Work Done by a Gas

- When a gas expands, it does work on its surroundings by exerting pressure on the walls of the container it's in
- This is important, for example, in a steam engine where expanding steam pushes a piston to turn the engine
- The work done when a volume of gas changes at constant pressure is defined as:

$$W = p \Delta V$$

- Where:
  - W = work done (J)
  - p = external pressure (Pa)
  - V = volume of gas (m^3)

- For a gas inside a cylinder enclosed by a moveable piston, the force exerted by the gas pushes the piston outwards
- Therefore, the gas **does work on the piston**

- The volume of gas is at constant pressure. This means the force *F* exerted by the gas on the piston is equal to :

$$F = p \times A$$

- Where:
  - p = pressure of the gas (Pa)
  - A = cross sectional area of the cylinder (m^2)
- The definition of work done is:

$$W = F \times d$$

- Where:
  - F = force (N)
  - d = perpendicular displacement to the force (m)
- The displacement of the gas *d* multiplied by the cross-sectional area *A* is the increase in volume ΔV of the gas:

$$W = p \times A \times d$$

- This gives the equation for the work done when the volume of a gas changes at constant pressure:

$$W = p\Delta V$$

- Where:
  - ΔV = increase in volume of the gas in the piston when expanding (m^3)

- This is assuming that the surrounding pressure *p* does not change as the gas expands
- This will be true if the gas is expanding against the pressure of the atmosphere, which changes very slowly
- When the gas **expands** (*V* increases), work is done **by** the gas
- When the gas is **compressed** (*V* decreases), work is done **on** the gas

Worked example

When a balloon is inflated, its rubber walls push against the air around it.

Calculate the work done when the balloon is blown up from 0.015 m^3 to 0.030 m^3 .

Atmospheric pressure = 1.0×10^5 Pa.

Step 1: Write down the equation for the work done by a gas

$$W = p\Delta V$$

Step 2: Substitute in values

$$\Delta V = \text{final volume} - \text{initial volume} = 0.030 - 0.015 = 0.015\ m^3$$

$$W = (1.0 \times 10^5) \times 0.015 = 1500\ J$$