

## Electromagnetic Spectrum

- (a) state that all electromagnetic waves are transverse waves that travel with the same speed in vacuum and state the magnitude of this speed
- (b) describe the main components of the electromagnetic spectrum
- (c) state examples of the use of the following components:
- (i) radio waves (e.g. radio and television communication)
  - (ii) microwaves (e.g. microwave oven and satellite television)
  - (iii) infra-red (e.g. infra-red remote controllers and intruder alarms)
  - (iv) light (e.g. optical fibres for medical uses and telecommunications)
  - (v) ultra-violet (e.g. sunbeds and sterilisation)
  - (vi) X-rays (e.g. radiological and engineering applications)
  - (vii) gamma rays (e.g. medical treatment)
- (d) describe the effects of absorbing electromagnetic waves, e.g. heating, ionisation and damage to living cells and tissue

### Electromagnetic waves

<b>What are they?</b>	Transverse waves that travel at a speed of $3.0 \times 10^8$ m/s in vacuum
<b>How are they produced?</b>	<ul style="list-style-type: none"> <li>• A charged particle (electron) produces an electric field</li> <li>• The electric field causes other charged particles to move</li> <li>• Moving charged particles in turn generate a magnetic field</li> </ul> <p>An electromagnetic field is basically a magnetic and electric field travelling through space at the speed of light (KIV)</p>
<b>Properties</b>	Transfer energy from one place to another
	Can be emitted and absorbed by matter
	Do not need a medium to travel through
	Obey the laws of reflection and refraction
	Carry no charge

### Components and uses of electromagnetic radiation

EM wave	Use	Reason
Radio waves	Radio and television communication	<p>Able to spread round hills and buildings (by diffraction)</p> <p>Ultra high frequency – television broadcast</p> <p>Very high frequency – radio broadcast</p> <p>Medium wave radio – sent up to ionosphere which acts like a reflector to bounce radio waves back to distant radio receivers</p> <p>Long wave radio – similar to medium wave with even longer wavelengths</p>
Microwaves	Microwave oven	<p>Microwaves are produced inside an oven by an electron tube called a magnetron. The microwaves reflect within the metal interior of the oven and are absorbed by food. Microwaves cause water molecules in food to vibrate, producing heat that cooks the food. This is why foods that are high in water content, like fresh vegetables, cook more quickly than other foods. Although heat is produced directly in the food, microwave ovens do not cook food from the "inside out." When thick foods are cooked, the outer layers are heated and cooked primarily by microwaves, while the inside is cooked mainly by the conduction of heat from the hot outer layers.</p>
	Satellite television	Highly directional microwaves (require line of sight)
Infrared	Remote control	All warm objects lose thermal energy by emitting infrared

	Intruder alarm	radiation
Visible light	Optical fibres	Make use of total internal reflection to transmit information
Ultraviolet (ionising)	Sunbed	Artificial tanning
	Sterilisation	Kills microbes by damaging their DNA (ionisation)
X rays (ionising)	Radiology – medical diagnosis	Very penetrating
	Engineering – e.g. detecting stress or cracks in airplane engines	
Gamma rays (ionising)	Medical treatment	Ionising and very penetrating

\* Gamma rays are emitted when radioactive nuclei decay (alpha or beta decay)

\* X rays are produced by accelerating electrons. When high speed electrons directed at an atom penetrate it, electrons in the atom gain energy. The **excited** electrons eventually return to a lower energy level, releasing the energy in the form of X rays in the process.

\* The electromagnetic spectrum is **continuous**; there is no clear gap between one type of radiation and the next.

\* Ionizing radiation –  $10^{15}$  to  $10^{17}$  Hz

\* Ionizing radiation causes electrons to be removed or added which results in a change in DNA of living cells

### Effects of absorbing electromagnetic waves

Radio waves	No significant effect
Microwaves	Heating effect
Infrared	Heating effect – skin exposed to infrared provides a warning mechanism in the form of pain but the eye is unable to detect infrared
Visible light	Long term exposure to blue light may result in macular degeneration (eye)
Ultraviolet	<b>Ionising radiation</b> Damages and kills living cells, causes sunburn
X rays	<ul style="list-style-type: none"> <li>• <b>Ionising radiation</b></li> <li>• Penetrating and dangerous</li> <li>• Able to affect atoms in living cells and damage their genetic material (DNA)</li> <li>• Cells that are unable to repair themselves could die or become cancerous</li> <li>• Same radiation as gamma but sources are different</li> </ul>
Gamma rays	<ul style="list-style-type: none"> <li>• <b>Ionising radiation</b></li> <li>• Able to affect atoms in living cells and damage their genetic material (DNA)</li> <li>• Cells that are unable to repair themselves could die or become cancerous</li> </ul> Very penetrating and dangerous