AS LEVEL CHEMISTRY

2.3.1 ENTHALPY CHANGES

TEST

Answer all questions

Max 50 marks

Name	……..
Mark	……../50 ……....% Grade ……

1. Methane reacts with oxygen to produce carbon dioxide and water. The equation for this reaction is given below.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Gas cookers use methane as a fuel because this reaction is exothermic and takes place at a fairly fast rate.

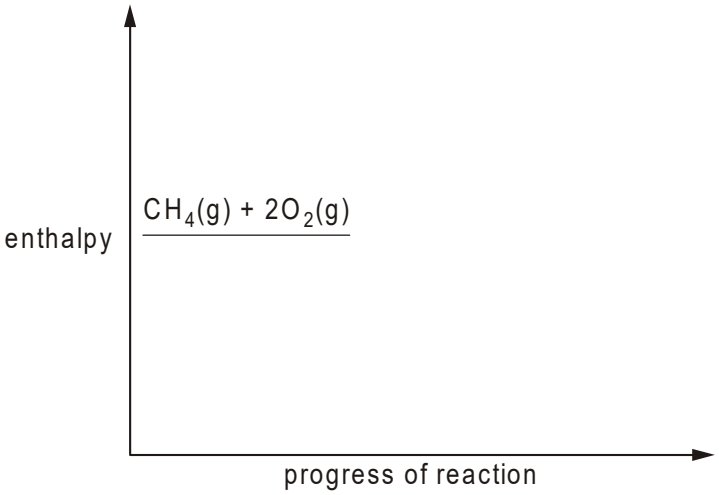
Activation energy is important in considering the conditions needed to change the rate of a reaction.

(a) What is meant by the term *exothermic*?

.....

[1]

(b) The figure below is an incomplete enthalpy profile diagram for the reaction between methane and oxygen.



(i) Complete the figure to show the complete enthalpy profile for the reaction.

[2]

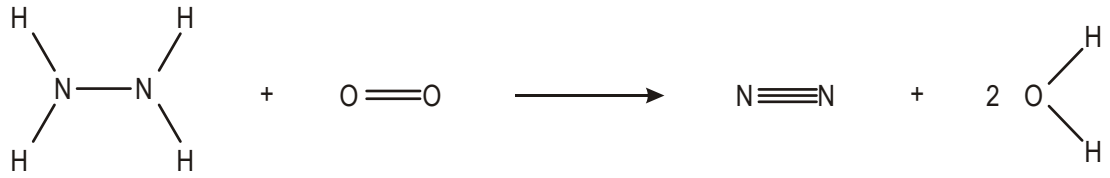
(ii) Label the activation energy, E_a, on the figure above.

[1]

[Total 4 marks]

2. This question is about hydrazine, N_2H_4, and ammonia, NH_3. These are both compounds of nitrogen and hydrogen.

(a) Hydrazine can be oxidised and used as a rocket fuel. The equation for one possible reaction taking place is shown below.



Some average bond enthalpies are given below.

bond	bond enthalpy / kJ mol^{-1}
N–N	+163
N≡N	+945
N–H	+390
O=O	+497
O–H	+463

(i) Use these data to calculate the enthalpy change for the reaction of hydrazine with oxygen, as shown.

answer ..... kJ mol^{-1}

[4]

(ii) Calculate the enthalpy change for one gram of hydrazine in this reaction.

answer ..... kJ

[1]

(b) Ammonia reacts with oxygen in a very similar way to that shown for hydrazine. The enthalpy change for one gram of ammonia is approximately the same as that for one gram of hydrazine.

Using the table above, suggest a reason why hydrazine is used as a rocket fuel and ammonia is not.

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[1]

[Total 6 marks]

3. Energy changes during reactions can be considered using several different enthalpy changes. These include average bond enthalpies and enthalpy changes of combustion.

Table below shows the values of some average bond enthalpies.

bond	average bond enthalpy / kJ mol^{-1}
C — H	+ 410
O — H	+ 465
O == O	+ 500
C == O	+ 805
C — O	+ 336

(i) Why do bond enthalpies have positive values?

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.....

[1]

(ii) Define the term *bond enthalpy.*

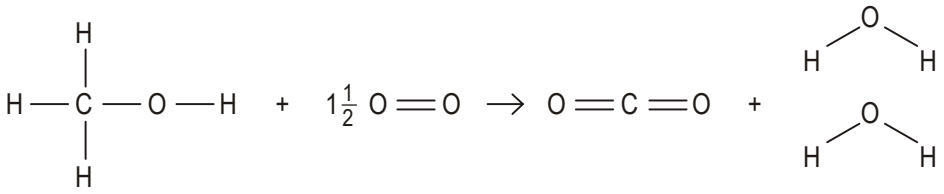
.....

.....

.....

[2]

(iii) The equation below shows the combustion of methanol, CH_3OH, in the gaseous state.



Use the average bond enthalpies from the table above to calculate the enthalpy change of combustion of gaseous methanol, ΔH_c.

ΔH_c = ... kJ mol^{-1}

[3]

(iv) Suggest **two** reasons why the **standard** enthalpy change of combustion of methanol will be different from that calculated in part (iii).

reason 1 .....

.....

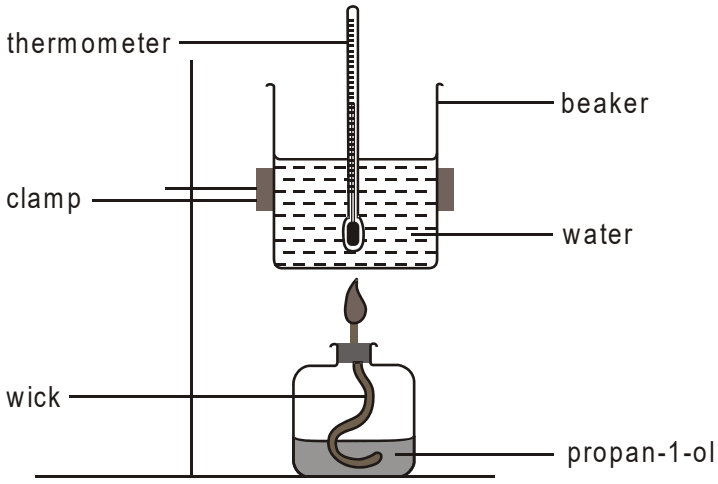
reason 2 .....

.....

[2]

[Total 8 marks]

4. In an experiment to determine the standard enthalpy change of combustion of propan-1-ol, C_3H_7OH, a student used the apparatus shown below.



(a) Define the term *enthalpy change of combustion*.

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[2]

(b) Write the equation for the standard enthalpy change of combustion of propan-1-ol, C_3H_7OH.

.....

[2]

(c) The student measured 50.0 cm^3 of water into the beaker and lit the burner. When the temperature of the water had gone up by 12.8 °C, he found that 0.100 g of propan-1-ol had been burnt.

(i) Calculate the energy, in kJ, produced by burning 0.100 g of propan-1-ol. The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

energy = ... kJ

[2]

(ii) Calculate the number of moles of propan-1-ol in 0.100 g.

number of moles = ...

[2]

(iii) Calculate the enthalpy change of combustion, in kJ mol^{-1}, of propan-1-ol.

enthalpy change ..... kJ mol^{-1}

[1]

(d) The student looked in a text book and found that the actual value for the standard enthalpy change of combustion of propan-1-ol was more exothermic than the experimental value.

Suggest **two** reasons for the difference between this value and the one he obtained experimentally.

1 .....

.....

2 .....

.....

[2]

[Total 11 marks]

5. Enthalpy changes of combustion can be used to determine enthalpy changes of formation.

(i) Write the equation for the standard enthalpy change of formation of butane, C_4H_{10}. Include state symbols in your answer.

.....

[2]

(ii) Use the following data to calculate the standard enthalpy change of formation of butane.

	standard enthalpy change of combustion / kJ mol^{-1}
carbon	–394
hydrogen	–286
butane	–2877

answer ..... kJ mol^{-1}

[3]

[Total 5 marks]

6. Methane can be reacted with steam to produce carbon monoxide and hydrogen. The equation for this process is given below.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

The table below shows the enthalpy changes of formation for methane, steam and carbon monoxide.

compound	ΔH_f / kJ mol^{-1}
CH_4	–75
H_2O	–242
CO	–110

(a) Define the term *enthalpy change of formation*.

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[2]

(b) Write the equation, including state symbols, representing the enthalpy change of formation for methane, CH_4.

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[2]

(c) Use the ΔH_f values in the table to calculate the enthalpy change for the reaction shown in the equation shown above.

..... kJ mol^{-1}

[3]

(d) State one important manufacturing process in which hydrogen is used.

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[1]

[Total 8 marks]

7. The changes in energy during reactions are often considered using enthalpy changes of reaction. One such enthalpy change is the standard enthalpy change of formation.

(i) Define the term *standard enthalpy change of formation*.

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[3]

(ii) Write the equation for the reaction corresponding to the standard enthalpy change of formation of magnesium nitrate, $Mg(NO_3)_2$. Include state symbols.

[2]

(iii) When magnesium nitrate is heated, it decomposes to give magnesium oxide, nitrogen dioxide and oxygen.

Use the standard enthalpy changes of formation to find the enthalpy change of reaction for this decomposition.

substance	standard enthalpy change of formation / kJ mol^{-1}
$Mg(NO_3)_2$	–791
MgO	–602
NO_2	–33

The equation for this reaction is shown below.

$$Mg(NO_3)_2(s) \rightarrow MgO(s) + 2NO_2(g) + \frac{1}{2} O_2(g)$$

enthalpy change = ...kJ mol^{-1}

[3]

[Total 8 marks]