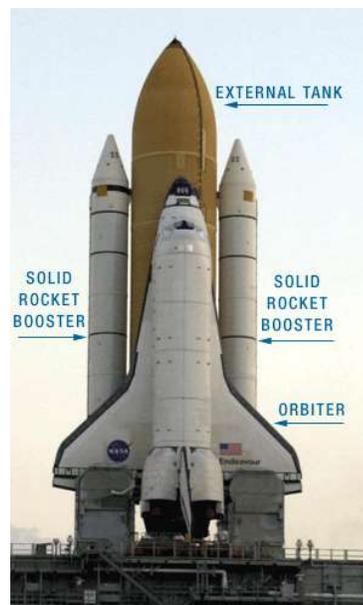


1. This question is about launching the space shuttle

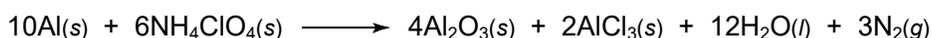
To launch the space shuttle, two propulsion systems are used. Most of the thrust for the first two minutes of flight comes from the two reusable solid rocket boosters. The so-called 'external tank' provides the remainder of the thrust needed to get the shuttle into orbit.

The external tank is filled with liquid hydrogen and liquid oxygen which react to form water. The solid rocket boosters use a mixture of aluminium powder and ammonium perchlorate, NH_4ClO_4 , together with an iron oxide catalyst and an organic binder.



- (a) Write the equation for the reaction between hydrogen and oxygen.
- (b) The external tank has a mass of 27 tonnes (27,000 kg) when empty and 745 tonnes when full. Assuming these are present in the correct stoichiometric proportions, calculate the masses of hydrogen and oxygen in the external tank.
- (c) In practice, the actual masses of hydrogen and oxygen used are 104 and 614 tonnes respectively. Given that the densities of liquid hydrogen and oxygen are 0.0708 and 1.141 g cm^{-3} , calculate the volumes of these liquids needed and hence the total capacity of the external tank in m^3 .

The reaction that takes place during the combustion of the solid rocket booster fuel has been summarized as:



- (d) Given the following standard enthalpies of formation, calculate the standard enthalpy change at 298 K for this reaction as given.

	$\text{NH}_4\text{ClO}_4(s)$	$\text{Al}_2\text{O}_3(s)$	$\text{AlCl}_3(s)$	$\text{H}_2\text{O}(l)$
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	-295.3	-1675.7	-704.2	-285.8

- (e) Given that 450 tonnes of solid propellant are used in the solid rocket boosters in total, and that aluminium is the limiting reagent present at 16% in the mixture, calculate the energy released when this is reacted according to the above equation.