1. The table below shows bond energies, measured in kilojoules per mole.

Bond	Bond energy, kJ/mol
F–F	158
Br–Br	193
H–H	436
H–F	565
H–Br	365

(a) Which of the bonds listed above is the strongest? Give a reason for your answer. [1]

H–F bond is the strongest. Largest amount of energy is required to break 1 mole of the bond.

(b) Calculate the enthalpy change for the reaction involving hydrogen and fluorine.

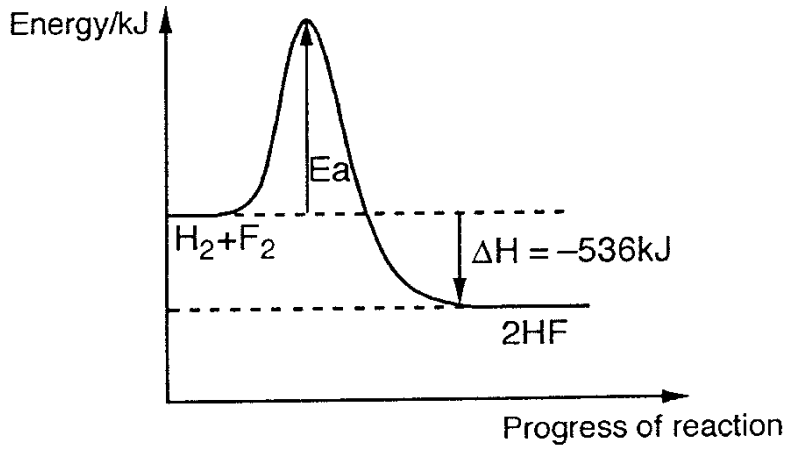
$H_2 + F_2 \rightarrow 2HF$ [1]

Energy absorbed during bond breaking = +436 +158 = +594 kJ
Energy given out during bond making =2x(–565)= –1130kJ
ΔH = energy absorbed during bond breaking
energy given out during bond making
ΔH = + 594 + (–1130) = –536 kJ/mol

(c) Is the reaction in (b) above exothermic or endothermic? Explain your answer in terms of bond making and bond breaking. [3]

Exothermic. The **total energy taken in during bond breaking** (H–H and F–F) is less than the **total energy given out during bond making** (H–F bond). Hence making the overall enthalpy change is negative.

(d) Complete the energy diagram below for the reaction between hydrogen and fluorine. [3]



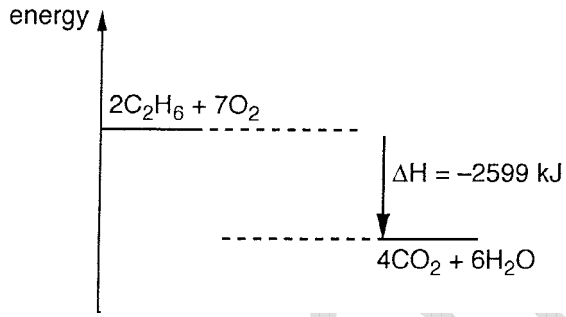
2. The bond energy data of some chemical bonds are given in the table below.

Bond	Bond energy/ kJ/mol
C – H	435
O = O	497
C = O	803
H – O	464
C – C	347

(a) Calculate the enthalpy of combustion of ethane. [2]

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
Heat absorbed =(2x6x435) + (2x347) + (7x497) = +9393 kJ
Heat given off =[4x2x(–803)] + [6x2x(–464)] = –11992 kJ
Enthalpy of combustion = +9393 + (–11992) = –2599 kJ/mol

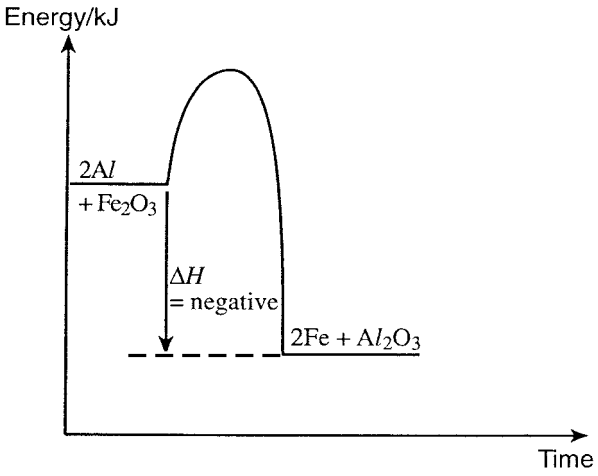
(b) Draw a labelled energy level diagram to represent this combustion process. [2]



3. The reaction below gives off a very large amount of heat and can reach temperatures of up to 3000 ℃. It can be used in welding.

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

Complete the energy profile diagram for the reaction above. [2]



4. The following reaction takes place in the Haber process used to manufacture ammonia gas:

$N_2 + 3H_2 \rightarrow 2NH_3$ $\Delta H = -75$ kJ

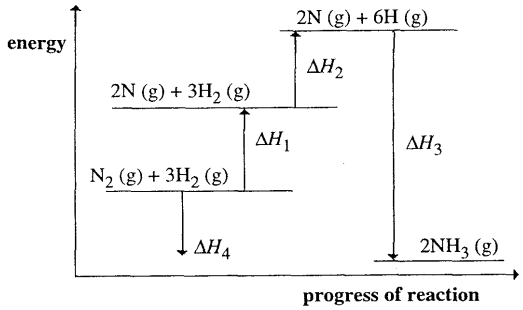
(a) Is this reaction an endothermic or an exothermic reaction? How can you tell from the equation? [1]

Exothermic. Enthalpy change is negative.

(b) The table below shows some bond energies, measured in kJ/mol.

Bond	Bond energy (kJ/mol)	Bond	Bond energy (kJ/mol)
H–H	436	N=N	409
N–N	163	N≡N	945

The energy profile diagram for the formation of ammonia gas from nitrogen and hydrogen can be drawn as shown below:



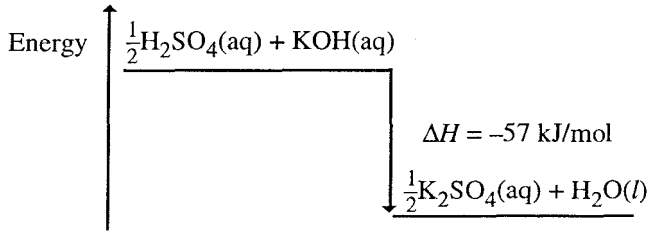
(i) Use the information given above to calculate the values of ΔH_1, ΔH_2, ΔH_3 and ΔH_4. What is the bond energy of the N–H bond in kJ/mol? [5]

$\Delta H_1 = +945$ kJ {breaking N≡N}
$\Delta H_2 = 3x(+436) = +1308$ kJ {breaking 3H–H}
$\Delta H_4 = -75$ kJ {from : $N_2 + 3H_2 \rightarrow 2NH_3$ $\Delta H = -75$ kJ}
$\Delta H_4 = \Delta H_1 + \Delta H_2 + \Delta H_3$
$-75 = +945 + 1308 + \Delta H_3$
$\Delta H_3 = -2328$ kJ
Bond energy of N–H bond = 2328/6 = 388 kJ/mol
{there's no need to have sign as we are talking about bond energy, not in terms of absorbing or giving out}

(ii) Use the energy profile diagram to estimate the activation energy needed for this reaction. [1]

Estimated activation energy = +945 +1308
= +2253 kJ/mol

5. The diagram below represents the heat change for the reaction between dilute sulphuric acid and aqueous potassium hydroxide.



(a) What does ΔH = –57 kJ/mol represent? [1]

Exothermic. Enthalpy change is negative.

(b) Write an ionic equation for the reaction. [1]

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

(c) In an experiment, 50 cm^3 of 0.5 mol/dm^3 sulphuric acid is mixed with 50 cm^3 of 1 mol/dm^3 potassium hydroxide. By using the energy diagram given above, calculate the heat change in this reaction. [3]

No. of moles of sulphuric acid = 50/1000 x 0.5 = 0.025
No. of moles of potassium hydroxide = 50/1000 x 1 = 0.05
Heat change = 0.05 x 57 = –2.85 kJ

(d) $HNO_{3(aq)} + NaOH_{(aq)} \rightarrow NaNO_{3(aq)} + H_2O_{(l)}$ ΔH = – 57 kJ/mol

The value of All for the reaction between nitric acid and sodium hydroxide is the same as that between sulphuric acid and potassium hydroxide. Explain. [2]

The ionic equation forboth reaction are the same ($H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$) indicating that the neutralisation reaction is the only reaction taking place. Hence, the main contribution of energy change comes from the bond making during formation of water.

(e) $HCOOH_{(aq)} + KOH_{(aq)} \rightarrow HCOOK_{(aq)} + H_2O_{(l)}$
ΔH = –***x*** kJ/mol

Ethanoic acid is a weak acid. The value of x is less than 57. Explain why this is so. [1]

The weak acid only partially ionised into hydrogen ions.

~ The End ~