Energetics Test

Answer ALL Questions. Max 50 marks. To Pass the Energetics Test you will need to achieve a score of greater than 70%.

1. (a) Explain the meaning of the terms *mean bond enthalpy* and *standard enthalpy of formation*.

Mean bond enthalpy .....

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Standard enthalpy of formation .....

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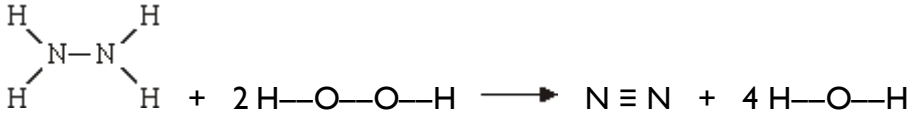
(5)

(b) Some mean bond enthalpies are given below.

Bond	N–H	N–N	N≡N	H–O	O–O
Mean bond enthalpy/kJ mol^{-1}	388	163	944	463	146

Use these data to calculate the enthalpy change for the following gas-phase reaction between hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2



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(3)

(c) Some standard enthalpies of formation are given below.

	$N_2H_4(g)$	$H_2O_2(g)$	$H_2O(g)$
$\Delta H_f^{\ominus}$ /kJ mol^{-1}	+75	–133	–242

These data can be used to calculate the enthalpy change for the reaction in part (b).

$$N_2H_4(g) + 2H_2O_2(g) \rightarrow N_2(g) + 4H_2O(g)$$

(i) State the value of $\Delta H_f^{\ominus}$ for $N_2(g)$.

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(ii) Use the $\Delta H_f^{\ominus}$ values from the table to calculate the enthalpy change for this reaction.

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(4)

(d) Explain why the value obtained in part (b) is different from that obtained in part (c)(ii).

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(1)

(Total 13 marks)

2. (a) State Hess's Law and use it, together with the data given in the table below, to calculate the standard enthalpy change for the following reaction.

$MgO(s) + 2HCl(g) \rightarrow MgCl_2(s) + H_2O(l)$

	MgO	HCl(g)	$MgCl_2$	H_2O
$\Delta H_f^{\ominus}$/kJ mol^{-1}	–602	–92	–642	–286

(4)

(b) In an experiment, an excess of solid magnesium oxide was added to 50 cm^3 of 3.0 mol dm^{-3} hydrochloric acid. The initial temperature of the solution was 21 °C. After reaction, the temperature had risen to 53 °C. (The specific heat capacity of water is 4.2 J K^{-1} g^{-1})

Use this information to calculate the enthalpy change for the reaction of one mole of magnesium oxide with hydrochloric acid. For your calculation you should assume that all the heat from the reaction is used to raise the temperature of 50 g of water.

(8)
(Total 12 marks)

3. The table below contains some mean bond enthalpy data.

Bond	H—H	C—C	C=C	N≡N	N—H
Mean bond enthalpy / kJ mol^{-1}	436	348	612	944	388

(a) (i) Write an equation for the formation of one mole of ammonia, NH_3, from its elements.

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(ii) Use data from the table above to calculate a value for the enthalpy of formation of ammonia.

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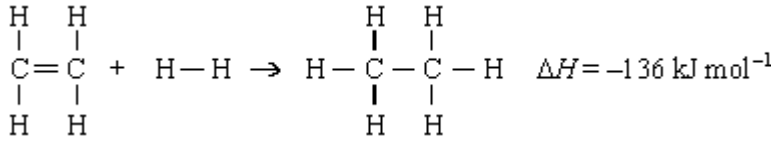
(4)

(b) Use the following equation and data from the table above to calculate a value for the C–H bond enthalpy in ethane.



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(3)

(Total 7 marks)

4. (a) Write an equation for the complete combustion of propanone, C_3H_6O, to form carbon dioxide and water.

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(1)

(b) In a laboratory experiment, 1.45 g of propanone were burned completely in oxygen. The heat from this combustion was used to raise the temperature of 100 g of water from 293.1 K to 351.2 K.

(i) Calculate the number of moles of propanone in the 1.45 g.

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(ii) Calculate the heat energy required to raise the temperature of 100 g of water from 293.1 K to 351.2 K.
(The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

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(iii) Hence, calculate a value, in kJ mol^{-1}, for the enthalpy of combustion of propanone.

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(5)

(c) In a similar experiment, the enthalpy of combustion of butanone, C_4H_8O, was found to be –1290 kJ mol^{-1}. A data book value for the same reaction is $\Delta H_c^{\ominus}$ = –2430 kJ mol^{-1}.

(i) Suggest one reason why the experimental value is very different from the data book value.

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(ii) This data book value of $\Delta H_c^{\ominus}$ for butanone (–2430 kJ mol^{-1}) refers to the formation of carbon dioxide gas and water in the gaseous state. How would this value differ if it referred to the formation of water in the liquid state? Explain your answer.

Difference .....

Explanation .....

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(3)

(d) Calculate a value for the standard enthalpy of formation for liquid ethanethiol, C_2H_5SH. Use the equation given below and enthalpy of combustion data from the following table.

Substance	$C_2H_5SH(l)$	C(s)	$H_2(g)$	S(s)
$\Delta H_c^{\ominus}$ / kJ mol^{-1}	–1170	–394	–286	–297

$2C(s) + 3H_2(g) + S(s) \rightarrow C_2H_5SH(l)$

(3)
(Total 12 marks)

5. Given the following data

$C(s) + 2H_2(g) \rightarrow CH_4(g)$ $\Delta H = -75$ kJ mol^{-1}

$H_2(g) \rightarrow 2H(g)$ $\Delta H = +436$ kJ mol^{-1}

which one of the following is the enthalpy change, in kJ mol^{-1}, of the reaction below?

$CH_4(g) \rightarrow C(s) + 4H(g)$

A −947

B +511

C +797

D +947

(Total 1 mark)

6. Use the information below to answer this question.

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H^{\ominus} = -393.5$ kJ mol^{-1}

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H^{\ominus} = -285.8$ kJ mol^{-1}

$3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$ $\Delta H^{\ominus} = -104.0$ kJ mol^{-1}

$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$ $\Delta H^{\ominus} = -125.2$ kJ mol^{-1}

The value in kJ mol^{-1} of the enthalpy of thermal dissociation when butane forms propane, hydrogen and carbon is

A −26.3

B −17.5

C +17.5

D +21.2

(Total 1 mark)

7. When ethanamide (CH_3CONH_2) burns in oxygen the carbon is converted into carbon dioxide, the hydrogen is converted into water and the nitrogen forms nitrogen gas.

Substance	ethanamide	carbon dioxide	water
Enthalpy of formation ($\Delta H_f^{\ominus}$) / kJ mol^{-1}	−320	−394	−286

Using the data above, which one of the following is a correct value for the enthalpy of combustion of ethanamide?

A −1823 kJ mol^{-1}

B −1183 kJ mol^{-1}

C −1000 kJ mol^{-1}

D −360 kJ mo1^{-1}

(Total 1 mark)

8. Use the information below to answer this question.

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H^{\ominus} = -393.5$ kJ mol^{-1}

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\quad \Delta H^{\ominus} = -285.8$ kJ mol^{-1}

$3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$ $\quad \Delta H^{\ominus} = -104.0$ kJ mol^{-1}

$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$ $\quad \Delta H^{\ominus} = -125.2$ kJ mol^{-1}

The value in kJ mol^{-1} for the enthalpy of combustion of propane is

A −211.7

B −419.7

C −2220

C −2878

(Total 1 mark)

9. The table below shows data for the four hydrocarbons ethyne, propyne, propene and propane. ΔHc is the standard enthalpy of combustion of these hydrocarbons.

Compound	Name	M_r	$-\Delta Hc^{\ominus}$ / kJ mol^{-1}
HC≡CH	ethyne	26	1300
HC≡CCH$_3$	propyne	40	1940
H$_2$C=CHCH$_3$	propene	42	2060
CH$_3$CH$_2$CH$_3$	propane	44	2220

The complete combustion of 2.0 g of one of the above hydrocarbons releases exactly 100 kJ of heat energy.

This hydrocarbon is

A ethyne

B propyne

C propene

D propane

(Total 1 mark)

10. Consider the reactions

$C_2H_4(g) + 2O_2(g) \rightarrow 2CO(g) + 2H_2O(g)$ $\quad \Delta H^{\ominus} = -758$ kJ mol^{-1}

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$ $\quad \Delta H^{\ominus} = +52$ kJ mol^{-1}

$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g)$ $\quad \Delta H^{\ominus} = -242$ kJ mol^{-1}

The enthalpy of formation of carbon monoxide is

A −111 kJ mol^{-1}

B −163 kJ mol^{-1}

C $-222\ kJ\ mol^{-1}$

D $-464\ kJ\ mol^{-1}$

(Total 1 mark)