Chemical Rockets

Types of Rockets

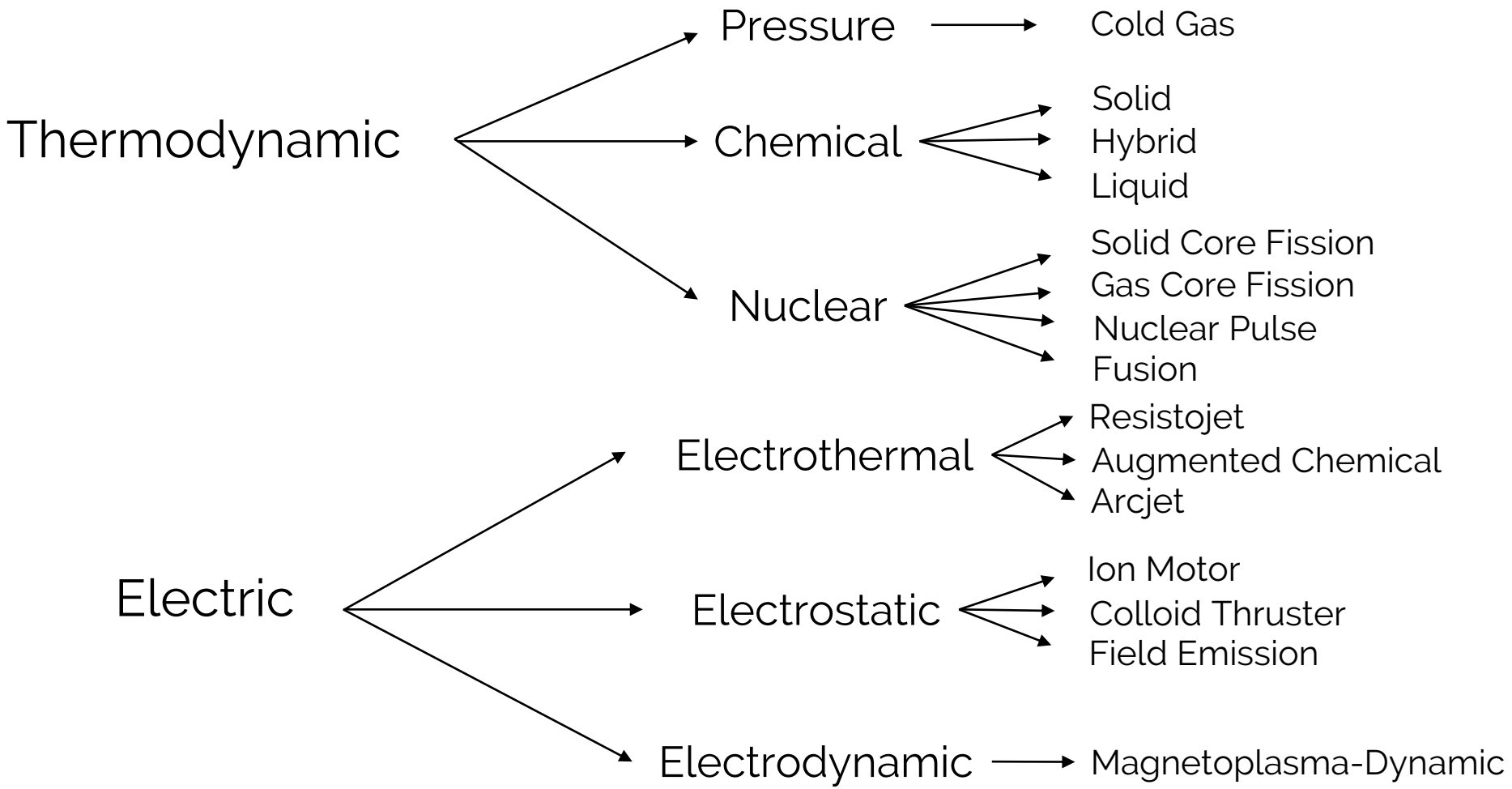
All we have seen so far applies to all types of rockets.

A rocket motor essentially takes energy from a source and transfers it to a fluid which is then ejected.

A rocket motor can be:

- Thermodynamic by heating gases
- Electric by moving masses electromagnetically

The Rocket Type Tree



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Chemical Rockets

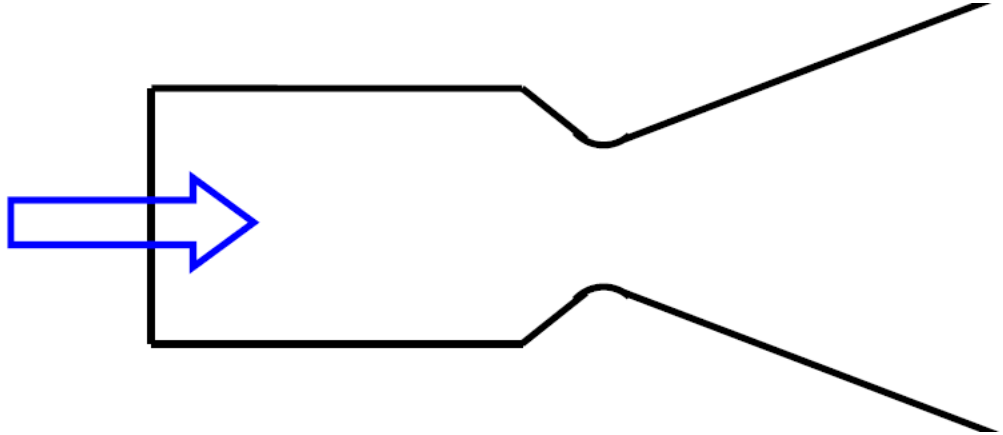
Essentially chemical rockets release the potential energy stored in chemical bonds through some form of reaction to heat up a gas.

The heated gas expands at high velocities creating thrust.

Three types:

- Liquid mono-bi-or tri-propellants
- Solids
- Hybrids

How Do Chemical Rockets Work?



Gas enters the chamber from outside or is generated by combustion of materials lining the walls

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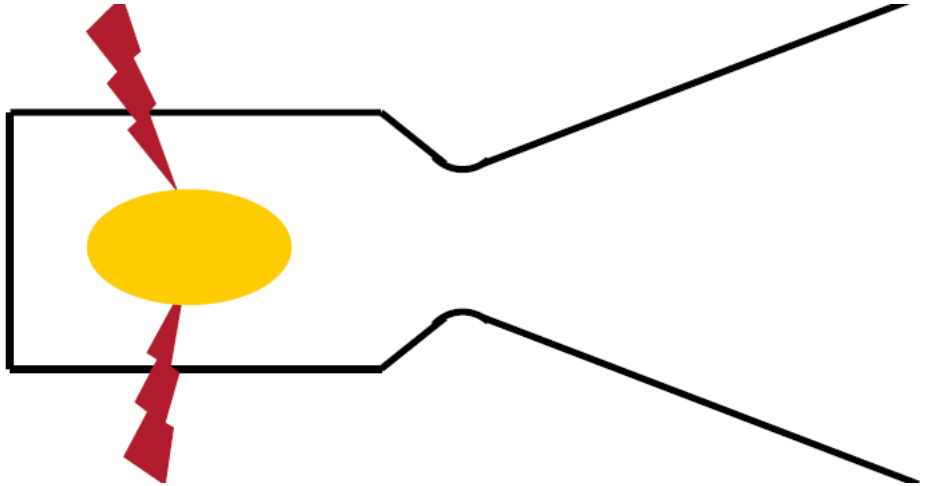
How Do Chemical Rockets Work?



Heat is added through chemical reactions or other means:

Increased random molecular kinetic motion ⟶ Gas expansion

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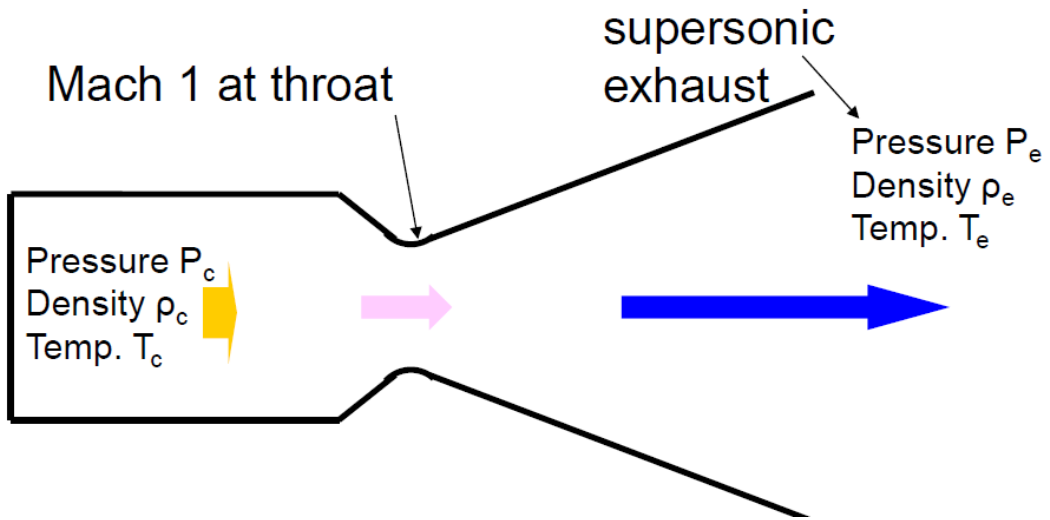
How Do Chemical Rockets Work?



- Gases and propellant escape down the nozzle accelerating and cooling down as they expand past the throat.

- Transfer of potential energy (Thermal/Pressure) to kinetic energy (gas velocity)

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Critical Performance Parameters

- For Nozzle Design:

  Thrust Coefficient: $C_F = \frac{F}{P_c A_T} = \frac{\dot{m} V_e + A_e (P_e - P_a)}{P_c A_T}$

- Propellant and Combustion Chamber Design:

  Characteristic Exhaust Velocity: $C^* = \frac{C}{C_F} = \frac{F/\dot{m}}{F/P_c A_T} = \frac{P_c A_T}{\dot{m}}$

  - This is affected by propellants, mixture ratio, combustion efficiency, etc.
  - Basically needs a high chamber temperature and low propellant molecular weight.

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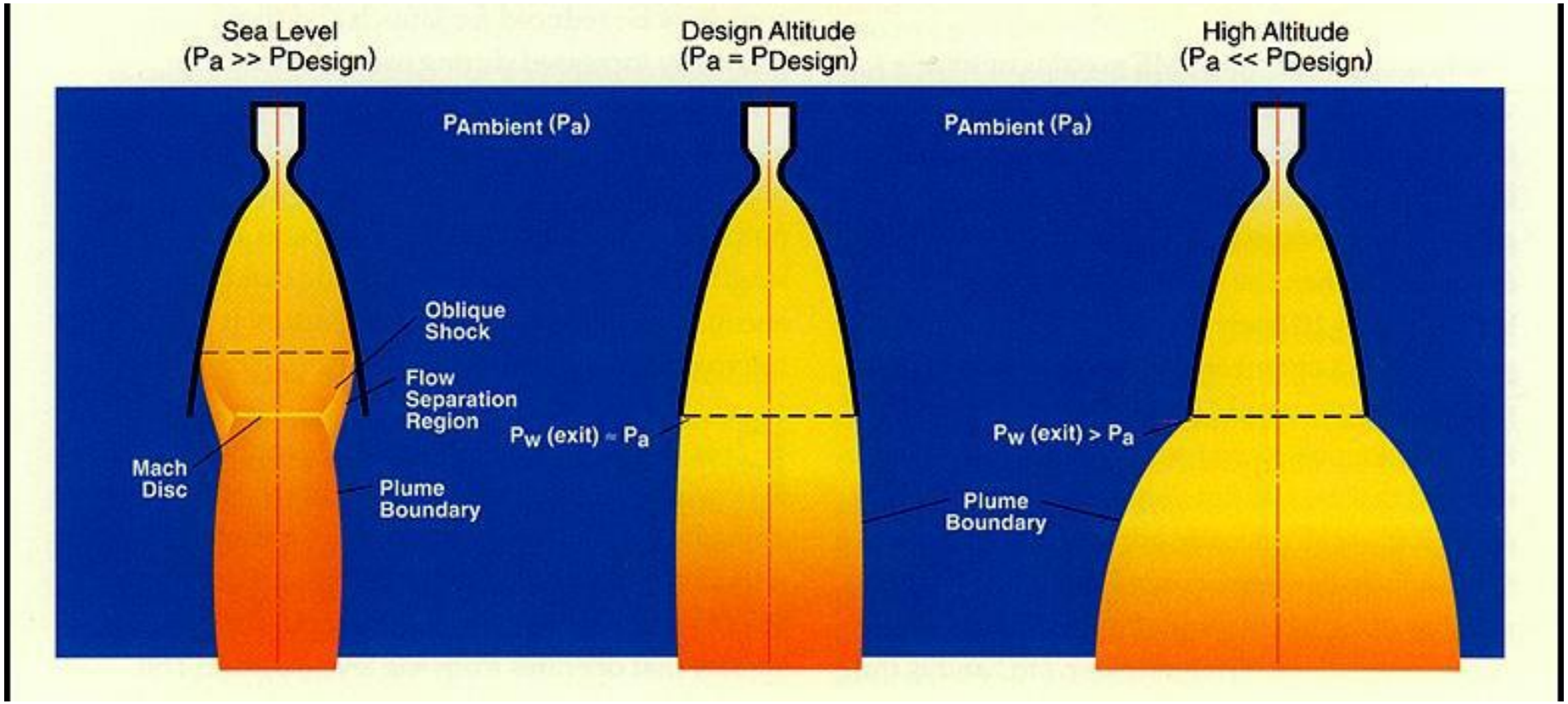
Nozzle Expansion

Over Expansion

Correct Expansion

Under Expansion



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Nozzle Expansion Implications

- Most trip at low atmospheric pressure: low exit pressure is desirable.
- At low altitudes high atmospheric pressure leads to suction and over expansion. This is dangerous and can lead to instabilities.
- Most Rocket Motor nozzles are designed to avoid separation at all altitudes.