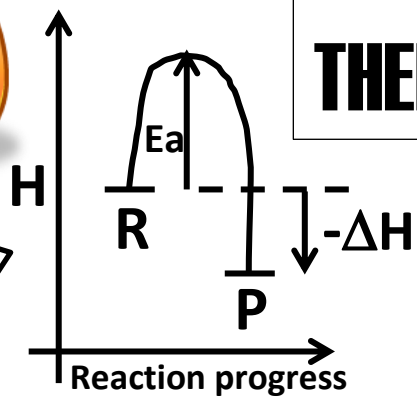


# EXOTHERMIC


 ● reaction mixture HEATS UP as reactants (R) lose  
 Out!! chemical energy to their surroundings

- $-\Delta H$  is negative
- products (P) have less enthalpy than reactants (R)

**Examples**  
 combustion  
 respiration  
 dissolve NaOH  
 in water  
  
 changes of  
 state  $G \rightarrow L$  or  
 $L \rightarrow S$   
  
 Mg & acid

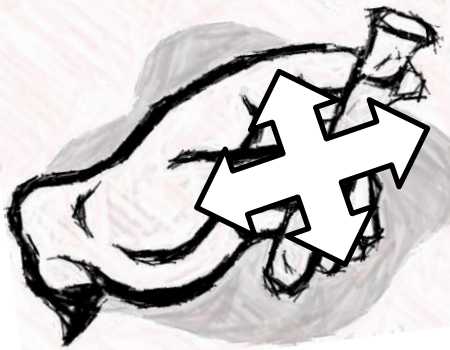


## THERMOCHEMISTRY


H = ENTHALPY, is  
 chemical potential  
 energy  
  
 Ea = activation energy

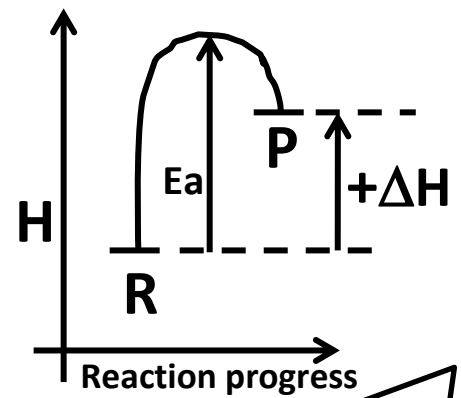
### REMEMBER

Bond breaking is endothermic  
 ...you have to put in energy to break  
 bonds e.g. if you glue (bond) your  
 fingers together you have to put in  
 energy to get them apart!!!  
  
 Bond making is exothermic



# ENDOTHERMIC


 in ● reaction surroundings cool  
 down as the reactants (R) gain chemical  
 energy ●  $+\Delta H$  is positive  
  
 ● products (P) have more enthalpy  
 than reactants (R)



### Examples

Photosynthesis  
  
 Some chemicals dissolving in water e.g.  
 $NH_4Cl$   
 changes of state  $S \rightarrow L$   
 or  $L \rightarrow G$

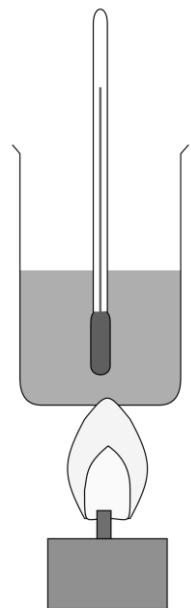


**“Burn it!”**

Burn a fuel under a known mass of water & measure the temperature change,  $\Delta T$  (final – initial temp.)

Calculation

Energy (J) =  $4.2 \times m \times \Delta T$   
where  $m$  is the mass of water.



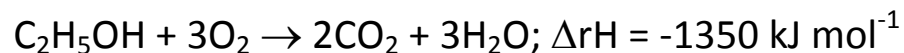
1 mL of water has a mass of 1 g.

1000J = 1 kJ

**Enthalpy experiments & calculations**

**“React it in a polystyrene cup!”** e.g. zinc powder & copper sulfate solution, OR dissolving NaOH in water.

Energy (J) =  $4.2 \times m \times \Delta T$  where  $m$  is the mass of the solution.  
Assume each 1 mL of solution has a mass of 1 g.

Calculations from equations...

1 mol      3 mol      2 mol      3 mol

The equation “says” that when you burn 1 mol of ethanol, 1350 kJ of energy are released (as was – sign, exothermic reaction)

**Moles: by straight proportion:**

Burn 2 mol of  $\text{C}_2\text{H}_5\text{OH}$  (in adequate oxygen) and  $2 \times 1350 = 2700$  kJ of energy would be released.

Burn 0.4 mol of  $\text{C}_2\text{H}_5\text{OH}$  (in adequate oxygen) and  $0.4 \times 1350 = 540$  kJ of energy would be released.

**Masses: You need the molar masses from periodic table or they will be given in the Q.**

$$M(\text{C}_2\text{H}_5\text{OH}) = (12 \times 2) + (1 \times 5) + 16 + 1 = 46 \text{ g mol}^{-1}$$

So when 46 g of ethanol are burnt, 1350 kJ of energy are released.

So....if 10 g of ethanol are burnt,  $1350 \times 10/46$  kJ of energy are released (293.5 kJ)

**CAREFUL!!** If the Q asks for  $\Delta_r H$  then you need a sign eg “ $\Delta_r H = -2700$  kJ”. If Q asks how much energy is released, say “2700 kJ are released”. **DON’T SAY “-2700 kJ are released! DON’T!!”**

Same for endothermic reactions: “ $\Delta_r H = +640$  kJ” or “640 kJ of energy are absorbed”.

**kJ mol<sup>-1</sup>** here  
since **1 mol** of  
ethanol is being  
burnt