GCE Physics Unit 4 Option D, Energy and the Environment

wjec cbac

The Earth receives most of its energy from the Sun. The origin and transmission of **solar energy** obeys the same laws as in unit 1.6, including , the Stefan-Boltzman law; $P = A\,\sigma\,T^4$, Wien's law; $\lambda_{max}\,T$ = constant and the inverse square law.

Some energy from the Sun is reflected by the atmosphere or by clouds, some is absorbed by the atmosphere, therefore only some energy is absorbed by the Earth's surface. The amount of energy absorbed is equal to the energy emitted by the Earth as they are in **thermal equilibrium**.

Due to greenhouse gases in the Earth's atmosphere, the **temperature of the equilibrium is higher** than expected if no atmosphere was present. These gases **absorb and re-emit the infra-red photons** emitted by the Earth so that many are reabsorbed by the Earth.

However, **increasing CO_2 levels** in the atmosphere have changed this equilibrium and caused an imbalance between the energy inflow and the energy radiated. This has caused the **Earth's temperature to rise**.

Archimedes' principle states that any object, wholly or partially immersed in a fluid experiences a force equal to the weight of the fluid dispersed by the object.

This means that icebergs floating in the sea **displace the same volume of water as its own volume when melted**. Therefore, when an iceberg melts it does not change the sea level.

An iceberg is only partially submerged because it has a density lower than the density of sea water, this can be calculated using this equation $\rho = \frac{m}{V}$ (see unit 1.1).

However, **ice caps and ice on land that melt will cause sea levels to rise** because they do not displace any water.

Efficiency is an important factor when considering any source of energy.

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

Renewable energy sources are sources where they will be **replenished naturally** and **non-renewable** are sources which cannot replenish themselves.

Solar power:

The Sun produces energy due to nuclear fusion. The main energy production mechanism in the Sun is the fusion of protons. This is the main branch of the chain:

Step 1: ${}^1_1\mathrm{H} + {}^1_1\mathrm{H} \to {}^2_1\mathrm{H} + {}^0_1\mathrm{e}^+ + \nu_\mathrm{e}$
Step 2: ${}^2_1\mathrm{H} + {}^1_1\mathrm{H} \to {}^3_2\mathrm{He} + \gamma$
Step 3: ${}^3_2\mathrm{He} + {}^3_2\mathrm{He} \to {}^4_2\mathrm{He} + 2{}^1_1\mathrm{H}$

This gives an overall equation for the chain:

$$4{}^1_1\mathrm{H} \to {}^4_2\mathrm{He} + 2{}^0_1\mathrm{e}^+ + 2\nu_\mathrm{e}$$

The energy output from a solar panel will depend on the intensity of the light that strikes it. This can be calculated using this equation:

$$I = \frac{P}{A}$$

This gives rise to the solar constant which is the solar radiated energy crossing a plane perpendicular to the line joining the Earth to the Sun, just outside the Earth's atmosphere, per second per unit area. The mean value is 1.35 kW m^{-2}.

Turbines:

The output of any power station that uses a turbine depends on the power available from the fluid (air or water) that flows through it. An equation for this power can be derived as follows:

1. The volume of the fluid through the turbine in each unit time = Av
2. The mass of the fluid = ρAv
3. The kinetic energy per unit time = $\frac{1}{2}mv^2 = \frac{1}{2}(\rho Av)v^2$

Therefore; the power available to a turbine with area A due to a fluid with speed v is

$$E = \frac{1}{2}\rho A v^3$$

Fuel cells use chemical energy from fuel to provide electrical energy directly. In a hydrogen fuel cell, hydrogen combines with oxygen producing electrical energy. This is especially beneficial as it **does not produce any CO_2**.

The key processes in generating electricity are described in the GCSE course but below is the additional information essential for this unit.

Wind power is dependent on many factors which affect its efficiency. The wind must be strong enough to cause the blades to turn, but will reach a maximum output before the wind becomes too strong.

Tidal barrages, hydroelectric power and pumped storage all convert gravitational potential energy to kinetic energy to turn turbines as water flows.

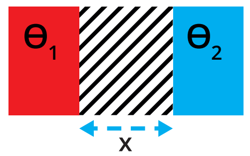
Nuclear fission requires uranium-235 as a fuel but most natural uranium is uranium-238, therefore the uranium undergoes these processes before being used:

1. **Enrichment**, this involves separating the uranium-235 from the uranium-238.
2. **Breeding**, this involves neutrons being absorbed by uranium-238 which then decays to form plutonium-239 which can be used alongside the uranium-235.

Nuclear fission requires high temperatures, T, a high density of the nuclei, n, and a long enough confinement time, τ_E. **The product of these factors, $nT\tau_E$, is known as the triple product**.

Thermal conduction:

The rate of conduction is important when considering the environmental impact of using different materials to insulate.



This can be calculated using this equation:

$$\frac{\Delta Q}{\Delta t} = -AK\frac{\Delta\theta}{\Delta x}$$

Where $\Delta\theta = \theta_1 - \theta_2$, and K is a constant for the material called its **thermal conductivity**.

Information about different insulating materials is given in terms of its ***U* value**. This describes how well a building material conducts heat. It is the rate of transfer of heat through one square metre of the material divided by the difference in temperature across the material.

$$\frac{\Delta Q}{\Delta t} = UA\Delta\theta$$

- I = intensity in W m^{-2}
- λ_{max} = peak wavelength in m
- ρ = density in kg m^{-3}
- v = speed in m s^{-1}
- E = power from a flowing fluid in W
- x = distance between surfaces in m
- P = power in W
- T = temperature in K
- V = Volume in m^3
- Q = heat in J
- K = thermal conductivity in W m^{-1} K^{-1}
- A = area in m^2
- m = mass in kg
- t = time in s
- $\Delta\theta$ = temperature difference in K