \mathbf{2.0} \text{ m}$$

3.1 C

- ultraviolet sits above infrared in frequency
- **A** reverses the order; **B** is wrong because all electromagnetic waves travel at the same speed in a vacuum; **D** reverses the energy order

3.2 B

- a digital signal has only two levels, so a regenerator can decide which was sent and transmit a clean pulse
- an analogue signal has no such reference, so its noise is amplified along with the signal

3.3

(a) security marking → ultraviolet; Bluetooth → radio waves; optical fibres → infrared; detecting cancer → gamma rays

(b) any one of: microwaves need only a short aerial; they pass through the atmosphere to satellites; they transmit data at a higher rate

(c) a low-orbit satellite is close to the Earth and moves quickly across the sky, so it is only in view for a short time

- a geostationary satellite orbits above the equator once a day, so it stays above the same point and a dish can point permanently at it
- low orbit: satellite phones
- geostationary: direct broadcast satellite television

(d) microwaves: internal heating of body cells

- X-rays: damage to cells, which can cause cancer

3.4

(a) analogue: the signal varies continuously and can take any value

- digital: the signal has only two values, 1 and 0

(b) both signals pick up noise as they travel

- a digital signal is regenerated at intervals, and because only two levels must be told apart the original 1s and 0s are recovered exactly
- an analogue signal cannot be separated from its noise, so amplifying it amplifies the noise too and the quality falls with distance

(c) a higher rate of data transmission

(d) $f = v/\lambda$

$$f = \frac{3.0 \times 10^8 \text{ m/s}}{1.5 \times 10^{-6} \text{ m}} = \mathbf{2.0 \times 10^{14}} \text{ Hz}$$

(e) all electromagnetic waves travel at the same speed in a given medium, whether the signal is digital or analogue

- what digital gives is a higher rate of data transfer and a greater range, not a higher wave speed