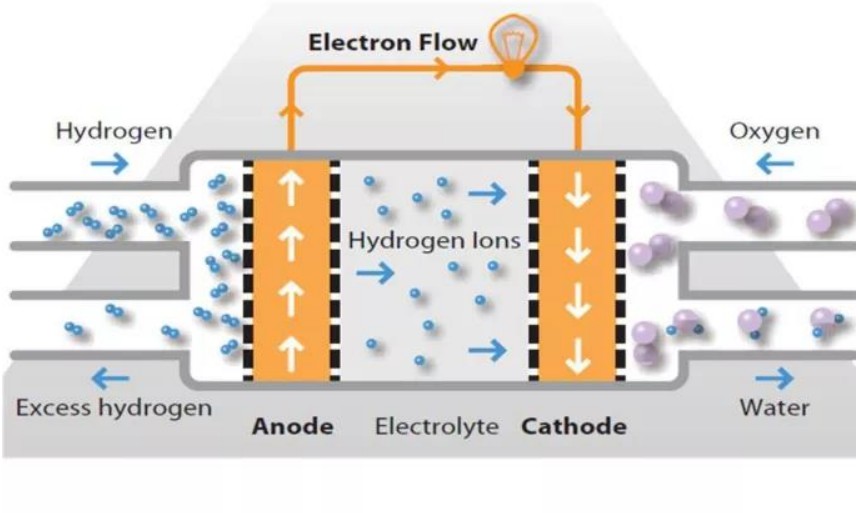
Fuel Cells



- a type of galvanic cell that doesn't need recharging as there is a continuous supply of reactants
- must be discarded once equilibrium is achieved
- provide energy for forklifts, power plants, cars
- generally 40-60% efficient (this can be increased to 80% if the steam they produce is used to power turbines)
- have a higher efficiency than thermal power stations as chemical energy is directly transformed to electrical energy
- ***hydrogen economy: proposed system of using only hydrogen for fuel—*** good for the environment as very low emissions (only emits water, heat and very small amounts of NO2)—could replace internal combustion engines

Reactions:

Anode: $H_2 + OH^- \rightarrow 2H_2O + 2e^-$ (basic)

$H_2 \rightarrow 2H^+ + 2e^-$ (acidic)

Cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

$O_2 + 2H^+ + 2e^- \rightarrow H_2O$ (acidic)

Overall: $H_2 + O_2 \rightarrow H_2O$

- hydrogen splits into H+ and e- and reacts with OH- in electrolyte to form water
- O2 reacts with water to replenish OH- in electrolyte, PH remains constant

Balancing alkaline half equations:

- ➢ O2—> H2O
- ➢ balance normally using KOHES— O2 + 4H+ 4e- —> H2O
- ➢ add OH- to cancel out H+—O2 + 4H+ 4OH- + 4e- —> H2O +4OH- (hydroxide and hydrogen form water)
- ➢ 4e- + O2 +2H2O —> 4OH-

Fuel Cell Electrodes:

- conducting
- inert (usually Pt)
- catalytic
- porous to allow H2 and O2 to come in contact with ions in electrolyte (this also increases surface area for reaction)

Catalysts:

- used to increase rate of reaction and current produced
- platinum is anode catalyst
- nickel is cathode catalyst

Electrolyte:

- either a strong acid (HCl) or strong base (KOH)
- semi-permeable to allow only reductant in—if it were permeable to both, they would react in electrolyte and thermal energy would be produced

Hydrogen as a Fuel

- higher energy content than most fossil fuels
- produced zero harmful emissions
- often produced through steam reforming of methane, therefore non renewable but can also be extracted from biogas and hydrolysis of water which is renewable
- difficult to store: liquid hydrogen requires lots of energy to keep as a liquid, compressed hydrogen takes up very high volumes
- unsafe: burns rapidly

Advantages	Disadvantages
more efficient energy conversion than thermal ower plants	require constant energy supply
no carbon emissions	expensive as technology is still developing
don't need to be recharged	hydrogen is mainly sourced from fossil fuels, non renewable
can use a variety of fuels	hard to store hydrogen

Applications:

- electroplating:
  - ➢ aqueous solution of cations of plating metal, cathode is the substance being plated

Rates of Reaction

Collision Theory:

Particles must collide with sufficient energy and in correct orientation to undergo fruitful collisions

Surface Area: an increase in surface area means that more reactant particles are exposed which increases the frequency of collisions

Concentration/Pressure: increased mol of reactants per volume therefore closer proximity which causes higher collision frequency

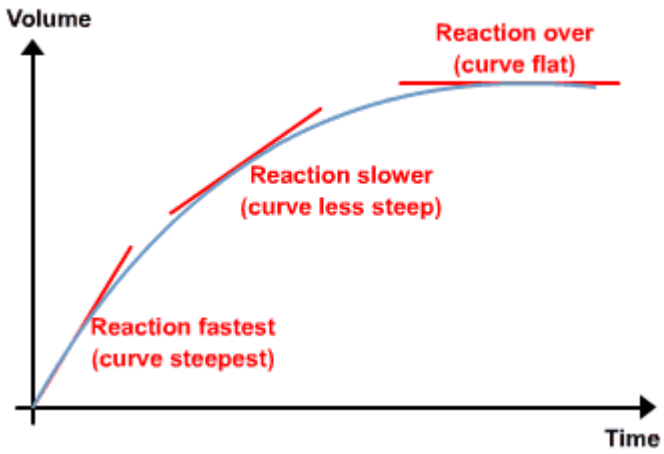
Temperature: average kinetic energy of reactants increases (more likely to have Ea) and also increases speed of movement, causing more frequent collisions

Catalyst: provides an alternative pathway with lower activation energy, more particles likely to have Ea for fruitful collision

- can be either *homogenous (same physical state)* or *heterogeneous (different physical state)*
- **adsorption** *(forms bonds with molecule to weak intramolecular bonds)—>* ***reaction****—>* ***desorption****—> products released from active site*

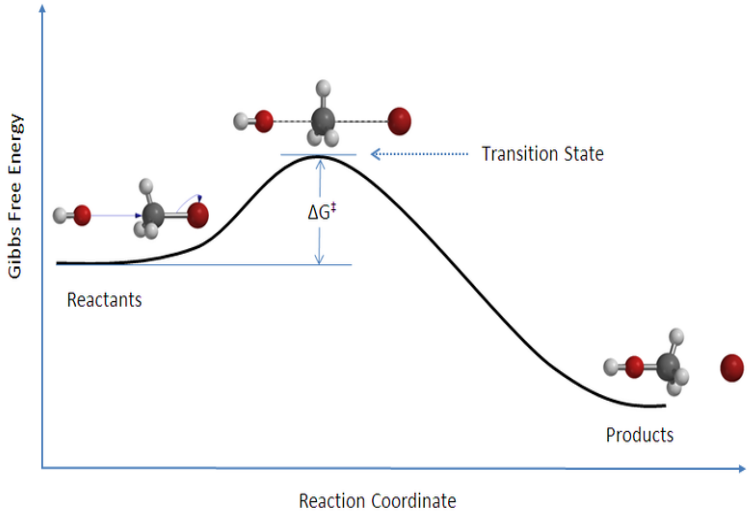
Measuring ROR:

change in concentration per unit time (M/s) or colour change, pH



Transition State:

Tthe new arrangement of atoms once the activation energy has been absorbed—occurs at the stage of maximum potential energy



Reaction: $HO^- + CH_3Br \rightarrow [HO{---}CH_3{---}Br]^{\ddagger} \rightarrow CH_3OH + Br^-$

Open/Closed Systems:

- open—matter and energy can be exchanged with the surroundings e.g a bushfire
- closed—only energy exchanged with surrounding e.g submarine