Edexcel Physics IGCSE

Topic 4: Energy Resources and Energy Transfers

Summary Notes

(Content in **bold** is for physics only)

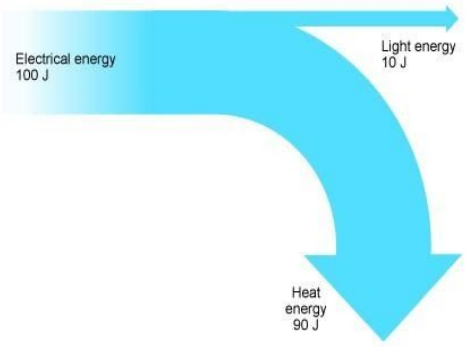
Energy transfers

Energy can be transferred between different stores including **chemical, kinetic, gravitational, elastic, thermal, magnetic, electrostatic** and **nuclear** as a result of an event or process.

Energy can be transferred in various ways including:

- **Mechanically** e.g. when gravity accelerates an object and gives it kinetic energy.
- **Electrically** e.g. when a current passes through a lamp and it emits light and heat.
- **By heating** e.g. when a fire is used to heat up an object.
- **By radiation** e.g. when vibrations cause waves to travel through the air as sound, or an object emits electromagnetic radiation.

Energy is always conserved. The total energy before is equal to the total energy after.



The **efficiency** is the **ratio** of the **useful energy output** to the **total energy supplied,** often expressed as a percentage.

$$efficiency = \frac{useful\ energy\ output}{total\ energy\ input} \times 100\%$$

Sankey diagrams can be used to represent the **transfer** of input energy into useful energy and wasted energy. For example, the diagram on the left shows the Sankey diagram for a lamp.

Conduction:

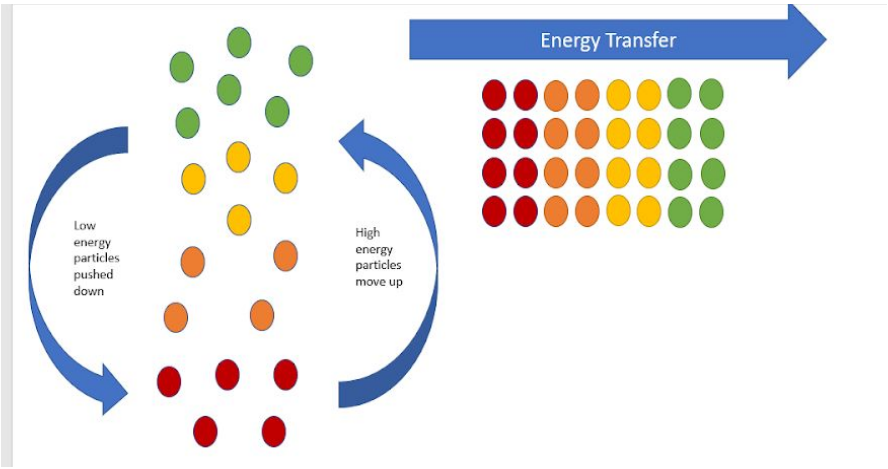
- Thermal energy in **solids** and **liquids** can be transferred by the vibration of particles - this is known as **conduction.**
- Non-metals are usually poor conductors known as **thermal insulators.**
  As a substance is heated up, the molecules **vibrate more** hitting and cause adjacent molecules to vibrate more too, **transferring heat energy** from hot parts to cooler parts.

Because insulators transfer heat much more slowly, they are used to **reduce unwanted energy transfer** such as in homes.

- Metals are usually good conductors. The electrons can leave the atoms and move freely among positively charged ions. As the metal is heated, the ions and electrons **vibrate more.** The **free electrons collide with ions** throughout the metal and **transfer heat energy** from hot parts to cooler parts.

Convection:

- Thermal energy in **fluids** (liquids and gases) can be transferred by **convection.**
- Convection occurs when molecules in a fluid (which are not fixed together by forces between molecules like in a solid) move from an area of high to low thermal energy. Preventing the circulation of the fluid can help reduce unwanted energy transfer by convection.
- When part of a fluid is heated, it expands - the particles move further apart - and becomes **less dense.** It therefore **rises** up to less dense areas in the fluid. Denser, colder fluid falls down to take its place.
- Examples of convection include in **water boilers** and **hot air balloons.**



Radiation

- Thermal energy is also transferred by **infrared radiation** which does **not require a medium.** Infrared radiation is part of the **electromagnetic spectrum.**
- **Black** bodies with a **dull** texture are the **best absorbers and emitters** of radiation. **White** bodies with a **shiny** texture are the **best reflectors** of radiation. Shiny surfaces can be used to **reduce unwanted energy transfer** such as on the surface of a vacuum flask.
- The **higher the temperature** and the **greater the surface area** of a body the **more infrared radiation** emitted.

Work and power

Work is done when a **force** moves something through a **distance** (whenever energy changes forms). The work done is **equal** to the energy transferred.

$$work\ done = force \times distance \qquad W = Fd$$

The conservation of energy produces a link between gravitational potential energy, kinetic energy and work. For example, when a ball is dropped, gravity does work on it and its gravitational potential energy becomes kinetic energy as it accelerates downwards:

- $kinetic\ energy = \frac{1}{2} \times mass \times speed^2$

$$E_k = \frac{1}{2}mv^2$$

- $gravitational\ potential\ energy = mass \times gravitational\ field\ strength \times height$

$$E_p = mgh$$

Power is the **rate at which energy is transferred** or the **rate at which work is done.** For example, a lamp with a greater power will be brighter because it transfers more energy from electrical energy to light and heat energy in a given time.

$$power = \frac{work\ done}{time\ taken} \qquad P = \frac{W}{t}$$

Energy resources and electricity generation

- Renewable energy is energy which can be replenished as quickly as it is used. Examples include:
  - Wind
  - Water (hydroelectricity, waves, tides)
  - Geothermal
  - Solar (heating systems and cells)

  All have a potentially infinite energy supply, but they are usually more costly (e.g. the manufacture and implementation of solar panels is very expensive) and less reliable (e.g. the wind is intermittent and solar energy relies on good weather).

- Non-renewable energy is used more for large-scale energy supplies due to the large energy output but will eventually run out. Examples include:
  - Fossil fuels (coal, oil, gas)
    - Cheaper than most renewable sources but harmful for the environment because they release greenhouse gases which cause global warming.
  - Nuclear power
    - A small amount of radioactive material produces a lot of energy, but they produce highly toxic nuclear waste which needs to be safely stored underground for many years.

Energy transfers take place in the generation of electricity. For example:

- In burning fossil fuels: chemical energy in chemical bonds
- In nuclear reactors: nuclear energy in atomic nuclei
- In a solar cell, light energy from the sun
- In geothermal energy: heat energy from the Earth's core
- In wind energy: kinetic energy from the moving wind
- In HEP: kinetic energy of the moving waves or GPE of water stored high up

… is transferred into kinetic energy in a turning turbine, then into electrical energy.